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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
JULY, 1960

76368

Complied by
Operation Managers

August 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

[redacted]

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 L. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE July 31, 1960

	At close of month			At beginning of month			Additions		Separations	
	Exempt	Nonexempt	Total	Exempt	Nonexempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	135	114	249	133	112	245	2	5	0	3
Reactor & Fuels Research & Development	198	191	389	194	189	383	4	5	0	3
Physics & Instrument Research & Development	79	41	120	77	40	117	2	1	0	0
Biology Operation	42	42	84	41	42	83	2	1	1	1
Operation Res. & Syn.	16	3	19	16	4	20	0	0	0	1
Radiation Protection	34	101	135	34	100	134	0	1	0	0
Laboratory Auxiliaries	54	191	245	54	190	244	0	7	0	6
Financial	14	16	30	14	15	29	0	2	0	1
Prof. Placmt. & R. P.	99	15	114	86	15	101	20	0	7	0
Programming	18	4	22	19	4	23	0	0	1	0
General	1	3	4	1	2	3	0	1	0	0
Total	690	721	1411	669	713	1382	30	23	9	15
Totals excluding internal transfers.	690	721	1411	669	713	1382	27	18	6	10

BUDGETS AND COSTS

July operating costs aggregated $1,757,000 or 7% of the tentative control budget of $25,403,000.

Hanford Laboratories research and development costs had the following relationship with the tentative control budget as of July 31:

(Dollars in Thousands)	Cost	Budget	% Spent
HLO Programs	$		
2000 Program	67	$ 597	11%
4000 Program	549	8 835	6
5000 Program	54	742	7
6000 Program	190	2 372	8
	860	12 546	7
IPD Sponsored	226	3 100	7
CPD Sponsored	124	1 658	7
	$1 210	$17 304	7%

The Preliminary Financial Plan did not include funds for the Specific Fuel Cycle Analysis or Fabrication of DMA elements; however, HOO-AEC has indicated that funds will be available.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels Research and Development

The Phase III portion of PRTR construction is about 96% complete as of August 1, 1960, versus a scheduled 100% complete based on a contract completion date of June 24, 1960. The over-all PRTR project is estimated to be about 97.5% complete versus a scheduled 98.3% based on the official AEC schedule. The river pump facility, including the condenser, was accepted from the contractor. Sixteen PRTR shim control assemblies were delivered to the reactor contractor along with two plugs to allow helium pressure testing. Two additional assemblies are now tested and available.

Approximately 96% of the PRTR Startup Process Specifications have been written and reviewed initially by the Start-up Council. Eighty-seven per cent of the specifications have been approved by the council, and 70% have been published in approved form.

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

[redacted]

Zircaloy-4 tubing now being received, although of improved metallurgical quality, still lacks precise control of internal diameter.

Further tests confirm the unlikelihood of the Zircaloy process tube hydriding rapidly as the result of proximity (one-fourth inch away) to a rupturing fuel element.

Further Zircaloy fretting studies demonstrate reduced attack by lowering the unit load, temperature, and/or rubbing rate. However, contrary to a previous report, increasing the clearance between the vibrating parts increases rather than decreases the rate of fretting attack.

Cold swaged UO_2 fuel specimens have achieved an exposure of 17,000 MWD/T without failure.

Forty-eight extrusion billets of Pu-Al alloy containing 2% Ni were cast during the month and all exhibited satisfactory corrosion resistance verifying earlier work. Experiments to determine the effective lower limit of nickel content are under way.

Injection casting of one Pu-Al rod per day is proceeding in recently activated prototype equipment. Two complete 19-rod clusters will be fabricated for PRTR testing.

Measurements of radiation dose rates at the front face of B Reactor indicate that the principal neutron dose is coming from dry tubes which are currently shielded with steel plugs. It is estimated that the neutron dose could be reduced by a factor of two by using concrete-filled plugs in place of the steel plugs.

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

A tubular element failed in KER apparently by a clad split mechanism similar to that which earlier caused failure of two rod elements. Exposure was 3450 MWD/T.

Two hot pressed fuel elements have been successfully irradiated in the MTR to 1400 MWD/T at an average power generation of 140 kw/ft.

Low carbon steel supports in NPR fuel have been shown to eliminate scratching of the process tube. If, however, the feet are rubbed on stainless steel before contacting the tube (as in the charging machine) extensive galling of the process tube results.

Preliminary tests show that satisfactory fuel closures may be made on S. A. P. material employing the magnetic force welder.

Nearly a 40-fold reduction in rupture severity was demonstrated for a predefected, irradiated, NPR-type fuel rod by adopting a more rapid cool-down cycle from 300 C to 230 C, followed by slower cooling below 230 C.

2. Chemical Research and Development

In connection with Salt Cycle process development, an electrolysis cell sized to permit production of pound lots of UO_2 was placed in operation. The first batches of UO_2 produced had good chemical and physical properties.

The simultaneous use of steam (vice air) for feed atomization and bed fluidization in the operation of the fluid-bed, waste calciner prototype was successfully demonstrated. Although some increase in agglomerate formation occurred, optimization of operating conditions is expected to circumvent this effect.

Operational difficulties encountered in the batch calcination of simulated, neutralized Purex waste can be obviated by acidification of the waste with sulfuric acid prior to calcination. In addition to smoother operations, additional benefits realized are a lower volume of solids per ton of uranium, and improved physical properties of the product.

The long-lived radioisotopes (cesium and strontium) in high level Purex waste can be converted to a compact solid by adsorption onto clinoptilolite providing the waste is first diluted with water. Volume reduction factors for cesium of about 30 and 7 are obtained when the high level waste is diluted by factors of 20 and 3-1/2, respectively.

The use of an inorganic ion exchange material, Decalso YG, also shows promise of utility for converting a purified, strontium-90 solution into a compact solid form. About 4000 curies of strontium-90 can be contained in one liter of resin. The potential use of this material for off-site shipment of strontium-90 is being determined.

Isotopic analysis of strontium in the Purex 1WW stream showed that greater than 90% of this material is of fission product origin and, therefore, quite suitable for use in thermoelectric power units.

A pilot scale facility to test the decontamination of reactor effluent water by means of an absorption bed packed with aluminum turnings was completed and placed in operation.

A test of the peroxy-acetate process for the recovery of cerium-144 from Purex waste was successfully carried out in the High Level Radiochemistry Facility using one liter of full level plant waste.

A hot cell experiment to demonstrate recovery technology for strontium-90 from Purex waste is nearing completion.

Preliminary studies show that the standard neptunium-239 separation procedure with minor modifications can be applied as a bioassay separation method for neptunium-237.

3. Physics and Instrument Research and Development

Graphite for the exponential mockup associated with the NPR program has been stacked and measurements will begin as soon as the fuel elements are received. Delivery of these elements, originally scheduled for February, has been pushed back in four successive postponements to August 1.

The final design decision on the NPR fuel failure monitor was announced by IPD. It will use the IPD-developed G-M tube system for monitoring each individual sample line for gross gamma activity and the HLO-developed slow-scan gamma energy monitor for backup.

Satisfactory progress was made in the development of remote area monitoring equipment for the NPR with continued successful field tests of the linear monitor and delivery of the logarithmic monitor to IPD for field tests. Fabrication on a prototype air monitor continued.

The Critical Mass Laboratory has been accepted from the contractor, and personnel of the Critical Mass Physics Operation are in the process of occupying the new building and planning the startup of experimental work. Meanwhile, experiments of the subcritical variety have continued with 2%, 2.6%, and 3% enriched uranium.

In connection with the Plutonium Recycle Program, work continued on developing techniques for measuring the prompt neutron lifetime in the PRTR, on instrumentation for in-reactor process tube inspection, on calibrations for lattice experiments and on development of the program for the PRPCF.

Nondestructive testing of fuel elements by electromagnetic methods may be materially advanced by the application of advanced techniques of signal interpretation which have been developed offsite for other purposes. Meanwhile, improvements were obtained in the application of infrared methods.

A major obstacle to the complete analysis of atmospheric dispersion data collected last summer was overcome with successful development and application of a method for measuring tracer material collected on filters which simultaneously and unavoidably collected dust. Measurements were completed on all filters and data reduction procedures are being programmed.

Improved ability to treat reactor physics problems is expected to result from new mathematical developments in handling neutron captures in plutonium resonances, and from the development of a more sophisticated model of the neutron rethermalization process. In the basic data field, measurement of the scattering of neutrons from water has been completed for neutrons of one energy (0.147 ev) and the data have been analyzed to give the spread in energy of the scattered neutrons at various scattering angles.

4. Biology

Contamination of Columbia River and terrestrial life forms was greater than that observed a year ago.

Research with Zn^{65} in large animals has suggested that some of the secondary parameters used for permissible limits in Handbook 69 may have to be revised. An interesting outgrowth of this work is that a technique may become available for determining viability of red blood cells.

It was determined that there is no difference in I^{131} uptake by lambs whether the radioiodine is administered as the iodide ion in the milk or cycled through the ewe to appear in the milk later.

Research with Np^{237} has started. Early results indicate that neptunium and its daughter protactinium are separately treated in the animal body. In connection with this work, some of the actual material which is causing concern was received for experimental purposes.

5. Programming

The necessary physics calculations for the study of plutonium enriched fuel cycles in the Advanced Pressurized Water Reactor were substantially completed. This included a few highly successful calculations in an attempt to find a long lasting, Phoenix type, fuel composition. Attainable fuel reactivity lifetime of more than 60,000 MWD/T was calculated for feed of 7.5% Pu-239, 15% Pu-240, and 77.5% U-238. A comparison case using 3% enriched uranium with boron poisoning gave lifetimes about one-fifth as great.

A complete description of PRTR critical tests was written and issued. The Plutonium Recycle Program Ten Year Plan report was issued.

Concurrent with establishment of nickel instead of silicon as the preferred alloying agent for Pu-Al cores for the PRTR spike fuel elements, revised material standards were determined and issued.

Negotiations were completed for the shipment to Hanford for Plutonium Recycle Program use of 2 kg of high exposure (16% Pu-240) plutonium for use in PCTR tests. Delivery is expected in September. This will enable the first lattice parameter tests ever made for material of this sort.

All Hanford Laboratories research and development programs for the Division of Reactor Development were reviewed for benefit of top DRD personnel on July 14 and 15.

A paper summarizing progress to date on the Plutonium Recycle Program was written for oral presentation at the IAEA sponsored conference on Small and Medium Power Reactors to be held at Vienna, Austria, September 5 - 9, 1960.

TECHNICAL AND OTHER SERVICES

Further work on the problem of determining optimum crew size has resulted in the general expression for the probability that a given number of reactors will be "down" during a given shift, and that of these a given number will be performing charge-discharge work.

The statistical analysis of zirflex data was completed. A model was constructed which appropriately defined the dissolution rate of zirconium as a function of solution pH and fluoride ion concentration.

A mathematical model was developed to express the transfer of thorium ions from solution to resin balls by unrestricted diffusion. A graphical method was devised for checking the theoretical model against experimental data and good agreement has been realized for all experiments to date.

A preliminary analysis was completed of post-irradiation data from 48 tubes of fuel elements discharged under the quality certification program.

Technical assistance is being given in developing a mathematical theory of the metallurgically-idealized continuously dislocated crystal. The analysis is somewhat unusual in that it employs as its major tool the pure mathematical discipline of generalized tensor calculus for non-Riemannian geometry.

Special vegetation and milk samples were obtained following the release of approximately 54 curies of iodine-131 from the Redox plant during a ten-day period. These samples did not show abnormal iodine-131 content. Approximately 0.08 curie of activity, principally Te-132 and I-131, was emitted from the 105-KW Reactor stack as the result of the discharge of a burning fuel element on July 7, 1960. Initiation of the fog spray system prior to discharge of the ruptured fuel element apparently prevented discharging of additional contamination.

There was one new case of plutonium deposition confirmed during the month. This brings the total cases which have occurred at HAPO to 257 of which 188 are currently employed. One CPD employee sustained a minor injury during installation of a pump in the solvent extraction hood of 234-5 Building. Preliminary bioassay results indicate plutonium deposition to about 10% of the maximum permissible body burden.

There are 21 currently active projects having combined authorized funds in the amount of $20,356,000. The total estimated cost of these projects is $23,818,000. All but five of those authorized are on or ahead of schedule. Four of the five are more than 3% behind schedule.

A review of Hanford reports in the now out-moded categories C-66, C-67, and C-68 has been completed and a final report made to the Commission. The Commission has also been supplied with a microfilm of the review sheets for future reference if needed.

The automation of the Classified Files issuance and routing procedures is getting down to the details of practical operation and initial programming is underway. Prospects are that a well worked out system can increase efficiency and reduce costs.

SUPPORTING FUNCTIONS

The physical inventory of movable cataloged equipment in the custody of Reactor and Fuels Research and Development Operation resulted in a write-off of $6,000 for 27 pieces of equipment that could not be located.

At the end of July, the Laboratory Equipment Pool consisted of 387 pieces of equipment amounting to $167,000.

A rise in the cost-of-living index has resulted in a 1.18% wage increase for weekly salaried employees, effective July 25, 1960.

As of July 31, 1960, the staff of Hanford Laboratories totaled 1,141 employees including 690 exempt and 721 weekly salaried employees. A total of 593 possessed technical degrees including 363 BS, 125 MS, and 105 PhD.

The medical treatment frequency for July was 1.97 as compared with 1.55 for the preceding month. There were six security violations during the month, bringing the total for the year to date to 17 compared with 26 for the corresponding period last year.

During July three PhD candidates visited Richland for interviews. Three offers were extended during the month and there are currently three open offers. For the recruiting year to date, acceptances have been received from eight PhD candidates.

Twenty new technical graduates were added to Program rolls and eight accepted permanent assignments during the month. At months end there were 85 technical graduates, including eight members of the Engineering and Science Program, assigned to this component.

Thirteen HLO employees completed the first section of the Technical Report Writing course under the instruction of Professor Elliott of the University of Washington.

Twenty-three weekly salaried vacancies were filled during the month.

Carl A. Bennett

for Manager
Hanford Laboratories

HM Parker:CAB:mlk

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Zircaloy-2 Corrosion Hydrogen Pickup in 340 C Flowing Water. A number of samples were removed from the 340 C flowing water corrosion test after six months of exposure in order to determine the effect of refreshed water on corrosion product hydrogen pickup. Eighteen samples were analyzed for hydrogen pickup, six following six months of exposure and twelve following nine months of exposure. The percentage of corrosion product hydrogen pickup for the samples ranged from 1.4% to 9.1%. This is considerably less than values of 40 to 55% for corrosion by water or steam in static systems. The eighteen samples represent exposures to flow rates of four, 15, and 32 feet per second with refreshment rates of 0.5, 1.75, and 3.75 gal/hr, respectively. The results indicate hydrogen pickup is less at the higher velocities and refreshment rates. This effect may be related to the maintenance of a higher oxygen level at the higher refreshment rates.

Corrosion of Various Iron and Super Alloys. Various iron and super alloys were tested in 360 C, 3200 psi deionized water for 3600 hours. The samples were descaled and the weight losses converted to average mils of penetration. Generally, the 400 series stainless steels (406, 406 mod., 430, 446) showed good corrosion resistance, though 410 stainless steel and a six percent Al, 24% Cr alloy were exceptions. The 410 stainless steel samples had an average penetration of 0.069 mil in comparison to 0.002-0.018 for the other 400 series stainless steel samples. The six percent Al, 24% Cr alloy had several deep pits. The 300 series stainless steels (304, 302, 316, 347) had average penetrations of 0.009 to 0.017, and were comparable in corrosion resistance to the 400 series stainless steels. Alfenol, Ferral, Ferral modified, and a one percent yttrium, 30% chromium, iron alloy exhibited higher corrosion losses than the stainless steels and ranged from 0.027 mil penetration for the one percent yttrium, 30% chromium alloy and Ferral modified to 0.50 mil penetration for Alfenol. The Alfenol and Ferral samples had a considerable number of pits. Four different heats of mild steel were also tested with results of 0.088 to 0.109 mil of penetration.

Hydriding of Zircaloy in Water Vapor-Hydrogen Mixtures. Hydriding of Zircaloy may occur by reaction with hydrogen produced during the reaction with water vapor or by hydrogen from other sources (i.e., the water-graphite reaction). If sufficient water is available to form and maintain a protective ZrO_2 film, the hydriding reaction is severely inhibited. The effect of water vapor concentration on the rate of hydriding

was determined after the test equipment was modified to operate under flowing conditions. This change was made to avoid the possibility that the water vapor concentration might be depleted at the metal surface.

The Zircaloy-2 was first activated for hydriding by vapor blasting the surface and vacuum annealing at 750 C. This produced the worst possible case since protection depends on the instantaneous film formation on a very active surface. A water content adequate for protection in this type of experiment should be safe for a less active surface such as a smooth tube. The data indicate that the hydrogen over-pressure had some effect on hydrogen pick-up at all water pressures. This is expected since the metal had no protective film in the early part of the experiment. Below 0.1 mm of water, the hydriding reaction was rapid.

Hydriding of Zircaloy Adjacent to a Rupturing Fuel Element. A test has been concluded to determine the probable extent of hydrogen pickup by Zircaloy process tubing in the vicinity of a fuel element rupture. Zircaloy-2 strips were attached to defected rod fuel element samples and exposed to steam at 300 C, 400 C, and 500 C. Two strips were attached to each element; one as-etched and one as-autoclaved (400 C, 72 hours). They were held in a position parallel to the fuel samples and 1/4 inch from the defect. Tests were run in steam at elevated temperatures to simulate the overheated conditions downstream from a rupture which has resulted in partial coolant blockage. Preliminary results at 500 C, 2000 psig show very little tendency for Zircaloy to pick up hydrogen from a nearby rupture. Further analytical work is in progress.

Chromium Plated Zircaloy-2. A vapor-deposited chromium coating on Zircaloy-2 greatly reduces the rate of hydrogen reaction with the Zircaloy. The kinetics of the hydrogen reaction with the plated coupons at 600 C and 700 C showed a linear relation between time and the square root of the hydrogen pressure. The 700 C run showed evidence of plate alloying which reduced the rate. The 500 C curve displayed two different linear portions on a plot of time versus the square root of hydrogen pressure. The change to a slower rate came between three to five mm hydrogen pressure. Autoclaving a plated coupon in 400 C, 1500 psi steam for 64 hours apparently dissolved some of the plate and increased the rate of hydrogen pickup at 500 C. An apparatus for applying the coating on coupons is being assembled.

Basic Metallurgy Studies

Mechanical and Physical Properties of Materials. The room temperature tensile properties of HSZ-A (zirconium - two a/o Nb - two a/o Sn) in various conditions of heat treatment and cold work by rolling have been determined. Annealed tensile specimens were heated in vacuum to 950 C for 30 minutes and furnace cooled to 75 C/hr. Water quenching was accomplished by heating tensile specimens to 950 C for 30 minutes in evacuated glass capsules after which the capsules were broken under water.

The water quenched HSZ-A consists almost entirely of martensitically transformed beta zirconium, "alpha prime", which exhibits very limited ductility. In an attempt to improve the ductility of the "alpha prime" by introducing controlled quantities of alpha into the structure, "as-hot-rolled" HSZ-A coupons were given heat treatments consisting of 10, 60, and 1320-minute holding times at 950, 900, 850, 800, and 750 C, followed by an oil quench. Hardness tests and metallographic examination show the ratio of alpha to "alpha prime" in the microstructure of HSZ-A can be controlled and does affect the mechanical properties of the alloy. HSZ-A is heat treatable in the same temperature range as that used in the heat treatment of metallic uranium to minimize dimensional instability during irradiation. Annealed HSZ-A having an original hardness of Rg 78 developed a hardness of Rg 87.3 after 1320 minutes at 750 C, followed by an oil quench.

Free bend welding test specimens, 2" x 0.080" x 1/2", were welded by the heliarc technique. Free bend tests indicated sound welds were obtained by the heliarc technique, the ductility of the weld material being less than that of the annealed alloy but greater than that of the alloy water quenched from 950 C.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material after irradiation is a direct way of detecting radiation damage in these materials. Thin films and foils suitable for electron microscopy offer advantages since radioactivity is a minimum.

Thin films of ZrO_2, Pt, Ge, Al, and SiO_2 evaporated on carbon have been irradiated in contact with UO_2 to 1×10^{16} and 2×10^{16} nvt to study fission fragment damage. Previous experiments had indicated that fission fragment tracks were present in regions free of uranium dioxide, but the observation of the track is dependent on the film thickness. In contrast with surface studies of ZrO_2 films in which the tracks are bordered by nodules, tracks on aluminum appear to be trenches from which the original material has been removed. When multilayer films of platinum are examined in the as-irradiated state, the tracks show perforations along their length. If such films are shadowed or if the uranium dioxide originally present on the platinum is dissolved after irradiation, the tracks on the platinum surface appear as perforated ridges. This morphology may be explained by plastic deformation and vaporization. If the underside of the carbon substrate is shadowed, fission fragment tracks are not observed.

Quantitative experiments to establish whether vaporization of uranium dioxide occurs during irradiation have begun. Thin films of evaporated uranium dioxide placed about one mm from a carbon substrate film are being irradiated in air and vacuum. Following irradiation the carbon substrates will be examined by electron microscopy and electron diffraction for traces of UO_2.

X-Ray Diffraction Studies. Orientation of extruded uranium rods and tubes with various fabrication and heat treatment histories is being determined. Growth Index, "inverse" pole figure, and pole figure data are being obtained. Various methods of obtaining pole figures for uranium have been evaluated, particularly with an eye to finding a quick, reliable method of characterizing orientation of extruded tubes. In any pole figure method several factors must be balanced in order to optimize the speed and accuracy of the determinations. Among those considered this month were: (1) sample size and geometry (flat plates, cylinders, hemispheres, etc.), (2) grain size, (3) surface condition, and (4) x-ray variables (beam size, beam intensity, focusing, absorption correction, etc.). A Schultz-type goniometer is being used for all pole figure determinations. It was found that with flat plate geometries, the adsorption correction for uranium became excessive after 20-30 degrees of rotation, thereby necessitating the use of seven to eleven separate determinations to completely establish a pole figure. With one-half inch diameter sphere the absorption correction is constant over all angular rotations and thus from that standpoint one sphere can be used to completely determine a pole figure. In this case the main limitation is the grain size of the uranium. Statistically representative pole figures have been determined from a one-half inch sphere having an ASTM grain size of 8.0. At ASTM grain size 6.5, the averaged data from single determinations were reproducible but localized fluctuations were present. These fluctuations can be reduced by increasing the number of crystallites in the x-ray beam. Methods of doing this include increasing beam size or making successive determinations with intermittent etchings to remove layers of diffracting material. In the latter case, the results are added until statistically representative.

Solid State Reactions. The kinetics of recovery and recrystallization in zirconium, Zircaloy-2, and Zircaloy-3 are being determined in order to establish optimum conditions of heat treatment during fabrication operations. The conditions under which abnormal grain growth occurs are being studied. Abnormal grain growth occurred in 50 percent C.W. zirconium after a vacuum anneal for 1000 minutes (approximately 16 hours) at 800 C. During this type of growth, a few grains grow preferentially, consuming the grains of the surrounding matrix. After annealing 50 percent C.W. zirconium in vacuum for approximately 16 hours at 800 C, numerous large grains, over 100 times larger in diameter than the original 0.01 mm grains, had formed. These grains were from 30 to 40 mils across. Annealing for the same period of time in helium resulted in only a slight indication of abnormal growth, and annealing in air under the same conditions effectively inhibited the abnormal growth. Abnormal growth conditions for Zircaloy-2 are also being investigated.

The effects of irradiation upon zirconium and Zircaloy-2 are being investigated in order to establish the behavior under reactor service. Six sample assemblies have been shipped to the MTR for irradiation in the rabbit facility. The highest goal exposure will be approximately 2×10^{19} nvt fast.

Effects of irradiation on non-fissionable materials are being studied by means of x-ray diffraction. Currently, the studies of irradiated molybdenum have been extended to include effects of annealing high exposure (5×10^{19} nvt fast flux) material. Isochronal anneals of molybdenum irradiated to 5.0×10^{19} nvt have been carried out to 900 C, and changes in x-ray line shape and lattice parameter have been observed. Anneals of 30 percent cold rolled molybdenum have been carried out simultaneously for comparison, and changes in line shape and position have also been observed. In each case the annealing changes are suggestive of more than one recovery mechanism. The changes in line shape with annealing may be studied analytically by Fourier methods. To this end, arrangements have been made for machine computation of the coefficients. Line broadening data for each of the isochronal anneals have been collected.

Metallic Fuel Development

Tubular Fuel Elements. Production Test IP-300A consisting of hot-headed projection weld closed inner tubes and TIG closed outer tubes has reached an exposure of 1000 MWD/T. The average specific power is 67 kw/ft, the maximum 77 kw/ft, and the outlet water temperature 288 C with a 55 C Δt.

Four enriched tube/tube elements of KER size with uranium and uranium - two percent zirconium cores were irradiated in KER Loop 2 from January 10 to July 3, 1960, at which time a fuel rupture occurred. The failure was a clad split on the outside of [redacted] inner tube. Local exposure, at the point of failure, was 3350 MWD/T, and local operating temperatures were 410 C maximum core and 287 C surface. The clad split was similar in appearance to the two failures seen previously in cluster elements exposed to 2240 and 2520 MWD/T at KER. A deep striation extended along the clad surface from the split. All four elements in the test are scheduled for intensive Radiomet examination beginning July 20.

Radiomet examination of a failed 36-inch long KER tube/tube element continued during the month. This element had ruptured at the end of April after 1250 MWD/T. Earlier work showed that the cause of failure was warping of the inner tube with subsequent contact with the outer tube leading to hot spot failure. A metallographic section confirmed the presence of a small corrosion pit in the uranium - two percent zirconium core. Massive hydrides were found near the failure. However, hydride content in the Zircaloy-2 clad was normal in areas away from the failure. Dimensional measurement showed an 0.020 inch diameter increase on the upstream end of the failed tube.

A fourth ETR rupture test was performed on June 17 in the ETR 3x3 P7 Loop using KER size tube/tube fuel elements. The defect was on the outer surface of the outer tube. A three to four mrad/hr increase in loop water activity was observed when the defect cap was sheared off and this increased activity level held steady for 20 minutes. During the next ten minutes loop water activity increased at a steady rate to 20 mrad/hr when the reactor was scrammed. Examination showed that the cladding was swollen and cracked around the defect saddle, and a blister an inch in

diameter had formed. The weight of the uranium converted to oxide was calculated to be 43 grams.

Fuel for Present Reactors. The current cap-tube and can used for the hot press aluminum components are rather expensive. The use of two simple tubes (inner and outer) with two end caps offers a less expensive set of components. This, however, would increase the total number of closures from one to two at each end of the fuel element.

Approximately two dozen short fuel elements are being hot pressed using the two tubes and two caps principle. These will be evaluated for closure and bond quality.

Temperature, pressure, and time will be nearly identical to the cycles worked out by previous investigators.

The MTR irradiation of two hot pressed fuel elements, GEH-4-42 and GEH-4-47, has been successfully completed after 3-1/2 cycles of MTR time. This amounted to an exposure of 1400 MWD/T at an average power generation of 140 kw/ft, and a maximum power generation of 165 kw/ft. These elements will be examined in the MTR basin and later in Radiomet.

Component Fabrication. Further testing of the three-roll straightener using the salt bath as a heating method indicates that reducing straightening force does not eliminate the surface dimpling caused by freezing salt. A tubular furnace with an argon atmosphere will be used for heating in an attempt to eliminate this problem. Results from straightening two percent Zr alloy KER inner stock indicate an average of 0.008" double throw warp in an 18" length. The warp increases 0.003" to 0.004" in 18" after relaxation at 400 C for two hours.

The quenching rates of sections of NPR outer tube stock, 2.460" OD x 1.850" ID, were determined for salt bath heat treatment of these components. Cooling conditions studied were air cooling, 590 C salt quench, water quench, and oil quenches with air delays. A quenching rate of 2750 C/minute can be obtained with a 30-second delay before oil quenching. Dimensional changes recorded indicate 0.005 to 0.010" increase in outer diameter, 0.005 to 0.015" increase in inner diameter, and a length increase of 0.0043" per inch of length.

Closure and Joining. The "extrusion-closure" shows considerable promise as an alternate method of making closures on coextruded Zircaloy clad tubular fuel elements. It would be more attractive, however, if a bond could be effected between the annular Zircaloy cap and the end face of the uranium. Several procedures for accomplishing this end are being explored. Already tried in a preliminary fashion are (1) pre-plating the face of the Zircaloy with a thin coat of tin as described in WAPD-BT-6; (2) pre-plating it with nickel as described in the same document; and (3) interposing a 0.002" washer of metallic Ni, Ag, or Ag-Cu alloy between the uranium and the Zircaloy cap before welding and extruding. This last method using Ni appears to have formed a good bond over part

of the interface, suggesting that closer attention to preparation of the surfaces may lead to success. Still to be tried are pre-plating with iron; interposing an AlSi washer between the uranium (previously nickel-plated) and the Zircaloy cap; and precladding the face of the cap-ring with AlSi.

The first production test of brazed fuel element end closures has been completed. This test involved ten NPR inner fuel elements, 17 inches in length. Of the ten original fuel elements, two were automatically rejected because of extrusion defects on the ID clad, and one element showed white oxide on the braze line after autoclaving. This left seven good elements, of which three elements had one end rebrazed once and one element had both ends rebrazed. Prior to brazing, these elements were vacuum outgassed at 850 C. The brazing cycle consisted of 30 seconds to heat to 1035 C, hold at 1035 C for one minute, apply about 25 psi pressure to the end cap for one minute, cool in vacuum three minutes, cool in helium three minutes, remove from the vacuum chamber and water quench. Counterboring the uranium to 0.300" by machining and then acid milling to remove residual uranium results in a smaller gas burst during brazing than if the uranium is removed entirely by acid milling. Brazing conditions are now being determined for the next production test. This test will involve both KER inner and outer fuel elements with a 1.6 percent enriched uranium core alloyed with two percent zirconium. Brazing conditions for the inner material appear to be 25 seconds to heat to 1035 C, hold for 30 seconds at 1035 C, then apply approximately 15 psi pressure for 30 seconds at a temperature of 1035 C. The outer material has the same time cycle, except for a shorter heating time of 15 seconds. This production te[illegible] should be completed in approximately two weeks, at which time, efforts will be shifted to investigation of alternate, lower melting temperature braze alloys.

Allied Fuel Studies. A total of nine, 1.6 percent enriched uranium, Zircaloy-2 clad fuel rods irradiated in NaK capsules in D Reactor are now undergoing Radiometallurgy examination. Five of the rods have sustained cladding failures. The type of failure appears similar to failures recently observed in 7-rod clusters irradiated in KER loops. The cladding thickness was 0.020" on four of the failures, and 0.030" on the other one. To gather information on the nature of the failures and the effect of cladding thickness and thickness variations on the failures, a complete metallographic examination is planned on one good and one failed rod of each cladding thickness. Another series of capsule irradiations is being designed to investigate the cause of this type of failure.

The thermocouple test element in KER Loop 1 was discharged on July 7, because of rupture indications in the loop. Accumulated exposure on the thermocoupled piece itself was about 430 MWD/T. The thermocoupled piece and the heater pieces were examined in the KE view pit. The only evidence of failure seen was what appeared to be a small crack in the cap-to-clad weld at the thermocouple end of the test piece.

Additional pinhole defected irradiated fuel rods have been tested by CSDO in the IRP loop. The failure behavior of high exposure (2400 MWD/T) co-extruded fuel rods at NPR normal shutdown and scram shutdown procedures has been compared. During a normal shutdown procedure following failure detection at 300 C, the defected rod lost 183 grams of fuel and was severely distorted. A filter in the recirculating loop accumulated about 40 rad/hr activity. The normal shutdown time of two to three hours was interrupted after only 38 minutes because of the high activity. During a scram shutdown procedure test on a companion fuel rod, the loop filter attained an activity of only one rad/hr by the time the temperature had been reduced to 98 C. The fuel weight loss and rod distortion have not been determined yet, but based upon the one rad/hr activity, corrosion damage should be considerably less than obtained with the normal shutdown procedure. From the view point of gross corrosion and fuel shape distortion, a scram shutdown should be much more desirable than a normal shutdown.

There is a need for in-reactor fuel element jacket burst tests at integrated fast flux exposures of 10^{20} nvt or greater. This is the fast flux exposure range an NPR fuel element jacket would experience during irradiation. Preliminary calculations indicate a Zircaloy-2 clad, 1.43 OD (NPR inner tube) fuel element drilled out to 0.9 ID would provide both the fast neutron exposure and temperature for test capsules. Bursting pressure would be applied after the required exposure was achieved.

Recent laboratory wear tests have shown that fuel element supports formed from 1010 and 1020 steels with a maximum radius of curvature of three inches perform satisfactorily against an autoclaved Zircaloy-2 surface. Because the NPR fuel element charging machine magazine may be of austenitic stainless steel, a test was made using 1008 steel supports against a 321 stainless steel surface. Results of this test show severe scratching of both the stainless surface and the bearing surface of the support. When a scratched support was subsequently tested against an autoclaved Zircaloy-2 surface, severe scratching and galling of the Zircaloy-2 occurred. Wear tests of low carbon steel supports against stainless steel using an oil lubricant will be made shortly.

The wide variety of metals under consideration for NPR supports makes it necessary to devise an attachment process which will be independent of the support material. Such a process is available in the riveted stud method of attachment. This requires a hole 1/16" in diameter in the support at the point of attachment. A Zircaloy-2 wire of the same diameter and 1/32 inch longer than the support thickness is placed in this hole. The resistance spot welder is then utilized to weld one end of the wire to the fuel element and to head the other end in the same operation. The average tensile shear strength of 16 specimens so prepared was 368 pounds. The maximum and minimum strengths were 460 pounds and 225 pounds, respectively. Further work is planned using machined rivets instead of wire in an effort to improve these strength values.

An experimental method of evaluating nonbonded end cap designs has been tested where the uranium fuel material is replaced with a high expansion alloy, P-alloy (Ni-Mn-Cu). By placing bonded Zircaloy clad rods of P-alloy with the proposed end cap design in an autoclave and thermally cycling the autoclave, the thermal incompatibilities encountered in an operating fuel element are duplicated. Fabrication and testing of the three rods with six different end closure designs have been completed. None of the closures failed after 25 autoclave cycles between 75-300 C. The bonds between the Zircaloy and the P-alloy failed in the four end cap regions which had separations of less than 200 mils between the end cap weld and the fuel end region. Since the bonds failed, this experimental technique did not adequately test the fuel element closure.

Facilities and Equipment. Equipment has been fabricated which provides an accurate geometrical description of the exterior of reactor fuel elements. Initial measurements have been made using linear differential transformers to record radial deformations while the fuel element is rotated. The measurements are recorded on an X-Y recorder where the ordinate is either the radial displacement, or diameter, and the abscissa is the angle of rotation.

Acceptance tests are being run on the heat treating furnaces for the 306 Building Addition, Project CA-744. Both the forced air tempering furnace and the large 60 kw box furnace have been accepted. The 15-foot deep Vertical Salt Bath, the High Temperature (2500 F) Heat Treating Furance, and the Endothermic Gas Generator will be accepted as soon as the contractor makes the required changes. Acceptance tests on the quench tanks will be completed when the quenching oil is received. Most of the instruments for the Instrument and Electrical Laboratory have been received.

2. REACTOR PROGRAM

Coolant Systems Development

Nickel-Plated Fuel Elements. Additional corrosion testing has been completed on the nickel-plated aluminum clad fuel elements. Two series of fuel elements, one having a 0.6-mil chemplate and one having a 1.2-mil chemplate are being tested in process water at 120 C with 35 gpm flow and at 165 C with 20 gpm flow. The elements were defected with a file to cut through the plating. After approximately two weeks of exposure, none of the elements showed any significant corrosion of aluminum at any of the defected spots and no increase in size of any of the defects. The film formed on these pieces is readily removed by wiping.

Single Pass Decontamination - Corrosion Measurements. Additional corrosion measurements have been made on three solutions considered as possible decontaminants for the present reactors. These solutions are: (a) inhibited sulfuric-oxalic acid solution (0.3M H_2SO_4, 0.1M $H_2C_2O_4$, 0.025M 1-phenyl-2-thiourea); (b) Turco 4518; (c) Turco 4306 B. The tests are cyclic. The flow tube is conditioned by exposure to 130 C process water.

at 35 gpm for 156 hours, and then is decontaminated by exposure to the decontaminant for 30 minutes. The inhibited oxalic-sulfuric acid solution caused pitting of the aluminum and hence in its present form appears unsatisfactory. The best over-all results were obtained with Turco 4518, although it did leave an appreciable film on the carbon steel. Only Turco 4306 B caused any measurable corrosion of the Zr-2. After three cycles the uniform corrosion of Zr-2 averaged 1.1 mils. With Turco 4518, after three cycles the corrosion of Zr-2 was less than 0.01 mil.

Rust Removal. The Wyandotte 75 process (inhibited bisulfate) was investigated to determine if this process would adequately remove rust and barnacles from mild steel pipe. This process, when used at room temperature, was successful in removing all the rust from Richland irrigation water pipe during a 20-hour exposure. However, the process did not remove heavy barnacles from sanitary water pipe during a 25-hour exposure at room temperature. Neither did it remove the barnacles from the same pipe during a five-hour exposure at 75 C.

In comparison, all barnacles were removed from a sample of sanitary water pipe using a 10% sulfuric acid solution inhibited with one percent Rodine 82 during a 20-hour exposure at room temperature. The inhibited sulfuric acid at 75 C removed the barnacles from another sample in two hours. The sulfuric acid solution costs about one-half as much as the bisulfate solution.

Loop Decontamination With Phosphoric Acid. The cyclic decontamination test in CEP-4 using the alkaline permanganate-Turco 4512 (H_2PO_4) has been completed after eight decontamination cycles. Crevice-stress coupons of Type 304 s/s, Zr-2 and A-212 c/s were discharged after exposures of two, four, and eight cycles. There were no signs of non-uniform corrosion on any of the metals except a surface roughening of the carbon steel. The solutions do a good job of removing corrosion product films and do not leave deposits on the coupons. Weld samples of Zr-2 tubing were also in good shape. Analysis of the corrosion rate data is in progress.

Thermocouple Slug. The thermocouple slug was discharged July 7, following a rupture indication. This had been charged in KER Loop 1 on May 14, to study crud deposition on Zr-clad fuel elements at pH 10 (LiOH). The test ran for the first 22 days at about 260 C bulk water temperature and at low temperature for the remainder of the test because of a leak in a loop check valve. During the entire test the temperature difference between the bulk water and the thermocouples under the cladding remained remarkably constant (with appropriate corrections for changes in power level and temperature), indicating that no significant insulating film was deposited. The loop temperature was dropped to a minimum of 90 C for a day and then returned to the normal 260 C. Such thermal cycle gave no sign of crud deposition. The five thermocouples continued to function well during the test, although the recorder gave some trouble. The crud content of the water was sampled by passing a hot sample through a fine carbon filter. Concentrations were measured of 80, 130, 13, and 39 ppb during the first, third, fifth, and sixth weeks, respectively.

Decontamination of Loop Containing Fission Products. The IRP loop was decontaminated using the Turco 4502 and Oakite 88 process. The loop decontamination factor was only two to four, and the coupons discharged from the loop were reading about five rad/hr including 500 mr/hr. Since the decontamination was not successful, the coupons were not analyzed individually. The loop was cleaned up using Turco 4502 and Wyandotte 1112. This process reduced the loop activity to background readings. The loop is now operating on the filming cycle for the next test in which the APACE process will be used. The corrosion inhibitor will be 1-phenyl-2-thiourea.

Oxygen Scavenging Studies. Several tests have been run to evaluate the effectiveness of hydrazine as a scavenging agent for dissolved oxygen using both activated carbon and finely divided magnetite as catalysts. Data obtained using the activated carbon and 100% excess hydrazine indicated that the reaction was time dependent during the initial operation. These data indicate that a significant amount of hydrazine must be adsorbed on the carbon before an appreciable amount of scavenging occurs. Ultimately about 98% of the initial oxygen in the water was removed during passage through the carbon bed. The evolution of ammonia indicates that in static tests the hydrazine becomes unstable as the amount adsorbed on the carbon increases. The tests conducted using finely divided magnetite did not yield very efficient scavenging. Only about 30% as much scavenging occurred as when activated carbon was used under similar conditions. Static tests did not indicate any hydrazine instability in the presence of magnetite.

Rupture Test of Irradiated Fuel Element. A fifth rupture test was made using a rod from the third ETR rupture. (Beta heat treated, air cooled, exposed to 2400 MWD/T at low temperatures.) This rod was from the same cluster as that used in Test No. 4, in which a slow cool-down was employed. The cooling schedule in this test consisted of an initial rapid temperature drop from 300 C to 230 C, followed by a continued slow cooling. The rapid cool-down essentially stopped the rupture. As the temperature approached 200 C, activity was again released confirming a uranium hydriding mechanism. Based on activity measurements of a previous test, the modified cool-down reduced the severity of the rupture by a factor of almost 40.

Structural Materials Development

NPR Process Tubes. A decision has been made to add silicon up to 250 ppm to the Columbia National zirconium sponge used by Harvey Aluminum Company in fabricating the production order of NPR process tubes. Such an addition may be expected, on the basis of an industry-wide series of tests, to improve the corrosion resistance of these tubes. Samples have been obtained of Zircaloy-2 plate made from CN sponge with and without silicon additions. These have been further hot rolled and cold rolled here at HAPO on a schedule designed to produce 0.030" sheet with a fabrication history approximating that of Harvey NPR tubing (35% cold work). A series of tests is planned to show the effect of the silicon addition on such properties as corrosion, hydriding, microstructure, tensile, and

abrasion resistance of the autoclave film.

Harvey Aluminum and Allegheny Ludlum Steel Corporation have had difficulty in consistently producing a glossy black film on corrosion coupons from their NPR tubes. Harvey has apparently solved this problem by adjusting the pH in their autoclaves toward the high end of the six to eight range. Since making this adjustment, their coupons have consistently shown a deep black color.

At Allegheny, 43 samples out of 102 tested showed a surface with more grayness than our acceptance standard. Of these 43 rejects, 26 were in one autoclave load, nine in another, and six in a third. Several other autoclave loads contained no rejects. These results indicate testing technique rather than metal quality to be the probable cause of the difficulty. Autoclave records are being studied to discover possible causes for the difference between runs. The 43 rejects will be vapor blasted and retested under conditions considered most favorable for production of a good black film.

A section cut from the weld area of an Allegheny Ludlum NPR tube was autoclaved in the 20-foot autoclave at White Bluffs. The treatment was for three days at 425 C as presently proposed for the NPR process tubes. The sample emerged with a good black film all over with no trace of gray film, flecks, or stringers. Sections before and after autoclaving showing weld metal, heat affected zone, and parent metal were prepared for metallography. Examination showed no apparent effect on microstructure produced by the autoclave treatment. Occurrence of hydride particles was negligible in both samples even at magnifications as high as 400X.

Nonmetallic Materials Development

NPR Reflector Graphite. Four transverse and four parallel tensile specimens from four bars each of AGOT-LS and GLC-IC have been pulled. The arithmetic mean tensile strength for the transverse specimens was 493 lbs/in^2. The mean of 32 parallel samples was 1810 lbs/in^2.

Two graphite test boats to allow NPR reflector graphite to be irradiated under compression have been completed. Each boat holds five samples under a load of 160 psi and 10 unloaded reference samples.

Dosage Units for Irradiation Damage. On the basis of the best theoretical damage model for graphite, it is believed that damage is principally caused by those neutrons with energy in excess of about 0.18 Mev. Previously, inter-reactor comparisons of damage were made considering neutrons with energy greater than one Mev. Multi-group diffusion computations with the GNU-II code have been made of spectral shape in the GETR and at HAPO. Readjustment of previously published information to more appropriately include damaging neutrons above 0.18 Mev can now be made. This results in even better agreement among experimental data from the several reactors. As an example, the contraction rate of CSF graphite in C Reactor

is about 0.011%/10^{20} nvt (E >0.18 Mev) as compared with a contraction rate of between 0.010% and 0.018%/10^{20} nvt (E > 0.18 Mev) measured in the GETR.

In order to adjust the data published in Table VI of HW-64287, "Technical Basis for NPR Graphite Recommendations," all estimated NPR contraction rates should be multiplied by 0.474 which then relates to contraction as a function of 10^{20} nvt of E> 0.18 Mev. Results of calculations cited in Table I of HW-64393 adjusted to include the flux > 0.18 Mev then become the following for C, K, and N Reactors, respectively: 1.17 x 10^{17}, 1.48 x 10^{17}, and 2.78 x 10^{17} nvt/(MWD/AT).

Low Density Graphite. Low density graphites obtained in 1957 have accumulated up to 5000 MWD/AT in the Hanford hot test-hole facilities. The irradiation results are of interest because the contraction rates are much lower than anticipated for the raw materials and graphitization temperatures used.

Texas Lockport coke was used in all of the graphites. Graphitization temperatures for the 1.3 density Speer Graphite and the National Carbon Graphite were 2300 to 2900 C, respectively. A large amount of resin gum was added to the binder of Speer's 1.3 density graphite. Further processing details will be obtained from the vendors to determine those factors contributing to low contraction rates.

Thermal Hydraulic Studies

Heat Transfer Experiments Pertaining to Present Production Reactors. Heat transfer experiments were performed to provide information concerning the postulated situation at K Reactor where a BPA electrical failure is followed by the failure of the secondary cooling system to pick up the pumping load. In such a case, the stricken reactor is furnished with cooling water from the secondary cooling system of the other K Reactor through the cross-tie pipelines. Under these conditions the initial power decay is much more rapid than the flow decay so adequate cooling prevails for some time after the start of the incident. However, it has been predicted that eventually there would be a period when the flow would reduce to where boiling would take place. A question arises as to whether the cooling by boiling would be sufficient to prevent excessive fuel temperatures.

The laboratory experimentation was performed with a test section simulating 38 I & E fuel elements in a full length K process tube. During the shutdown transient from full power and flow, the front header pressure was controlled to follow the flywheel decay curve for the K Reactor pumps until at the end of the decay a pressure difference of six psi was maintained across the process tube. The power input was tripped two to three seconds after the start of the pressure reduction and followed a 500 ih shutdown curve with a constant five percent of initial power added to simulate graphite heating.

Runs were made at initial power levels of 1000, 1500, and 2000KW with a 15 psig rear header pressure. It was found that adequate cooling existed for the 1000 and 1500 KW cases, but the 2000 KW run was terminated due to an excessive temperature buildup in the test section. It should be realized that these results from a single tube do not immediately answer the question for the entire reactor, but they are valuable data which can be used in further analytical solutions concerning the reactor as a whole.

Experiments to Check Heat Capacity of Experimental Apparatus. A brief series of runs was made to determine the heat capacity and rate of sensible heat removal during power decays in the laboratory test section and to compare the results with reactor data. To a test section simulating a K process tube full of I & E fuel elements the heat output was measured under two conditions: (1) constant flow rate with decreasing water temperature, and (2) constant outlet temperature with decreasing flow. The data from the runs checked very closely with the best available reactor heat output data taken at constant flow. This comparison is important in that it gives further confidence in the application of certain laboratory results to the reactors.

Hydraulic Studies. Data were obtained in the hydraulic laboratory to determine the effect of support devices on the pressure drop for NPR tube and tube type fuel elements. Preliminary data indicated that using "suitcase handles" 1/4 inch wide, 1/16 inch thick, and two inches long increased the pressure drop 10 to 20 percent above that without any support devices. Plans were made to obtain additional data with different sizes of supports.

Boiling Burnout Conditions of NPR Fuel Elements. Laboratory heat transfer experiments were continued to determine the boiling burnout conditions of flow and heat generation rates for the NPR tube and tube fuel element. The runs applicable to the middle cooling annulus were terminated when the test section failed after obtaining 41 boiling burnout points. During the final runs under subcooled boiling conditions, heat fluxes up to 2,600,000 B/hr-sq ft were obtained at mass flow rates of 6,800,000 lbs/hr-sq ft.

An analytical study was started to derive relationships predicting the fluid temperature at any point in a horizontal annulus as a function of flow rate, annulus eccentricity, and inner and outer wall heat flux. The analysis will be extended to conditions of two-phase flow in an effort to arrive at means of predicting boiling burnout as affected by annulus eccentricity and boiling length.

Critical Flow Experiments. One of the unknowns that makes it difficult to compare experimental data with theoretical predictions of flow rates during critical discharge is the difference in velocities between the steam and water mixture. In order to measure this difference, called the slip ratio, a momentum chamber was built to determine the momentum of the discharging fluid. Initial runs to calibrate the device showed

excellent agreement between experimental and calculated values for 100% steam and 100% water. Then, while using the momentum chamber, critical flow data were obtained for a test section at low pressures and with steam qualities varying between zero and 10 percent by weight.

Shielding Studies

Attenuation Measurements. Measurement of neutron dose rates were made on the front face of B Reactor. A horizontal traverse of row 27 and a vertical traverse of column 78 indicate that the primary dose rate generated by neutrons is coming from air (dry) tubes which are currently shielded with steel plugs. The present study indicates that more effective neutron shielding could be obtained by using concrete in place of the steel. It is recommended that the shielding in tubes 1578, 1879, and 2778 be removed and replaced with bayonets filled with iron-serpentine concrete with a density of about 265 lb/ft^3. It is estimated that the maximum dose rate due to neutrons can be reduced by a factor of two simply by adequately shielding the existing air tubes. It was found that the neutron dose rate could further be reduced by another factor of 3.9 by placing two inches of masonite between the dosimeter and the front face. It may be that after the air tubes have been shielded properly it would be worth-while to place about 1.25 inches of polyethylene, which has the equivalent hydrogen content of two inches of masonite, on the front face of the reactor. This would cut the dose rate to about two mrem/hr of neutrons and 20 mr/hr of gamma. Similar conclusions apply to three other production reactors. A detailed report (HW-66117) is being prepared in conjunction with IPD Operational Physics personnel.

The last irradiation of the 210 lb/ft^3 iron-serpentine concrete (after being baked at 320 C) is being made at the present time. This will be the final test of this concrete.

Calibration of the Perlow Spectrometer has been temporarily suspended due to prior commitments of the positive ion accelerator. Preliminary results indicate that the gas amplification for methane is very critical. A change of 0.5 cm in chamber pressure provides a 20 channel shift as seen by the 100-channel analyzer in the peak from the same energy monoenergetic neutrons. Therefore, it is necessary to use a cathetometer to measure the chamber fill pressure to the nearest 0.002 cm as well as applying the appropriate temperature corrections. A minor failure in the PA-100 channel analyzer was encountered when a tube in the master timing circuit developed a direct cathode-to-heater short.

Design and Component Testing

NPR Charging Machine. Fabrication of the magazine positioner prototype was started. Design of the nozzle adaptor continued during the month.

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

PRTR Fuel Fabrication. The Mark I-G fuel elements for the first spike loading are being assembled at the rate of one or two per day. To date, a total of 367 PRTR spike fuel rods have been successfully etched and autoclaved. The rods have surface appearances adequate for power runs by comparison to the standard established by the Corrosion and Coatings group. If present rates continue, the first thirty clusters will be complete by mid-August.

Forty-eight extrusion billets were cast of the Al-2 w/o Ni-1.8 w/o Pu alloy for continued corrosion testing and for application in the refabrication of PRTR spike elements. Two heats of the alloy were cast with a high purity (99.9%) Al base and six heats were cast using recycled Al-Pu scrap of 99.45 Al base. The billets were cast under varying conditions, but no difference in corrosion resistance was found, indicating that Al purity and casting conditions are not critical within the range tested. Since nickel has a high cross-section, the lower limit of nickel concentration required to impart corrosion resistance to the 1.8 w/o Pu alloy is being determined. Extrusion billets of a 1.75 w/o Ni alloy have been cast but have not been extruded.

Zircaloy-4 tubing of 0.495 inch ID is now being received for refabrication of spike elements. The tubing is generally of sound metallurgical quality, but dimensional control of the ID has been less than desired. A premium payment is to be made for each tube that does not vary more than two mils on the ID and stays within 0.495 and 0.500. Thirty-one tubes were gauged before inspection and none were within the premium two-mil tolerance.

Fabrication Development. Three, full-size, Zr-clad, Pu-Ni-Al (1.8 w/o Pu, 2 w/o Ni) fuel rods were injection cast. Reject Zr tubing was used for two trial castings which will be used for testing purposes. One of 38 castings scheduled for irradiation in the PRTR was made with 0.035 inch wall Zr tubing. After it is radiographed, the fuel element with the 0.035 inch cladding will be counterbored and decontaminated for final closure welding. The other fuel elements for the two 19-rod clusters will be cast at the rate of one per day in the recently activated prototypic equipment.

The two test run castings which were radiographed were found to have hot tears and shrink voids in the lower half of the castings; however, the effect of these defects on in-pile performance can only be determined by reactor testing. The pattern of the casting defects was typical of the type found in alloys with a long freezing range. It is expected that the core to clad bond which occurs in injection casting is more important than the mechanical strength of the core.

In preparation for the fabrication of uniformly enriched UO_2-PuO_2 fuels, plutonium equipment is being evaluated using UO_2 and plutonium techniques.

Prewelded tubes filled with UO_2 have been reduced by swaging 42% in area. These rods have passed the Zyglo inspection and the autoclave. There is a slight surface roughness which is not removed in the etching process. It is hoped that a die modification will eliminate this defect and the necessity for surface dressing after swaging. From preliminary work with the gamma absorptometer, it is plain that swaging rods with prewelded end caps will present a density problem at the lead end of the tube. Reversing the feeding direction on subsequent passes, adjusting the swaging sequence, and loading the tubes to a maximum tap density should help this problem.

Attempts were made to load twenty tubes with UO_2 powders of varying tap densities. It was planned that the tap densities would be 6.0, 6.4, 6.8, and 7.3 grams/cc. The powder available for this work was high fired UO_2. Preliminary loading tests showed that this powder could be loaded to a maximum tap density of 6.2 grams/cc. With this limitation it was decided to run a preliminary investigation of the effect of fines on the tap density. A master mix of 17 w/o - 20 + 30 mesh and 22 w/o - 30 + 40 mesh was used in all cases studied. The remainder of the mix was composed of -40 + 60 mesh and -140 mesh. The fines were varied between 29 w/o and three w/o which in turn altered the percentage of the -40 + 60 mesh powder. Increasing amounts of fines increased density in a linear manner. Tap density increased from 6.1 gms/cc to 7.3 gms/cc with three and 29 w/o fines, respectively. The bulk density increased from 5.0 gms/cc to 5.5 gms/cc. Tap density can be controlled to ± 1% while the bulk density can only be controlled to ± 3%. Bulk density is an arbitrary number with no real significance to the swaging problem.

Fused UO_2 will be blended with PuO_2 or PuO_2-UO_2 powder and evaluation studies on this material are under way. X-ray diffraction has failed to reveal to date any of the U_4O_9 phase tentatively identified in metallographic studies of Spencer and Norton fused oxides. Since the U_4O_9 structure is isomorphous with that of UO_2 and differs in lattice parameter by less than 0.3%, it is understandably difficult to resolve this phase. Its concentration in the Spencer material is so slight (estimated at less than 1%) that the diffraction analysis could not be expected to show anything even if the resolution problem could be solved. However, Norton material shows an estimated 5-10% of this second phase, which is enough to detect by x-ray. Coulometric chemical analyses are being run on both materials to check the O/U ratio of 2.02 previously determined by oxidizing to U_3O_8.

A vertical welding positioner in the vacuum chamber has been activated for the closure of ceramic fuels. Welds made on unsintered UO_2 test elements show it is not necessary to have an outgas hole in the end cap to eliminate weld porosity since the head weld design requires a low heat input and short weld time.

Fuel Evaluation. Twelve irradiated UO_2-PuO_2 capsules were nondestructively examined, and eleven have been returned to the MTR for additional exposure. The twelfth piece is scheduled for transfer to the MTR in the next cask shipment.

Metallographic examination of rods from the irradiated four-foot long, 19-rod cluster indicate that very few, if any, microstructural changes have occurred in the core due to irradiation even though bonding between the core and Zircaloy cladding has taken place. Additional pre-irradiation samples are being examined to compare the pre- and post-irradiation core grain size as well as the hydrogen content of the cladding.

Radiometallurgical examination of the eleven-inch long, Zircaloy clad, 3-rod cluster containing one-half inch diameter graphite lubricated Pu-Al cores is continuing. Two of the rods were drilled and sampled both qualitatively and quantitatively for gas. A very small amount of gas was obtained from each sample, and it was not very radioactive, indicating that the graphite did not outgas appreciably and that no fission products had been released. There was no evidence of bonding between the core and cladding, and the cores were removed from the cladding by tapping on their ends. Dimensional data, metallography, and density determinations are being obtained.

The eleven-inch long, Zircaloy clad, 3-rod Pu-Al cluster which has as much as nine mils gap between the core and cladding is also being examined in Radiometallurgy. The external appearance of the irradiated cluster was about the same as the one which contained graphite lubricated cores, i.e., there was some mottling on the heat transfer surfaces of the rods. Some of the rods have been sectioned, and the ends of the cores were inadvertently cut so post-irradiation core length measurements were lost. So far, however, there is no indication of core melting due to the excessive gaps. Dimensional data, metallography, and core density determinations will now be obtained.

The four-foot long, Zircaloy clad, 7-rod cluster containing UO_2-PuO_2 sintered and ground pellets as the fuel material has completed 20 days of operation at full power in the 3x3 loop. The element generated a maximum of 15 kw/ft of rod with an associated heat flux of 346,000 BTU/hr-ft^2 and a maximum calculated core temperature of 1850 C.

A proposal for an in-pile thermal cycling test of a 7-rod cluster is being submitted. The element is a PRTR prototype and will operate as nearly as possible under PRTR conditions. It is planned to operate the element for about 10 days under steady state conditions followed by 18 days of cycling. During this time it will receive about 54 thermal cycles in which the core temperature will vary from about 198 to 368 C. The heating and cooling rates will be controlled at 5 F/minute. The autoclave equipment used for out-of-pile thermal cycling experiments is being modified, and additional experiments will be conducted to determine the effect of pressure and tube crack depth on cycling results.

A Zircaloy clad, 7-rod cluster Pu-Al rupture experiment is also being proposed for the 3x3 loop.

Irradiation experiments to investigate the self-shielded and Phoenix fuel concepts are being formulated. Reactivity change data will also be obtained in conjunction with the irradiation tests.

Preliminary physics and heat transfer calculations on a self-shielded element consisting of a 70 percent dense, 3/32-inch diameter, PuO_2 core surrounded by MgO and clad in 0.030 inch Zircaloy have been made by people in Reactor Technology and Thermal Hydraulics Operations. Such an element will generate about 17 kw/ft in a thermal flux of 1×10^{14} nv. Heat transfer calculations considering non-uniform heat generation due to the high degree of self-shielding and the change in thermal conductivity of the components as a function of temperature indicate a maximum core temperature of about 20,000 F. Obviously, this is an undesirable condition so other fuel designs and operating conditions are being evaluated in an effort to more efficiently utilize the heat that is generated.

Some plutonium containing six, 13, and 29 percent Pu-240 is available for Phoenix fuel experiments. Calculations were made to determine the total plutonium composition of a Pu-Al alloy for the various types of plutonium in an effort to obtain the same power generation for each one in the same neutron flux. An Al-2.84 w/o Pu alloy consisting of plutonium containing six percent Pu-240 will generate 30 kw/ft in an unperturbed flux of 2×10^{14} nv. A 3.12 w/o Pu alloy is required for the 13 percent Pu-240, and 3.91 w/o Pu is necessary for the 29 percent plutonium in order to generate 30 kw/ft in a flux of 2×10^{14} nv.

UO_2 Fuel Development

PRTR Fuel Elements. "PRTR Power Test for Fuel Element Inspections" and "Fuel Element Defect Tests" were written in support of PRTR startup activities. Special reviews of several PRTR Operating Procedures also were provided.

The first 1500 pounds of a 6000-pound batch of fused UO_2 was received from the Spencer Chemical Company. The material has a sufficiently high density, but its O/U ratio (2.04) is higher than specified according to data from combustion analyses. (Data from a coulometric process indicate that the O/U ratio is less than 2.01.) It also releases approximately 30 ppm nitrogen upon vacuum extraction at 1000 C. Evaluation of the material will continue.

Two lead-filled, 19-rod cluster, PRTR fuel elements for reactor loading tests were assembled.

A set of Pb-Sn alloy density standards has been fabricated for the Plutonium Metallurgy Operation. The set consists of four groups of three standards each, covering the UO_2 density range of 85-92% of theoretical density in four steps. Standards were made by casting the alloy into five-inch segments of swaged, 9/16 inch Zircaloy-2 tubing.

Internal pressures produced at elevated temperatures by gases desorbed from UO_2 contained in PRTR Mark I fuel elements have been measured. At 800 C, the average bulk operating temperature of PRTR UO_2 fuel, an internal pressure of 8.33 atm was observed. These data indicate no danger of fuel element distortion or rupture resulting from a negative pressure differential from fuel to coolant.

Fabrication Development. The applicability of the Magnetic Force Butt Welding Closure Process to a number of materials other than stainless steel and Zircaloy is being investigated. Preliminary data indicate that the process may be applicable for fuel rod closure welding of S.A.P. and other materials.

In other work, high speed motion picture (16,000 frames per second) studies were continued to observe the 1/60 of a second weld pulse. Infrared film was used to observe the actual heat buildup at the weld joint. The infrared film was difficult to interpret with any degree of accuracy; however, it was observed that excessive heat buildup does occur in the fuel rod cladding. As a result of observing this excessive heat buildup and weld microsection, the fuel rod closure cap has been redesigned to provide a better welding heat balance between the cap and the cladding. Future high speed film studies will be made with color film which should reveal the relationship of the heat buildup and the mechanical motion during the weld. In final finishing of fuel element closures, removal of the external upset material produced during the magnetic-force resistance butt weld may be accomplished by either machining or shearing. An air operated shearing fixture has been designed which will receive the end of the fuel rod, close the shearing die around the cladding and shear the upset material toward the end of the rod, with a short motion along the axis of the fuel rod. This fast shearing operation is expected to be an efficient method of removing this external upset material.

In studies of attaching spacing members to fuel elements by using the Thermatool 450 KC resistance welder, an improved sliding electrode contact design has minimized the arcing which had been experienced between the electrical contacts and the moving parts. The electrical contact which slides on the rib is placed forward, as close to the pressure wheel as possible. The electrical contact on the tube has been moved back, away from the point of weld. This provides a short welding current path in the rib and a long path in the rib and a long path in the tube, thereby minimizing the problem of heat balance. A weld has been accomplished with these electrodes between a round rit of 0.075" diameter and a tube 0.563" OD x 0.015" wall thickness in stainless steel. (Earlier work has required rib material having a trapezoidal cross section.) Distortion of the cladding and expulsion of metal from beneath the rib has been encountered and additional work is being performed to minimize these problems. A new gas manifold design is being incorporated to provide the necessary inert atmosphere protection required when welding Zircaloy. Porous metal gas diffuser manifolds will provide a uniform laminar flow of inert gas over the heated areas. It is expected that improved atmosphere protection will be provided with this

system, while using less than half the amount of gas required by the original flood purge system.

A unique, low amperage, welding power supply is being installed to provide close control of welding current from 1/4 ampere to 20 amperes. This power supply and a new miniature inert gas tungsten arc welding torch will provide the necessary accurate control of low welding currents for welding foil thickness fuel cladding material such as 0.005" stainless steel.

Zircaloy-2 has been successfully resistance brazed to itself using silver as filler metal. The brazes are metallographically sound and appear to be reasonably strong and ductile. Silver, rather than a silver solder, was used because of an anticipated superior corrosion resistance and bond ductility. It is doubtful that silver brazes will have adequate corrosion resistance for use in high temperature (600-700 F) water for extended periods of time; but for applications in which corrosion problems are less severe, such as in loop tests in low temperature coolant, they may provide adequate joints.

Vibrational compaction equipment to replace the Genisco-Savage equipment which is now located in a hot cell was installed and operated at its rated output of 5000 pounds force (125 g). An adapter was fabricated which initially will accommodate 18 PRTR fuel rods, as well as various measuring devices. The loading hood was modified to make it adjustable in height, thereby permitting simultaneous loading and compacting of fuel rods of various lengths. Specimens being fabricated with the new equipment include an assembly for thermal conductivity measurements at BMI and a fuel element consisting of nine stainless steel clad (0.008, 0.010, and 0.015 inch wall thickness) fuel rods containing enriched UO_2.

The resistance heating apparatus which, as an alternate to induction heating, is used to heat fuel rods prior to swaging was modified to include three brush holders rather than two. This arrangement provides a pre-heat area between the first and second brush holders and an area between the second and third brush holders in which the temperature is maintained within $\pm$ 50 C of the desired swaging temperature. Using only two brush holders, the "red hot" zone is only approximately four inches long. With this modification the "red hot" zone is extended to a length of approximately $\sim$12 inches. The fuel rod is, therefore, at temperature for a longer time, possibly providing higher and more uniform densities.

Hot swaging of micronized UO_2 in Zircaloy-4 tubes was unsuccessful. Adsorbed gases, released from the surfaces of the UO_2 at the swaging temperatures (600-1000 C), caused the hot, soft tubing to bulge and expand against the induction heating coil liner. A technique for degassing the UO_2 after it has been loaded into the tubes is being developed.

A short length of type 406 stainless steel welded tubing was reduced in diameter from 0.750 inch to 0.710 inch by hot swaging. Prior to swaging, the weld appeared to be very brittle. However, no evidence of cracking was observed during the swaging operation.

Corrosion Studies

Fretting Corrosion. The erosion effect of stainless steel on Zircaloy-2 has been determined as a function of temperature in the modified stirring autoclave. A loaded rod of 304 L stainless steel contacted a rotating Zircaloy disc under conditions of constant pressure (15.3 psi) and constant disc rotational speed (75 rpm). The atmosphere was deionized water at 1500 psi, and the time of the run was 24 hours. A comparison of the wear produced in tests using Zircaloy-2 discs and Zircaloy-2 rods with Zircaloy discs and stainless steel rods was made at 300, 250, 200 and 100 C. In both systems disc wear diminished with decreasing temperature from about six mils at 300 C to 0.3 mil at 100 C. Wear of the Zircaloy-2 rod diminished from about 100 to 30 mils. The wear of the stainless steel rod was much less, about six mils, and was independent of temperature.

In order to determine the effect of a pre-formed oxide film on the erosion behavior of Zircaloy-2, 300 C tests were run using pre-autoclaved discs, with rods in the etched or autoclaved conditions. In this series of tests both rods and discs were Zircaloy-2. The presence of an oxide film from the autoclave pre-treatment is not effective in inhibiting erosion of the type encountered in the tests.

A reduction of rod loading by a factor of three indicates both rod and disc wear are reduced in approximate proportion to the loading. Doubling the rotational speed of the disc approximately doubles the amount of wear which takes place on both the rod and the disc.

Fretting Tests. Zircaloy fretting corrosion tests are also being continued in CEP-2 under conditions partially prototypical of the PRTR fuel and process tube geometry. A previous preliminary report that larger clearances (viz., 50 mils vice five mils) produced less severe fretting attack has been reversed. In the earlier test with the large clearance, inadvertent wedging of the components had prevented vibration and resulted in the erroneous conclusion. In fretting tests to date, penetrations of one to five mils have been estimated after three weeks of exposure.

Long term testing is now in progress to determine the rate of penetration at prototypical PRTR conditions. Following this, it is planned to investigate larger contact areas on the supports to determine whether this change will minimize fretting.

Corrosion of Aluminum Alloys. The 1.8% Fe, 1.2% Ni alloy being heat-treated at 550 C has now reached three months at temperature. The ten-day 360 C aqueous corrosion results show no detrimental effect to the corrosion resistance of the material even though the metallography of the material shows a large amount of coalescence of the second phase material, especially in the higher silicon-content alloys.

One sample each of aluminum alloys containing 1.8% Fe - 1.2% Ni and 2.1% Fe - 0.64% Ni which had been subjected to 500 C, 1000 psi steam for 300 hours without failure have been examined metallographically.

Both alloys show a large amount of porosity. This porosity appears to be concentrated at the second phase alpha aluminum interfaces and is relatively uniform throughout the metal. It is probably related to hydrogen absorption of the metal which concentrates in the second phase particles.

Eight samples each of a one percent nickel binary alloy and a one percent iron binary alloy were tested in 500 C, 1000 psi steam for four hours. All eight of the nickel alloys suffered severe attack. The iron alloy showed small areas of attack at the hole in the sample on four samples; and the other four showed no evidence of severe attack.

Structural Materials Development

Burst Test Facility - Project CGH-896. Project CGH-896 provides an experimental facility for elevated temperature stress rupture testing of tubing and tubular components. Architectural scoping is completed and design has begun. Scoping and selection of pressure and temperature control instrumentation is approximately 30 percent complete.

PRTR Monitoring. The Mark prototype incorporates a TV camera for visual examination and a differential transformer device for ID measurement of PRTR pressure tubes. Development and construction of the ID measuring instrument is essentially complete although there has been a delay in the fabrication of the instrument housing. The TV camera and kinescope recorder are scheduled to be delivered August 1. Efforts to improve the optics and lighting are continuing. A borescope viewing head incorporating a wide angle lens and a right angle mirror was purchased. Modifications will be required to produce a clear sharp focus when using the right angle mirror in conjunction with the wide angle lens. Remote optical focusing, which will be supplied on the new camera, is expected to minimize this problem. To date, the best over-all view has been given by the 12.5 mm lens with a quartz pencil lamp. A preliminary experiment with a motor-driven rotating mirror was made, but it appears that scan speeds are too slow to use with a standard TV camera. Fabrication of the mechanical drive and positioning accessories are now approximately 80 percent complete.

The requirements for a radiation-resistant TV camera (Mark II prototype) was discussed with interested manufacturers. It appears to be feasible to remove most or all of the video amplifier circuitry from the radiation environment. Several of the manufacturers were asked to submit a brief description of their approach to radiation-proofing a TV camera and to indicate the magnitude of research and development work required.

Irradiation testing of electronic components and glasses is continuing. A quartz lamp was operated in air in a gamma flux to an exposure of 10^9 roentgens, and under these conditions the lamp produced enough heat to anneal out all radiation damage. Further testing with the lamp immersed in water is planned.

PRTR Sheath Tubing. The vendor (Wolverine Tube Co.) was official notified on June 6, 1960, of our acceptance of his revised bid incorporating the

changes in sizes and quantities on the Zircaloy-4 sheath tube order. Since this notification, the vendor has shipped 171, 0.495" ID tubes and indicates he will continue to ship this size tube at a rate of 100 tubes/week or more until completion. In addition, we have received to date 817, 0.680" ID tubes; 32, 0.505" ID tubes and all of the item 3 (0.750" OD x 0.025" wall) tubes. On-plant rejection rates for either internal or external surface Zyglo indications have varied from five percent to 40 percent of the tubes inspected. The vendor has been advised of these high rejection rates and that these tubes will be returned to him for replacement.

Radiometallurgy Laboratory Studies.

Examination was continued on the mechanically mixed UO_2-PuO_2 fuel elements, GEH-14-82 through 91. Metallography and replication on GEH-14-87 revealed no recrystallization and little cracking. Analysis of GEH-14-84 indicated a burnup of 150 MWD/T (RM-655). An Al-Pu, 3-rod cluster has been disassembled and one rod has been sectioned for metallography (RM-659). Fractography, metallography, and replication have been performed on UO_2 thermal conductivity and fractography specimens (RM-610).

Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

Thermal Hydraulics Studies

Two-Phase Pressure Drop in PRTR Discharge Piping. Experimental data were obtained concerning the pressure drop in the piping between the end of the fuel element and the outlet ring header during two-phase flow conditions. These data are of particular value in determining hydraulic stability of the reactor system and for use in reactor safeguard calculations.

The test section consisted of exact duplicates of a reactor outlet nozzle and piping with pressure taps added in appropriate places. The test section was placed in the laboratory heat transfer apparatus such that the flow conditions could be varied between all liquid and high quality steam. In particular, three different runs were made. With outlet conditions corresponding to constant tube powers of 1500 KW, 1200 KW, and 700 KW, the flow was reduced stepwise to the point where the outlet steam quality was approximately 30% by weight. Plans were made to duplicate the runs with two different sizes of outlet orifices.

An initial analysis of the data indicates that pressure drop values are greater than had been predicted from theoretical calculations.

PRTR Project Management and Design

Phase III PRTR Contract. The Phase III contractor is estimated to be about 96% complete as of August 1, 1960, versus a scheduled 100% based on a contract completion date of June 24, 1960, or versus 99% based on the official AEC schedule. Over-all PRTR Project is estimated to be

about 97.5% complete versus a scheduled 98.3% based on the official AEC schedule.

The river pump facility up to and including the condenser has been accepted from the contractor. Acceptance Test Procedures were performed on zeolite water softening units. The chilled water system was filled with glycol and the system has been placed in operation. Insulation of the chilled water piping is estimated to be 90% complete. Flushing and testing of the softened water system piping is being performed.

The process tube and nozzle assemblies and the process tube inlet bellows assemblies were installed.

Sixteen (16) of the eighteen (18) shim control assemblies were installed. The two remaining shim assemblies were received too late to be installed by the contractor and they will be installed post Phase III.

All gas seals in the reactor dry gas system have been installed and a leak test is being attempted. Numerous leaks have been found and eliminated thus far.

The helium gas blower for the reactor dry gas system and the bottle manifold for the helium makeup system have not been received. These are contractor procured items.

The outlet ring header and jumper assemblies were helium leak tested and hydrostatic tested. The header has been insulated ready for installation.

PRTR Rupture Monitor System. Fabrication of the mechanical portion of the Fuel Element Rupture Monitor System is proceeding as fast as materials can be procured. Difficulty with procurement of certain key items such as rotameters and valves threatens the current completion date of September 9. Currently, the sample chamber rack and the shield support framework are completed and the stainless steel sample chambers are nearing completion. Test pours of sample shielding casks were scheduled for the week of the 25th. Fabrication of the probe cooling coils and cask liners was completed.

The electronics portion of the Fuel Element Rupture Monitoring System was scheduled for delivery the last week of July. Test procedures for the system were approved and returned the first week of July.

Maintenance and Mockup Facility. The Fuel Element Rupture Test Facility annex, the gas loop 500 KVA load center, and the PRTR stack filter vault were added to the M&M bid assembly by addendums 1 and 2. The tentative bid opening date is August 10, 1960. Design of the filter vault was completed during the month.

Load Out Cask. Construction of the cask is continuing. The vendor encountered machining difficulties and did not meet the scheduled shipping date of 7/17/60. The cask shell was shipped to National Lead for

filling with lead the week of 7/25/60. Estimated completion is three weeks after the pouring of the lead.

Design Tests. Equipment needed for the tests is about 80% on hand with the balance scheduled by August 15, 1960. PRTR Operations has reviewed the design tests and has specified attachment locations for the design test equipment.

Fuel Element Examination Facility. The primary manipulator vendor continues to have difficulty in obtaining the specified finish on the main frame. Assembly of the other components is under way.

The ATP covering leak rate when the facility is water-filled has been completed by the Phase III contractor.

PRP Critical Facility (Project CAH-842). The bid opening date for the building was rescheduled from 7/27/60 to 8/10/60 to provide for the addition to the bid package of the Fuel Element Rupture Test Facility underground annex and the PRTR filter chamber.

The drawings of the periscope were completed and are being circulated for approval.

Design of the reactor tank and grid assembly was started.

The initial bids on the motors for the control and safety rod drives were high. Specifications are being reviewed prior to rebidding. Bids are due at month-end on the revised fuel transfer lock.

Fuel Element Rupture Test Facility (Project CAH-867). The design criteria has been issued. Detail design by CE&U has been initiated; equipment specifications are being prepared.

Purchase requisitions and specifications have been issued for procurement of the regenerative heat exchanger, immersion heaters, and circulating pumps.

Review of the scope designs for the pressure tube-nozzle and pressure tube-inlet jumper connections is being made to determine the applicability of these PRTR type joints to the higher pressure and temperature rupture facility joints. When this review is completed and necessary changes in the design are made, procurement of pressure tubes for test section "A" will be initiated. Basket tubes will be furnished by the user.

Two outlet nozzle-to-jumper connectors were purchased from Tube Turns for testing and evaluation at HAPO. These connectors are sized to 1-1/2 inch ID pipe and should withstand 2100 psi at 600 F, with a simultaneous loading of 10,000 pounds torsion and 10,000 pounds bending movement. Two 2100 psi, 600 F bellows were purchased from Parts Engineering Company for testing and evaluation at HAPO. These are for test section "B", which has a Hastelloy-X backup pressure tube outside or Zircaloy-2

pressure tube. The procurement of other test section "B" components will be deferred.

The transient studies with the planned temperature control system have been completed. The calculations show a 30 F peak increase in outlet temperature upon a 50% instantaneous flow reduction, smooth responses to instantaneous changes in temperature controller setting, and excellent temperature control during heatup at a rate of 350 F/hr.

Design and Component Testing

PRTR Fueling Vehicle. The special tubing required for fabrication of the replacement shroud assembly was received. A requisition was issued for the bridge drive shaft emergency brake. The fueling vehicle tracing revisions were begun.

PR-10 - Primary Loop Mockup. The spare PRTR primary process pump has continued to operate satisfactorily throughout the month. The present test run, after 850 hours of operation, has not shown any signs of rapid seal wear. The leak rate is normally less than 0.05 gph. The vibration has generally been approximately one mil, but during the first extended operating period increased to 1.8 mils. At this time the suction pressure to the pump was reduced from 1050 to 1025 psig, thereby increasing the pump down-thrust approximately 200 pounds. Since then, the vibration has never been higher than 1.2 mils. The pump operation in the reactor should have more stable downthrust conditions due to an approximate 17 psi higher pump head.

The Byron Jackson self-adjusting seal assembly in the small pump has continued to operate satisfactorily for 1415 hours. Operation was halted on July 23, 1960, due to a bearing failure in the variable speed drive assembly. The motor was found to have a 160 volt short to ground.

Document HW-65724 was issued, summarizing pump testing through June 1960.

Testing of Chesterton Style 324 Superlon was discontinued in the prototype injection pump after 60 hours due to high leakage even with repeated tightening of the packing glands. R/M Vee-Flex rings with finger-type springs installed on the pressure side of the packing gland have given initial satisfactory results with no heating of the gland as a result of compacted rings.

Process Tube No. 586-6063 has operated 393 hours and 11 thermal cycles during the month for a total of 3300 hours at simulated reactor conditions.

A series of pressure drop readings using different sized process tube inlet orifices established 0.843 inch as the desired size to give 34 psi pressure drop across the orifice and fuel element at 123 gpm.

Process Tube Seal Experience. Leakage experience during the past month has been essentially unchanged with the cap and nozzle-to-process tube leakage rates in the range of 0.1 to 0.5 ml/hr except for the shimmed nozzle-to-process tube joint in the flexure loop which has been leaking about 1.5 ml/hr. The flexure loop was operated for 520 hours and 61 thermal cycles.

PR-40 - Shim Control Mockup. Sixteen shim control assemblies were delivered to the reactor and were installed. Plugs were furnished for the other two shim control holes so the contractor could pressure test the helium systems.

Two complete additional drives were received; one of these was badly damaged during shipment. One other drive was received from San Jose without motors. The motors were removed from the damaged drive and installed in the unassembled drive. Both complete drives were tested and are now ready for installation in the reactor. The damaged drive was returned to San Jose for repair.

Another unassembled drive was received from San Jose and will be assembled with two of the motors received from Western Gear and tested to failure in the 314 Building mockup.

One of the Western Gear motors was placed in an irradiation facility to check its components for nuclear radiation resistance.

PR-80 - Air Cooling Duct Test. Purchase requisitions were issued for bids on the bellows to provide for thermal expansion. The design was changed to incorporate a drain and float in the bottom of each duct. The mockup of the transition piece from the wall to the duct is 80% complete.

Unit Motion. Fabrication of the photographic equipment for PRTR unit motion readings has been completed and testing will begin August 1, 1960. A system for placing the targets to be used with the optical measuring equipment has been established. The system will eliminate the need for measuring large distances and will automatically compensate for temperature effects.

Design Analysis

PRTR Process Specifications. Approximately 96 percent of the Startup Process Specifications have been written in first draft form and given initial review by the PRTR Startup Council, including two new specifications which were added during the month. Eighty-five percent of the specifications have been approved by the Council, and 70 percent have been published in approved form.

PRTR Startup Preparations. Review of several PRTR Operating Procedures has been completed. Preparation and review of power test descriptions is also continuing in conjunction with the Power Test Sub-Council.

The first draft of Physics Chapter of the PRTR Technical Manual has been completed and is being prepared for review.

The precision servomanometer for PRTR Critical Tests has been received. An evaluation test has been scheduled prior to installing the equipment.

PRTR Shielding. Calculations of the maximum temperature in a PRTR thermal shield slab for the case of a plugged cooling loop were made. Preliminary results indicate that temperatures near the plugged tube may approach the melting point of lead.

PRP Physics Analyses. Two dimensional, three-group calculations of the PRTR core have been performed with the 9 ANGIE Reactor Code, and power distributions determined for several practical cases. The runs were based on green fuel. Further studies are planned to investigate the effects of shim insertion and fuel burnout.

A study of heat generation for 80% and 90% theoretical density PuO_2 (1/16" in diameter) rods, surrounded by MgO have been performed using the S-4 One Group Cylindrical Cell Code. Pronounced self-shielding effects were noted. A report on this work is being prepared.

A study of a Phoenix fuel rod has been completed for a Pu-Al alloy bearing high exposure plutonium in varying amounts. These calculations will be used by Plutonium Metallurgy Operation in the development of fuel elements for irradiation in MTR.

PRP Critical Facility. In support of neutron kinetic studies of the PRCF, improved values of the prompt neutron lifetime for several probable loadings have been calculated. The core of the PRCF is composed of at least two types of fissile materials and is surrounded by a reflector. In this case, applicable to any type of core and reflector with radial symmetry, the prompt lifetime was found to be 6.0×10^{-4} sec.

Plutonium Fabrication Pilot Plant

The project physical completion notice is to be prepared based on the financial status as of July 24, 1960. Remaining funds are to be used for painting of second floor areas.

PRTR Operations Planning

Pre-Startup Activities. Review of PRTR Operating Procedures by design and technical personnel selected by the Startup Council continued during the month. Several procedures were revised as a result of this review. Four procedures were approved by the Council. Two new procedures were issued during the month for review.

Preparation of PRTR Operating Standards continued with first drafts of approximately 50 of the 100 standards completed to date. To keep the PRTR Operating and Construction Data Handbook up-to-date, revisions are issued periodically; the third set of revised pages was distributed during July.

A contract was signed with Betz Laboratories to provide consulting services for the PRTR recirculating coolant systems. Three meetings were held with Analytical Laboratories Operation personnel to formulate plans for an analytical training program for PRTRO personnel. Procurement of analytical equipment for this training program was completed during the month.

Assistance was rendered to HLO Radiation Monitoring Operations in preparing procedures and in planning radiation zones in the Service Building and containment vessel. Training of PRTR Technicians continued with emphasis on Reactor Operating Procedures and electrical circuits. The secondary light water injection system was reviewed and an operational test procedure was prepared.

Fifty-four drums of D_2O were received July 6. This completes the initial shipment of D_2O from Savannah River Plant. All D_2O containers are sealed and will be kept in the Central Stores warehouse until needed.

Requests have been issued for 75 percent of the spare parts required for the reactor. A number of bid reviews are currently being processed. Lack of BPF data from the Phase III contractor on contractor-purchased items is causing delay in ordering some items.

All spare parts needed for the Corblin helium compressor have been received. However, no spare parts for the Hofer high-pressure helium compressors have been received to date due to the difficulties encountered by the American vendor in obtaining the same. Present goal is to obtain a partial shipment by September 1, 1960. Alternate supply sources are being investigated.

The Design Test Sub-Council reviewed all design tests to determine if these tests duplicate any portions of the Acceptance Test Procedures. The Sub-Council continued its efforts to integrate Design and Acceptance tests. At month-end about 80 percent of the revised Design Tests have been prepared and are awaiting Design approval before issuance.

The PRTR Startup Council approved the scope outline for the power tests. The Power Test Sub-Council continued preparation of the Power Scope document.

Preliminary tests by Laboratories Auxiliary personnel indicate that low concentrations of potassium metaborate can be removed from D_2O by using ion exchange resins. If further test results indicate that potassium metaborate does not adhere to aluminum surfaces, this material will be used for poison calibration of the moderator during the critical tests.

A document, PRTR Critical Tests, HW-61900-B, was issued. Detailed test procedures are now being prepared.

Procurement specifications for a 40-station telephone-type communication system for PRTR were prepared. The specifications were forwarded to Design Development Operation for procurement purposes.

Calibration of PRTR instrumentation continued during the month. The water softeners and the river pumps were the major components accepted during July. The acceptance tests were witnessed by PRTRO personnel.

Liaison was maintained with the designers of the Gas Loop, Fuel Element Rupture Loop, and the PRP Critical Facility.

2. PLUTONIUM CERAMICS RESEARCH

Initial preliminary investigation of the PuO_2-ZrO_2 phase diagram has shown phase boundaries at room temperature equilibrium to lie at approximately 40 w/o and 70 w/o PuO_2. In order to verify the above and further define the room temperature equilibrium conditions, twenty-eight specimens ranging from 0.5 w/o to 95 w/o PuO_2 have been prepared. These specimens will be homogenized in the hydrogen sintering furnace and analyzed by x-ray diffraction methods. Stabilization of ZrO_2 begins at a low concentration of PuO_2; this point will be more exactly located.

Dilatometric expansion data have been obtained on several UO_2-PuO_2 solid solutions in an effort to obtain information on the discontinuity consistently seen between 625-700 C with pure PuO_2. A UO_2-25 w/o PuO_2 sample gave a very smooth expansion plot to 950 C on heating in vacuum. A UO_2-75 w/o PuO_2 sample on the other hand gave a plot with a small bump at 250 C and an expanded discontinuity between 425 and 600 C. From this temperature to 1000 C the curve was continuous. The above "eruptions" in the curve occurred on heating only. During cooling the $\Delta L/L_0$ versus temperature plot was continuous to room temperature.

Much of the past month was spent in installing equipment in the 308 Building laboratory. The research hydrogen sintering furnace is now in use along with powder preparation equipment, and sintering studies are again under way. A GE XRD 5D/F diffractometer has been received and will be hooded shortly. The present time is being spent in becoming familiar with the apparatus and in obtaining instrumental constants and characteristics of the pulse counting tube.

3. URANIUM DIOXIDE FUELS RESEARCH

Fuel Evaluation. A 19-rod prototypic PRTR fuel element is being irradiated under approximately PRTR coolant conditions in the ETR. The 36" long element is operating at a maximum surface heat flux of 460,000 BTU/hr/ft^2 and a power generation of 380 kw/ft.

Preparations for a fourth defect test of swaged UO_2 fuel rods have been completed. A test assembly containing a deliberately defected (0.005" hole), Zircaloy-4 clad rod containing swaged, sintered, and crushed enriched UO_2 is at the MTR; it is scheduled for irradiation in the GEH-4 Loop in August. Two of the previous defect tests involved Zircaloy-2 cladding, and one Zircaloy-4 cladding. Post-irradiation studies revealed localized hydriding of the Zircaloy-2 but not of the Zircaloy-4. However, more data are obviously required before drawing any conclusions, particularly since the Zircaloy-4 was irradiated for a somewhat shorter time than had been scheduled.

A fuel enrichment test is being conducted in the MTR. It involves a 4-rod cluster containing three different vibrationally compacted enriched UO_2 rods, and one rod containing sintered UO_2 pellets. This fuel assembly is generating a maximum surface heat flux of 633,000 BTU/hr-ft^2, which is an average heat generation of 26 kw/ft, and the estimated maximum UO_2 temperature is 4500 F. The four rods of the assembly contain the same average enrichment of U-235, but differ in the method of enrichment, as indicated below:

Rod No. 1: Sintered UO_2 pellets (1.6 w/o U-235).

Rod No. 2: Vibrationally compacted, sintered, and crushed UO_2 (1.6 w/o U-235).

Rod No. 3: Vibrationally compacted, 60 w/o fused natural UO_2, 40 w/o enriched fines (2.9 w/o U-235).

Rod No. 4: Vibrationally compacted, 75 w/o fused natural UO_2, and 25 w/o enriched UO_2 fines (4.15 w/o U-235).

Analyses of gases released from as-received, fused UO_2 during vacuum annealing at 800 C indicated approximately one ppm of hydrogen and argon. The release of these gases during annealing explains the presence of these same gases in irradiated fuel elements containing fused UO_2.

Swaged UO_2 capsules attained estimated exposures to 17,000 MWD/T in MTR-ETR. A swaged UO_2 capsule having achieved an estimated exposure of 15,000 MWD/T was discharged and is awaiting post-irradiation examination. No failures of swaged UO_2 have occurred.

Basic Studies. Fabrication of UO_2 specimens for fundamental studies is being conducted with Dynapak high energy impact forming equipment. Specimens compacted to 90-95% T.D. in the Dynapak were sintered for 12 hours at 1750 C, resulting in final densities of 98.8-99.6% T.D. In previous experiments, compaction of UO_2 in the Dynapak to densities as high as 99.4% T.D. were achieved by using an expendable steel reinforcing ring around the sample. Current attempts to heat the UO_2 by resistance heating in a stainless steel capsule in the Dynapak die have resulted in excessive heating of the steel reinforcing ring; there is an accompanying loss of strength of the ring. The sample extruded into the steel ring, preventing the development of pressures high enough to compact the UO_2 to 99% T.D. Densities obtained were 96.4 and 93.5% T.D., for micronized UO_2 and PWR type UO_2, respectively. Improved dies for compacting larger UO_2 samples at extremely high pressures have been designed for further studies.

Sintered, 94% dense UO_2 pellets (0.190" dia. x 0.200" long) were compacted in the ultra-high pressure and temperature facilities at the General Electric Research Laboratory, at pressures of 40 and 80 kilo-

atmospheres and at temperatures of 600-2000 C. X-ray diffraction studies of the UO_2 revealed no change in the crystal structure. Electron microscopy revealed that little or no closed porosity remained in the samples pressed at 1200-1700 C. A suitable method for measuring the density of the small pieces of UO_2 has not yet been developed.

To eliminate uncertainty as to the reasons for the previously reported high temperature behavior differences between irradiated and unirradiated UO_2, work has been initiated to determine the effects of deliberately varying the heating rate, the composition of the atmosphere, and the quantity of UO_2 in contact with the hot UO_2. Variations in these conditions caused no change in the melting point or vapor pressure of UO_2 in the temperature range 400 C - 2800 C. These results indicate that the observed changes in the high temperature properties of irradiated UO_2 (increase in melting point, decrease in volatility) probably is attributable to irradiation and not to extraneous effects.

Compilation of US/UK Research Newsletter #9 (Uranium Oxides) was completed.

Measurements of thermal conductivity of HAPO irradiated UO_2 were resumed in the equipment at BMI. Measurements were completed on a sintered UO_2 specimen having a burnup of 3.48×10^{19} nvt. The data obtained to date suggest that at least two changes affecting thermal conductivity of the UO_2 have occurred. The first appears to be proportional to sample burnup but anneals out at about 200 C. The second type is less sensitive to irradiation history, does not anneal out easily below 800 C, and has an effect on thermal conductivity which is inversely proportional to the temperature of measurement.

Irradiation of two more sets of UO_2 specimens in the series has been completed to approximately 5.09×10^{19} nvt.

4. BASIC SWELLING STUDIES

Irradiation Program. The major components for eight of the total of ten capsules planned for the metallographic swelling studies have been completed. Partial assembly, including charging of the uranium specimens and NaK, has been completed on two of these capsules in preparation for laboratory tests prior to shipment to the reactor for charging. Two reactor reflector pieces have been received from the ETR for modification. Changes will be necessary in these pieces to accommodate the metallographic swelling capsules and permit insertion of the correct orifice for the desired coolant flow and pressure drop consistent with the reactor requirements. Additional tests are partially complete on mockups of the heater to extension lead connections in the metallographic swelling capsule. Failures of these connections in the last four capsules makes it necessary to conduct additional development tests to determine the maximum permissible power carrying capacity through this connector.

Tests have been completed on a dummy general swelling capsule. Four split hollow cylinders of natural uranium were immersed in NaK in this dummy capsule and thermally cycled approximately 50 times between 100 and 500 C. The purpose of this test was to determine whether the 30-mil wall specimens would be distorted by the thermal cycles and to determine the surface condition of the uranium in a NaK environment. After two weeks of cycling the specimen geometry was not changed; however, the specimen surface had a thin oxide coating indicating the presence of oxygen in the NaK. The test results indicated that the environment of NaK coupled with ex-reactor thermal cycling will not adversely affect the specimen geometry and detract from the test results after irradiation. The assembly of two capsules that was delayed pending results of the laboratory tests is continuing, as well as fabrication and fitting of the parts for the next eight capsules on this program.

Capsule No. 4, containing natural uranium spheres, has now undergone five months of irradiation at a control temperature of 550 C. All of the capsule components are behaving satisfactorily, including the thermocouple that behaved erratically for a short period of time. The control instrumentation has performed adequately since installing the new potentiometers and pre-aged tubes. Capsule No 5, shipped to the reactor in April, is waiting to be charged.

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. Various applications of microscopy to uranium are, therefore, being investigated.

Post-irradiation annealing of uranium with burnups of 0.29 a/o and 0.41 a/o is continuing. Specimens have been annealed for one hour at temperatures of 600, 650, 700, and 880 C, and the metallographic processing has begun. Density results for samples after 650 and 700 C anneal for one hour have been obtained.

Replicas of a precharacterized sample of uranium having calculated burnup of 0.07 a/o at a temperature of approximately 200 C (GEH-14-35) have been received from the Radiometallurgy facility and are being studied. The specimen shows an increase in volume of 3.0% as compared to a specimen (GEH-14-33) having a calculated burnup of 0.03 a/o with an associated volume change of less than one percent. Density determinations on the two specimens are in progress.

Statistical analysis of pore void fraction and pore density values as a function of post-irradiation annealing is continuing.

Radiometallurgy Laboratory Studies. Density determinations have been made on six small unirradiated samples of uranium. A technique has been developed to produce reliable results on specimens of 1-1/2 to two grams in weight (RM-265). Results and conclusions from these examinations will be reported in more detail in connection with the development programs served.

5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

This program has been initiated to determine the mechanical properties of structural materials during irradiation. Currently, the study of in-reactor creep properties of Zircaloy-2 is in progress. The test is being conducted in a prototypical capsule in a reactor. At the same time a duplicate specimen is being tested in the laboratory to provide a direct comparison with the in-reactor test.

Data have been accumulated for several months on the in-reactor creep rates of a Zircaloy-2 specimen, as well as on the behavior of the components of the capsule. As reported previously, creep rates at a stress of 30,000 psi have been obtained at two test temperatures, 500 F (260 C) and 550 F (287 C). During the month the stress was raised ten percent, to 33,000 psi, as another step in the program to obtain the creep rates at another set of operating conditions. The new stress level should provide a higher creep rate than has previously been measured. A higher rate will be closer to the mid-range of the transducer sensitivity. The first two rates were at the extreme limit of sensitivity of the transducers. Insufficient time, however, has elaped since the stress was raised to allow the higher creep rate to be reported this month. The component parts of the capsule are still operating satisfactorily; daily resistance measurements on the transducer windings have shown no change that would affect the sensitivity or accuracy of the transducer. The helium tight feed-throughs made of radiation-resistant ceramic are still holding. There has been no increase in helium consumption in the capsule. The bellows are still intact and leak-free and all heaters and thermocouples are operating.

In support of the in-reactor measurements program, activation energies for creep have been measured on a series of cold worked Zircaloy-2 specimens at various test temperatures and stress levels. Creep rates for metals can be usually expressed in a modification of the Arrhenius rate equation.

Activation energies for creep can be determined by the measurements of the creep rates immediately before and after an abrupt change in temperature and using these values to solve the activation energy for creep. Activation energies have been determined on cold worked Zircaloy-2 by establishing a secondary creep rate under 13,000 to 21,000 psi stresses at 752 F (400 C), abruptly raising the temperature 25 F, measuring the newly established creep rate, and using these values to calculate the activation energy for creep. The creep rates established immediately upon an abrupt change in temperature did not display any transient characteristics indicating a constant value for the structure factor in the temperature range studied. The Zircaloy-2 specimen being creep tested displayed a transient creep rate upon an abrupt temperature change from 500 F (260 C) to 550 F (287 C), a steady state creep rate being established about ten hours after the temperature change. An activation energy of 66,000 cal/mole was calculated from creep rates measured immediately before and immediately after the temperature

change. The transient creep rate observed can be accounted for by the structure factor, a function of temperature at the conditions of the ex-reactor test, changing from a lower value to a higher one with time. The changing value of the structure factor with temperature is believed to be the result of strain aging in Zircaloy-2. A transient creep rate is expected to be established upon an abrupt temperature change in the in-reactor test. In fact, the observations of the secondary rates on the in-reactor test show that strain aging is occurring in the reactor. The calculations of activation energies on the in-reactor specimen is impossible since the present creep capsule does not have the sensitivity to accurately measure transient creep rates. The second generation capsules are believed to have the sensitivity required to measure these effects and allow determination of activation energies and study of the structural effects of neutron bombardment on the creep of Zircaloy-2.

The four capsules are now completed for the next series of tests and are at the vendor's plant awaiting the installation of digital recording equipment. The recording equipment should take about a month to install and check out. The data logging system will be capable of producing both a visible record and a punched or magnetic tape that will be amenable to automatic computation. At present, the prototypical capsule cannot provide data during reactor shutdown or startups. With the automatic data collecting equipment, continuous monitoring of strain will be possible.

6. GAS-GRAPHITE STUDIES

CO_2-Graphite Reaction Studies. Graphite did not react with high pressure (130-560 psi) carbon dioxide in the temperature range 360-660 C during ex-reactor tests for as long as 298 days. No measurable reaction was detected by weight change of the graphite sample, by pressure change, or gas composition change of the gas. Since some reaction should have been measured, it is concluded that the reaction products (probably CO) poisoned the reaction in the sealed system.

The only reaction observed ex-reactor at high pressures was in the temperature range 1200 to 1400 C with two capsules loaded with CO_2 at 139 and 205 psi. After three hours, the gas composition was 96% CO and 4% CO_2, and there was no appearance of the dark, sooty material on the sample or walls of the quartz that was seen in capsules from in-reactor experiments.

A static all-glass system designed for the study of gas-graphite reactions from seven to 22 psi and up to 975 C has been put into operation. The extent of reaction is followed by changes in pressure and gas composition.

O_2-Graphite Reaction Studies. Refined experiments with CSF graphite in the range 450 to 675 C have shown the order of reaction of oxidation of graphite to be about 0.7 with respect to oxygen between 0.2 and one atm. These experiments were conducted with both flowing air and oxygen at ten temperatures. The rate of oxidation can be expressed as:

$$\text{Rate (gm/gm-hr)} = (P_{O_2})^{0.7}(4.3 \times 10^{10})\, e^{-25{,}000/^{\circ}K}.$$

EGCR Oxidation Hazard Evaluation. Construction of the EGCR oxidation prototype has been completed. Testing and calibration is now in progress. Preliminary testing has demonstrated the unit will function as an adiabatic vessel, as required by the experiments which are planned. With no forced convection, the temperature drop is only 10°C/hr (at 300 C).

Coatings Evaluation Studies. The program of irradiation testing of siliconized-SiC coatings on graphite is continuing. The samples reported last month with "A" grade graphite as a coating base have survived post-irradiation oxidation in flowing air at 1000 C for periods up to 300 hours. Coatings of the same type applied to "W" grade graphite are being tested under the same conditions. One sample failed and lost three grams in 63 hours. Visual inspection indicated only small pits at one edge. After several days at room temperature a section of the edge fell away revealing a large hole in the substrate. Another irradiated sample of this type is under test.

Thermal Cycling Studies on Coatings. Samples in this test are cycled from 200 to 100 C three times per hour while exposed to flowing air. All SiC coatings subjected to this pre-irradiation test have survived without failure. There have been reports that exposure to a non-oxidizing atmosphere will cause the siliconized-SiC coats to evaporate. A sample was cycled as above for 69 hours in air (the sample gained 0.006 gms), and then cycled for 38 hours in helium (gain 0.0002 gms). The sample was again exposed to air and cycled. After 13 hours it had gained 0.006 gms. The rapid gain in weight is probably due to the silicon metal diffusing to the surface during the inert gas treatment and then oxidizing rapidly upon exposure to air. At present another sample is under test on a continuous-weighing balance to measure the effect of helium-air-helium cycling.

Gas Loop Project Management and Design (Project CAH-822). A trip was taken by J. F. Fletcher, D. E. Baker, and D. P. Schively to the Struthers-Wells plant at Warren, Pa. The purpose of the visit was to assure continuity of the interconnection diagrams now being prepared by the vendor to facilitate installation of the gas loop facility. Main items of concern were the instrument panel supplied by Minneapolis-Honeywell and the motor control center supplied by Westinghouse. A few discrepancies were uncovered and have been corrected. An additional object of the trip was to review in detail the piping stress calculations with the vendor. A number of points in the system appear to be overstressed and some calculations not fully in accord with the ASA Pressure Piping Code. At this juncture, there was no immediate answer available on some questions. Accordingly, these questions were left with the vendor for resolving after which the vendor will supply written answers and a proposed course of action.

The Hastelloy-X tubes for the preheater and the bellows for the remainder of the bellows sealed valves are expected by Struthers-Wells before the end of July. These are the only significant items yet to be installed in the Phase "A" package.

No firm delivery date has been received from Bristol-Siddeley for the gas circulating blowers. Latest reports are encouraging but hold little promise for the immediate future even with restricted operating conditions. Alternate methods for conducting hot tests at the Struthers-Wells plant are being evaluated but do not appear promising.

Because of the blower procurement difficulties and interference with PRTR critical tests, it is now planned to install the gas loop test section after the critical tests. The project proposal is being revised to change the completion date of June 30, 1961.

Procurement and preliminary fabrication for the Phase "C" package of gas loop service piping is continuing.

Gas Loop Component Testing. The first prototype of the in-reactor test section is essentially complete. Equipment is now being assembled for a mockup test of this section at design temperature with helium shroud flow. The three sets of gimbal joints from Solar have been received and will be placed on test in the near future. The Arrowhead orders for compensators and joints have been extended following a failure of their bellows to withstand a specified test at design temperature.

Technical Shop's work on the second prototype in-reactor section is 95% complete. Final fabrication of this section has been delayed due to the higher priority work of installing the first in-reactor section in the 314 Building Gas Loop Mockup. This mockup installation is 35% complete with procurement 85% complete.

Fabrication was begun on equipment intended to monitor in-pile movement of the high pressure tube relative to the shroud tube in the PRTR Gas Loop. Two independent systems, one temperature dependent and the other velocity dependent have been included in the design which will be evaluated in the mockup of this loop in the 314 Building. A third detection method has been assembled and scheduled for an irradiation test prior to installing on the loop. From these three techniques it is expected that two will be incorporated in the final design.

Final testing of the pickup hook and sample holder for the graphite sample cask has been completed and the design of these items accepted.

7. GRAPHITE HIGH TEMPERATURE IRRADIATION DAMAGE STUDIES

Four hot capsule experiments have been prepared and shipped to the MTR for irradiation. Exposure is expected to be about 6000 MWD/AT. The first two experiments which include experimental graphites prepared by the Armour Research Foundation are designed to test the effect of binder variation on dimensional stability, and compare the furfuryl alcohol impregnation technique with reactor graphites. The other experiments will provide an evaluation of the base stock of the UK Dragon graphites as compared to the CSF control.

Helium Density Measurements. A note, HW-66066, suggests that the ultimate contraction of graphite may not be limited by the theoretical density of graphite. In an attempt to perform a quick check of this possibility, samples have been sent to the G.E. Research Laboratory for He density measurements. Since these measurements yield data on the density of the graphite grains, the determination of He density in material irradiated at high temperature should be the critical experiment with regard to the above suggestion.

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.

Evaluation of the isothermal annealing fixture has extended through the month. A basic problem associated with the study of solid state reaction kinetics is the effect of the time involved in heating to and cooling from the isothermal annealing temperature. One means of compensating for the heating and cooling periods is to obtain an "integrated time at temperature". This calculation has been carried out for a zirconium specimen annealed in helium and in a static vacuum for five minutes at 500 C. Heatup time was 2.6 minutes in helium and 6.1 minutes in vacuo. Cooling rates were of similar magnitude. Using the activation energy for self-diffusion in zirconium as the basis of the calculations, the integrated time at temperature was found to be 9.0 minutes in helium and 15.2 minutes in vacuo. Work is currently in progress to improve the heating and cooling rates.

Strain aging studies of irradiated iron reveal that solute redistribution occurs concurrently with the accumulation of radiation damage. This is manifested by a loss in aging response due to nitrogen after moderate exposures. The process is thought to involve a breakup of nitrides by spikes and the trapping of nitrogen atoms, as well as other solute atoms at complex dislocation defects formed by the radiation. This mechanism is supported by tempering curves performed on specimens having differing degrees of irradiation. The tempering zones associated with the formation of coherent and incoherent precipitates from supersaturated solution are present after low exposures but are absent after exposures in the range 10^{20} nvt(neutron energies above 29 Mev).

Radiation embrittlement was prevalent in two ingots studied, but a third ingot remained ductile to exposures of 10^{20} nvt (fast). The cause of embrittlement is attributed to oxygen content which ranged from 0.013 to 0.020 w/o for the embrittled ingots and only 0.006 w/o for the unembrittled ingot. The cause of embrittlement is associated with the segregation of an oxide phase at the grain boundaries. The presence of this phase seriously retards stress relaxation across the boundaries during plastic deformation and favors the formation of microcracks which promote cleavage failure.

E. CUSTOMER WORK

Metallography Laboratories

The results and interpretations of the metallographic examinations and electron microscopy work performed during the month will be reported in connection with the respective research and development programs.

Samples Process During the Month

Total samples	346
Carbon replicas	56
	402

Photographs

Micrographs	433
Macrographs	38
Electron Micrographs	104
	575

Special Fabrications

To date, 1104 coextruded fuel rods have been shipped as scheduled to the Savannah River Laboratory. The coextruded rods contain Al-7.35 w/o Pu alloy and are clad with aluminum (X-8001 alloy). A casting yield of 94.5% was obtained during the month, and ultrasonic bond tests on the last 327 fuel rods showed a yield of 94.5 percent.

Evaluation of the I & E extrusion previously reported was continued. This extrusion based on a reduction ratio of 6.6 was designed to have an inner and outer cladding thickness of 0.100" and a core thickness of 0.064". Measurements from the sectioned extrusion showed an inner clad thickness of 0.115", outer clad thickness of 0.080" and core thickness of 0.070". These measurements indicated the variation in reduction of the cladding and core segments on a cross section of the element. The outer cladding reduction was 8.1, the core reduction 6.6, and the inner cladding reduction 4.6. Evidence of very slight "dogbone" and "stringering" at the core ends indicate modification of the billet core configuration is necessary. Based on the above information, two billet designs (Mark II and Mark III) with core and cladding modifications have been completed. The core material for both models is C 823 Al. The cladding material is X-8001 Al and is designed to have an as-extruded wall thickness of 0.050". The knowledge obtained from these two models will be used to fabricate an I & E with a Pu-Al core.

Eight Zircaloy clad 4-rod clusters containing UO_2-PuO_2 sintered pellets are being fabricated in support of Bettis reactivity studies at the MTR. About 50% of the required 240 pellets have been sintered and are ready for grinding. UO_2-PuO_2 densities in excess of 96% of theoretical have been attained by sintering at 1450 C for 5-1/2 hours. The eight clusters should be ready for shipment by the end of August.

J. J. Cadwell
For Manager, Reactor and Fuels
Research and Development

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

JULY 1960

FISSIONABLE MATERIALS - 2000 PROGRAM

FUELS

Nuclear Safety in FPD

Recommendations were made for the safe handling and storage of 3500 lbs. of 1.6 percent enriched uranium in the Fuel Cladding Facility. Thirteen uranium billets are to be extruded into fuel tubes; the dimensions are as follows:

	Billet	Extruded Tube
OD	5.6"	1.74" (Clad)
ID	1.9"	1.07" (Clad)
Length	18 "	20' approx.
Weight	270 lbs.	

After extrusion, the tubes are cut to the desired length and finished for reactor use. Nuclear safety limits for this uranium were based on a safe mass of 278 lbs. and a safe slab thickness of six inches.

STUDIES RELATED TO PRESENT PRODUCTION REACTORS

Neutron Rethermalization

1) Water-Graphite Experiment

The bare and cadmium covered activity traverses of gold and copper have been processed with the IBM code APDAC-I. Reduction of these data to traverses of the thermal activity of copper and to traverses of the epithermal activity of gold has started. A literature search for the diffusion coefficient of water as a function of temperature is being made. It is needed before analysis of the traverses can be made. Since the rethermalization properties of graphite are to be considered known in the water experiments, their analysis must also await the outcome of the pure graphite experiments.

2) Diffusion Coefficient for Graphite

The preliminary values of the rethermalization cross section of graphite reported in the Monthly Report for May, 1960, were determined under the assumption that the diffusion coefficient of graphite was temperature independent. This assumption has been shown to be invalid for thermal neutrons which have low characteristic temperature, Tn. Further, it has been shown that the rethermalization cross section at low temperatures shows a marked dependence upon the value of the diffusion coefficient and its temperature

dependence. In view of these conclusions, simple calculations, which neglect the effects of crystal binding on the transport cross section, have been done to obtain the diffusion coefficient of graphite for various combinations of graphite temperature and neutron temperature. Relative total cross sections, $\Sigma_t(E, Tg)$, were used from BNL-325. The calculated coefficients were normalized to the value of $\bar{D} = 0.809$ cm at $Tn = Tg = 293^{\circ}K$. The calculations were made by numerical integration (with the IBM code "ACE") of the expression

$$\bar{D}\,(Tg, Tn) = \int_0^{1.0\ ev} \frac{1}{3\Sigma_T(E, Tg)}\, M(E,Tn)\, dE.$$

The error of integration in all cases was less than 0.2%. The normalizing value of 0.809 cm was calculated with a microscopic transport cross section of 4.95 barns (HW-51175) and a graphite density of 1.66 gm/cm^3. The diffusion coefficients are given in Table I.

TABLE I

DIFFUSION COEFFICIENT OF GRAPHITE (IN CM.)

Tg/Tn	100	144	300	478	720
100	1.168	0.988	0.836	0.787	0.757
144	1.060	0.932	0.823	0.782	0.764
300	0.944	0.874	0.809	0.777	0.762
478	0.896	0.850	0.807	0.774	0.760
720	0.871	0.833	0.806	0.773	0.760

3) Approximate Calculations of Rethermalization Cross Sections Using Calculated Diffusion Coefficients

In earlier monthly reports an approximate method of calculating rethermalization cross sections has been used. These calculations were based upon a constant diffusion coefficient. The values of the diffusion coefficients as a function of temperature, presented above, have been used to recalculate the rethermalization cross sections by this method. The new and old values are tabulated below. The important point is that the cross sections, and even the relaxation lengths, are sensitive to the values of D.

RETHERMALIZATION CROSS SECTIONS AND RELAXATION LENGTHS

Region Temperature °K		Lengths for					Cross Section for	
		D(Tg,Tn)		D = Cont.			D(Tg,Tn)	D = Const.
							$10^{-3}cm^{-1}$	
T_1	T_2	L_{11}(cm)	L_{21}(cm)	L_{12}(cm)	L_{22}(cm)	L(cm)	Σ_{reth}	Σ_{reth}
108	285	21.6	20.1	19.0	18.7	35.7	2.32	0.63
491	320	9.41	9.41	9.6	9.57	12.5	8.76	5.29
666	350	4.26	4.26	4.34	4.34	6.6	42.0	18.5

4) Experimentral Traverses

Inspection of the traverse data for the water and graphite experiments has revealed a sensitivity drift in the two counters used to count the activated foils for that experiment and the graphite experiment. This has led to the discovery of a significant drift during counting of the latter data which heretofore had not been noted completely. Arrangements have been made to correct for this drift prior to the reanalysis of the graphite experiments. It should be noted that the detection of this counter drift is due to the unique methods of statistical data analysis employed in APDAC-I. It is recommended that APDAC-I rather than FOIL DE COR be used exclusively in future analysis of counting data.

Effect of Absorber on Neutron Energy Spectrum

The investigation of the effect of an absorbing cylinder on the thermal neutron flux spectrum in the surrounding nonabsorbing moderator is continuing. The assumption of a Breit-Wigner resonance absorption in the cylinder has resulted in integrals which are difficult to evaluate. It appears that a combination of numerical and analytic methods will be necessary for evaluation. Several methods are now being investigated for their adequacy.

Digital Computer Codes for Reactor Analysis

Debugging has begun of the HAPO version of the multigroup diffusion theory code F-N. This work involves both the bulk of the original program and the revised input routine which has been rewritten in FORTRAN to be compatible with the HAPO monitor system. The test case which has been used was previously run on F-SUPER, the modified version of F-3; this case is a two-group, five-region problem. Since F-N is basically an expanded version of F-3, the two codes should give essentially the same results. With this test case, F-N runs to completion, but the calculated fluxes and multiplication factor are incorrect. The complete running of the code is an encouraging indication that the remaining bugs are minor.

A description of QUAD-1, the code for evaluating the slowing down density as a function of position inside a ring of N symmetrically placed line sources, was submitted for inclusion in the quarterly report.

Work was continued on the program of preparation and adaptation of computer codes for use in neutron spectrum studies. An additional General Atomics code was adapted for local use. This code computes group average cross sections and related quantities over a read-in spectrum. Both microscopic and macroscopic group average cross sections are computed for each material. In addition, group cross sections averaged over all materials and material cross sections averaged over all groups are supplied. With codes for calculating the thermal spectrum and performing group averaging now completed, the preparation of a slowing down spectrum code remains to complete the preliminary system of codes for spectrum calculations. Work on this slowing down code will begin in August.

The use and relative advantages of the diffusion theory codes AIM-5 and F-3 are still being investigated. A number of problems have been run on AIM-5. Previous difficulties in getting proper data into AIM-5 are attributable to ambiguities in the instructions; these instructions are being clarified. These problems are now being run on F-3.

After two months of production use, the PCTR data analysis code, APDAC-I, encountered a bug which is being eliminated.

Two errors were found in the harmonic correction section of the production code for exponential pile data reduction. One of these errors carries over into COFIT, the companion cosine fitting code. The necessary changes have been made and are being debugged. Fast source corrections are also being incorporated into COFIT. These two production codes, which are non-monitor, are being converted to the monitor system for increased convenience and accuracy of processing.

Instrumentation and Systems Studies

The analog simulation study of reactor transients due to lithium loss was completed. The results have been prepared in graphical form for inclusion in a document.

The 1000-channel slow-neutron time-of-flight analyzer specifications were drawn up and approved by the customer. Inquiries have been sent out to manufacturers on specific components, and some testing work has started on special circuit configurations.

Theoretical considerations are being given to the possible use of microwave techniques for in-reactor neutron flux monitoring. It appears this may develop into an attractive field to investigate towards the objective of obtaining a high flux level, high temperature, long life, in-core neutron monitor. Several new ideas are being further considered to determine if they are indeed novel and possible subjects for an invention disclosure.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Exponential Pile Measurements of Large Diameter Fuel Elements

Material buckling and extrapolation length measurements have continued this month in a 9-1/2 x 8 foot exponential pile. The fuel element used was a tube-in-tube with a 2.5 x 2.0 inch outer tube and a 1.66 x 1.11 inch inner tube. The fuel elements were placed in graphite at a lattice spacing of 14-9/16 inches, and the coolant used was H_2O.

First, measurements of buckling and extrapolation length were made with 3-3/32 inches of graphite from the center of the outer column of fuel elements to the outside edge of the pile. Then graphite was added in 2 inch increments to the outside edge.

Table I gives the results of the buckling measurements with various thicknesses of graphite buffer.

TABLE I

Buckling 10^{-6} cm^{-2}	Source Position	Graphite Added (inches)
-126*	Split	0
-132	Split	4
-128	Split	6
-110	Clustered	4

* Previously reported

An estimated extrapolation length of 1.0" has been used for the analysis since the measured values were not yet available. The sources are placed at $(\pm \frac{a}{4}, 0)$ and $(0, \pm \frac{b}{4})$ for the split source case, and ± 1-1/16 inches for the clustered source case. The effective width of the pile is a, and the effective length is b. The bucklings for the split source cases agree reasonably well with each other and with the buckling of $-126 \times 10^{-6} cm^{-2}$ measured in a 4-foot pile. The buckling for the clustered source case does not agree but has yet to be corrected for the measured extrapolation length.

Table II lists extrapolation lengths measured with the various graphite thicknesses.

TABLE II

λ(side-side) inches	Source Position	Graphite Added (inches)	Number of Points
0.6 ± 0.2	Split	0	14
0.2 ± 0.1	Split	2	14
0.0 ± 0.1	Split	4	14
-0.3 ± 0.2	Split	0	12 (end points dropped)
-0.8 ± 0.2	Split	2	12 " " "
-1.0 ± 0.2	Split	4	12 " " "
3.7 ± 0.5	Clustered	4	14
4.5 ± 0.8	Clustered	4	12 (end points dropped)
-4.3 ± 0.8	Clustered	4	14 (no harmonic correction)

All traverses in Table II were taken as close as possible to the radius of the equivalent cylindrical cell and at the same perpendicular distance from the neutron sources. The λ for the split sources becomes negative when the end points are dropped. But for the clustered sources λ gets larger when the end points are not used and it is already unrealistically large. These results seem to indicate that something is wrong with the present method of calculating harmonic corrections. In order to analyze this situation fast source harmonics are being added to the COFIT program for analysis of horizontal traverses.

Other horizontal traverses have been taken at various cell positions with 4 inches of graphite added to the outside of the pile. The results are shown in Table III.

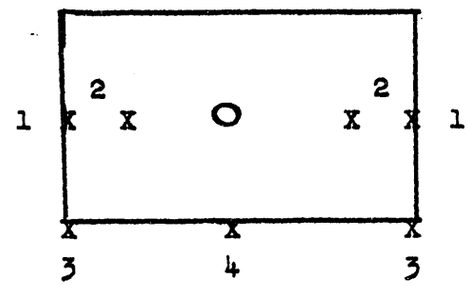
TABLE III

λ(side-side) inches	Source Position	Number Points	Cell Position*
0.2 ± 0.2	Split	15	3 + 4
-0.3 ± 0.3	Split	7	3
+0.3 ± 0.1	Split	8	4
0.6 ± 0.1	Split	14	2
0.0 ± 0.1	Split	7	1
3.1 ± 0.5	Clustered	14	2
3.0 ± 0.3	Clustered	7	1

*See Table IV

TABLE IV

CELL POSITIONS



The results in Table III show the same general form in that the λ with the split source is small and in some cases negative and λ with the clustered source is very large. The variation in λ as a function of cell position is not nearly as large as that measured with this same fuel element and lattice in a 4-foot pile.

PCTR Measurements on Large Diameter Fuel Elements

The counting of depleted U foils for p measurements is handicapped by background in the counting window at 100 Kev. To reduce this background, the 256 channel analyzer has been set up with two crystals looking at the same foil to try coincidence counting of the 100 Kev activity and other gammas in the decay scheme. The system appears workable and will be tested the next time a measurement of p is made, checking the results of the coincidence method against the standard window counting method. If successful, it might be possible to use natural U foils for p measurements because of the large reduction in background by coincidence counting.

The experimental work with the 2.5-inch diameter natural uranium fuel element in a 10-1/2 inch lattice, with water coolant, has been completed in the PCTR. The measurements with air coolant were completed the previous month. Data were taken to determine k_∞, f, p, ϵ, and the neutron temperature index at various places in the lattice.

The counting data for copper and gold foils, and neptunium decay and fission decay activities of enriched, natural, and depleted uranium foils, have been treated by the APDAC-I IBM code.

The enriched-uranium fission foils used in the experiment have yet to be intercalibrated. This will be done when the residual activity due to irradiation during the experiment becomes sufficiently small.

Data Correlation and Analysis

A complete compilation of all buckling measurements on graphite lattices is in progress. The list will include detailed description of results, geometries, enrichments, atom ratios, void fractions, densities, etc.

The P_3 part of the IDIOT program has been used to calculate flux distributions for the lattices with 1.92", 2.5", and tube-in-tube fuel which have been measured in the PCTR. This is part of an attempt to determine the effective neutron temperature in the lattice by adjusting the temperature used in the P_3 to give the best fit to the experimental fluxes.

For the first attempt the P_3 flux was compared directly to the experimental 1/v flux distribution, even though the P_3 result is essentially a monoenergetic traverse with the cross sections adjusted to a Maxwellian average. This essentially assumes that the epithermal 1/v flux distribution in the cell is the sane as the thermal distribution. This approach yielded temperatures for the moderator which seemed somewhat high, ranging up to 200 C.

The second attempt treated the eipthermal flux as constant through the cell, which is the usual assumption for the 1/E slowing down spectrum. This approach was not too reasonable since some of the resulting neutron temperatures were less than the physical temperature.

It is apparently necessary to use a more exact calculation for the epithermal part of the absorption in the cell, since most of these absorptions occur between 0.1 ev and 2 or 3 ev. In this energy range the absorption is strong enough to depress the flux significantly, so the fine structure of the flux in this energy region must be calculated independently.

Exponential Measurements for N Reactor

Graphite for the mockup lattice has arrived and the pile has been constructed. The inner tube of the fuel is being canned with satisfactory welding of the thin walled cans (.020"). Measurements can proceed whenever the outer tube arrives.

PCTR Measurements for N Reactor

The graphite for the condensed lattice is complete. Uranium foil for the p and ϵ measurements has been rolled to .005" and the foils are being fabricated along with the other uranium pieces used in the p and ϵ measurement.

N Reactor Temperature Coefficient

A feasibility study has been started on the use of the PCTR to measure the cell flux distribution for a high temperature mockup of the N reactor lattice, including static water under pressure in the process tubes. The basic concept is to heat the graphite (without the process tubes) to the required operating temperature, then insert the sealed tubes with water inside and allow the tubes to rise to their normal operating temperature. Then foils for the flux traverse would be irradiated quickly before the water temperature changes very much. The tubes would be removed immediately to avoid exceeding the rated pressure for the tubes and the whole assembly allowed to cool enough to remove the foils. This traverse compared to the cold flux traverse would yield the part of the temperature coefficient due to the flux distribution, that is, the change in both f and L^2 would be determined. This technique can not be used for the total temperature coefficient because reactivity measurements are needed which take too long. The tube temperature and pressure would be excessive long before the reactivities needed could be taken. Thus a pressurized flowing water system would be needed, which

has already been abandoned as too complex for the present PCTR. However, the flux traverse would be a substantial step toward determination of the over-all temperature coefficient if the proposed technique proves feasible.

Instrumentation and Systems Studies

The design decision on the NPR fuel failure monitor system was announced by the NPR Project Section at month's end. The system will combine parts of the two candidate systems which have been under development by IPD and HLO with provision for possible future conversion to the total HLO dual-scanning system. The IPD GM tube detectors will be used to individually and continuously monitor each of the 1004 sample lines for gross gamma activity. This will be backed up with the higher sensitivity HLO Slow-Scan gamma-energy monitor. The GM tubes will be mounted around the periphery of the circular arrangement developed for the HLO dual-scanning concept. The design will provide for minimum cost replacement of the GM tube system with the HLO fast-scan gross-gamma system if found desirable at some future date.

During the month development work and testing of the previously developed circuits continued on the mockup prototype NPR Scanning-Type Fuel Element Rupture Monitor. A complete system (fast-scan) checking circuit and a general alarm circuit were developed, fabricated, and successfully tested. A 20-point display identification panel was completed and placed in operation. Since the described circuits are yet in the development stage, further testing will be required to prove their reliability. The "wheel" was stopped late in the month, after one month of continuous rotation, in order to permit installation of the received commercial slip-rings to replace the plant-built unit. Maintenance personnel are presently preparing the wheel for the slip-ring installation. Fabrication is continuing on the remainder of the packaged alarm circuitry. Discussions were held concerning the complete system on July 12 to an assembled panel of interested personnel. In addition, a successful demonstration of the completed fast-scan portion of the mockup system was made to NPR Project and other interested personnel on July 19.

The prototype scintillation NPR (dual-probe) Scintillation-Remote Area Monitor was field-tested, successfully, for one month by IPD. The two probes (unenergized) were lowered into the 100 Area high-level radiation pit in a radiation field of 2×10^3 r/hr. Periodically, the probes, previously calibrated, were moved to radiation fields within their operating ranges ($\sim$100 mr/hr and 1.0 r/hr, respectively). The probes were then energized and checked for change of calibration. To date, after an accumulated exposure dose of about 5×10^5 r, there has been no change in the calibration-check readings. Complete system operation is successfully continuing.

The prototype (alternate) logarithmic scintillation area monitor has undergone 1.5 months of successful testing with radioactive source reading variations of less than plus or minus three percent for the test period. The unit and three direct copies are all now ready for field delivery except for remarking of the meter scales to the 5 mr/hr to 5 r/hr logarithmic range.

Electronics shop fabrication continues on the transistorized circuitry for the prototype NPR Scintillation-Beta-Gamma Air Monitor. This unit utilizes our transistorized logarithmic count-rate-meter extending from 10^2 to 10^6 C/M with recorder-driving capabilities.

Test equations similar to the reactor kinetics equations were solved on the GEDA computer. The solution is an exponentially increasing periodic function whose exponent is 0.00311 in the exact solutions. The machine solution yielded exponents ranging from 0.00313 to 0.00330. The errors are believed to originate from three sources, (1) the apparent necessity to operate the electronic multipliers at near-zero volts, (2) the use of low potentiometer coefficient settings and (3) the questionable accuracy of some of the GEDA integrators for long time constants. It is planned to program the problem on the EASE computer and to reduce as many of the above sources of error as possible. An attempt will be made to determine the relative effects of various types of error sources on the over-all solution accuracy.

The equations describing the NPR primary loop have been obtained. A four-region heat transfer model will be used. A five-region heat exchanger, identical to that used by GEL for a HAPO study, will be used. A single amplifier reactor kinetics simulator has been designed incorporating standard computer logic. The necessary components have been ordered and should be received within the next four weeks.

An estimate was compiled of the cost of determining the time constants for the rate meter on the NPR.

An estimate is being compiled on the cost of determining the pressure transients in the NPR confinement vessel due to various types of ruptures. This problem was studied previously using different constants.

STUDIES RELATED TO THE SEPARATIONS PLANTS

Plutonium Critical Mass Facility

Progress toward startup of the facility was limited during the month because of continuing delays by the vendor in the completion and testing of the in-hood reactor components for the initial criticality experiments. During the acceptance tests at the end of the month, several design errors became evident in some of the components; these are being corrected by the vendor. An estimate for the completion date of the in-hood components is now about August 15.

During the month three persons from Critical Mass Physics moved into the facility.

Minor Construction forces completed some small jobs on the facility which were not originally included in the project. The covered walkway between the control and reactor buildings was enclosed; a roof was installed over the entrance door to the shop in the control building.

The period and level potentiometer for the Critical Mass Facility was debugged, adjusted, run-in for a period of nearly one month, and given a final test. The results of the test were satisfactory, and the unit is ready for delivery. This unit fills the same job as the standard galvanometer and bucking voltage systems that have been standard. The important differences are a bucking voltage that is adjustable in steps of e, and an electronic null detector. This type of null detector is more sensitive than a practical galvanometer, and provides an output for recording purposes, or for controlling a period timing clock.

The unit is thus more flexible, more compact, and easier to operate than the conventional system.

Critical Hazards Specifications

Nuclear Safety in CPD

The design of a geometrically safe vessel to replace the L-16 recycle tank currently in use in the Redox Plant was reviewed. (This was a "second" review, the initial review was made by CPD.) This new vessel consists of three vertical sections of six-inch schedule 40 pipe which are 50 inches in length, spaced in a line with 24 inches between centers. The three pipes are connected at the bottom by a straight length of two-inch diameter pipe and at the top by a loop of two-inch diameter pipe. Service piping to and from the vessel will be one inch in diameter. The array of vessels is critically safe provided that the design is as defined in the drawing and that plutonium concentration does not exceed 500 g/l. Reflection is considered nominal.

Nuclear Safety in HLO

Specification D-2 was reviewed and approved for the Chemical Engineering Development Operation. This specification covers the preparation of a three percent U-235 enriched UNH powder-polyethylene mixture for use in experimental work by Critical Mass Physics. In order to obtain a homogeneous mixture of these materials, the procedure requires that about ten containers of UNH (62 Kg U) be emptied into a mixing trough where polyethylene pellets are added and then mixed. After mixing, the UNH is placed back into the original containers.

The poisoning effect of stainless steel, when used as a basket material for containing tube-in-tube fuel elements for testing in the ETR, was evaluated for the Fuels Design Operation. Calculations were made of the neutron flux distribution and the thermal utilization for two similar lattices using the IBM-709 IDIOT Code. The first lattice had Zircalloy-2 designated as the 0.03-inch thick basket material, and the second, stainless steel. The eleven regions of the cell were defined as follows:

Region	Material	Diameter (Inch)
1	Water	0.50
2	Zr-2	0.52
3	Natural Uranium	1.03
4	Zr-2	1.05
5	Water	1.45
6	Zr-2	1.47
7	Natural Uranium	1.80
8	Zr-2	1.82
9	Water	2.01
10	Basket (Zr-2 or S.S.)	2.04
11	Water	2.83

The thermal utilization was calculated for a lattice of these rods in water with an H_2O/U volume ratio of 3.42. For the case of the Zircalloy-2 basket, the thermal utilization was $f_u = 0.942$, and in the case of the stainless steel, $f_u = 0.720$.

Criticality Studies in Support of Processing Power Reactor Fuels

Experiments were continued for determining criticality parameters of enriched uranium relevant to the reprocessing of power reactor fuels. The experimental work included critical approach and exponential measurements with two percent enriched uranium rods in light water, exponential experiments with 2.6 percent enriched UO_2 rods in light water, and k_∞ measurements in the PCTR of a three percent enriched uranyl nitrate mixture. The data obtained from these types of experiments are used for establishing the nuclear safety of process designs.

1. Critical Approach and Exponential Measurements with Two Percent Enriched Uranium Rods

Critical approach and exponential measurements which are being made with two percent enriched uranium include fuel rods of two different diameters, 0.925 and 0.600 inch. The results of the measurements with the 0.925-inch rods were reported previously.

The first measurements were begun with the 0.600-inch fuel rod size. Ten critical approach and five exponential experiments were completed. Five different lattice spacings were used in these experiments. The critical approach measurements were made with 16 and 32-inch length fuel rods. The exponential measurements were made with the 32-inch rods. The uranium was encased in thin walled (1/32") Lucite tubes for insertion in the lattice assemblies which were fully water reflected. A hexagonal pattern was used for the lattices.

A value for the extrapolation length, λ, was determined for each lattice spacing by equating the expression for the buckling from the critical approach to that for the buckling from the exponential measurements.

The results of the critical approach and exponential measurements are summarized as follows:

[redacted]

CRITICAL MASS DATA AND BUCKLING FOR 2.00 PERCENT U-235, 0.600-INCH DIAMETER RODS

Lattice Spacing (Inches)	H_2O/U (Volume Ratio)	Critical No. 16-inch Rods (Cyl. Geometry)	Critical No. 32-inch Rods (Cyl. Geometry)	Calculated Critical Mass (Spherical Geometry)	Extrapolation Length, (λ)	Critical or Material Buckling ($10^{-6}cm^{-2}$)
1.00	2.06	254.5 (783 lbs. U)	176.3 (1084 lbs. U)	745 lbs. U	6.84 cm.	10,660
1.10	2.71	198.0 (609 lbs. U)	139.0 (855 lbs. U)	574 lbs. U	6.13 cm.	11,596
1.20	3.41	178.6 (549 lbs. U)	124.2 (764 lbs. U)	519 lbs. U	6.32 cm.	11,012
1.30	4.18	178.9 (550 lbs. U)	120.7 (742 lbs. U)	518 lbs. U	6.18 cm.	10,218
1.42	5.18	204.3 (628 lbs. U)	128.0 (787 lbs. U)	579 lbs. U	6.14 cm.	8,769

The critical numbers of rods was determined from a least square fit to the neutron multiplication data between 85 and 96 percent of the estimated critical number of rods. The above results are preliminary and subject to changes on further measurements and analysis of the data.

The minimum critical mass for the 0.600-inch fuel rods of two percent enrichment is $\sim$ 510 lbs. U for an H_2O/U volume ratio of $\sim$3.8. The maximum buckling for the 0.600-inch fuel rods is $\sim$11,200 x $10^{-6}cm^{-2}$ for an H_2O/U ratio of $\sim$2.9.

From previous measurements with 3.06 percent enriched uranium rods of the same diameter as above, the corresponding values were 282 lbs. U for the minimum mass, and 15,250 x $10^{-6}cm^{-2}$ for the maximum buckling.

2. Exponential Measurements with 2.6 Percent Enriched UO_2 Rods

Preliminary calculations were completed during the month on a series of exponential pile measurements using 2.6 percent enriched uranium dioxide fuel rods in water. The results of these calculations are shown in the following table.

BUCKLING AND CALCULATED CRITICAL MASS FOR 2.6 PERCENT ENRICHED UO_2 RODS IN LIGHT WATER

Lattice Spacing (Inches)	H_2O/UO_2 (Volume Ratio) (with Lucite rod)	λ* (cm)	Buckling ($10^{-6}cm^{-2}$)	Calculated Critical Mass (Spherical Geometry)
1.00	1.81	8.68	7832	658.0 lbs UO_2 (579.9 lbs U)
1.20	3.04	7.53	9341	369.1 lbs UO_2 (325.5 lbs U)
1.40	4.50	7.30	7760	397.3 lbs UO_2 (350.2 lbs U)
	(without Lucite rod)			
1.00	1.54	9.75	6224	927.6 lbs UO_2 (817.6 lbs U)
1.20	2.78	7.68	8917	397.1 lbs UO_2 (350.2 lbs U)
1.40	4.24	7.31	7668	405.7 lbs UO_2 (357.7 lbs U)

* Values of λ were obtained from a curve drawn from data in YAEC-94.

The uranium dioxide fuel was in the form of hollow cylindrical pellets with an inside diameter of 0.323 inches and an outside diameter of 0.705 inches. The UO_2 density of the pellets was 10.38 gm/cc. The pellets were arranged in lucite tubes in columns approximately 32 inches in length for insertion in the lattice frameworks.

Three lattice spacings were used, 1.00, 1.20, and 1.40 inches. A hexagonal pattern was used for the lattices. The six water-to-fuel volume ratios shown were obtained by making measurements with and without a lucite rod down the center of the fuel (lucite being assumed equivalent to water).

Measurement of k_∞ in the PCTR for Three Percent Enriched Uranyl Nitrate Mixtures

Measurements are being made of k_∞ in the PCTR for enriched uranyl-nitrate mixtures. The purpose of these measurements is to determine the effect of nitrate on the value of k_∞ and to evaluate the limiting concentration for the uranyl-nitrate mixtures, i.e., to determine the concentration for which k_∞ becomes $\leq$ unity. Previous measurements were made with hydrogenous mixtures of three percent enriched UO_3.

Measurements were begun to determine k_∞ at a nominal hydrogen-to-uranium atomic ratio of 9. The measurement of k_∞ at this H/U ratio, together with the value previously measured at an H/U atomic ratio of 6, will make possible the determination of the maximum value of k_∞ for the three percent enriched uranyl nitrate.

Irradiations were made for determining the fast effect (ϵ), and the resonance escape probability (p) of the above mixture.

Kinetics with Time Dependent Reactivity

Reactor kinetics calculations for the Critical Mass Laboratory hazards report have been completed. The kinetics code HAIREK was used in these calculations. The survey considered homogeneous spherical and cylindrical systems at various plutonium concentrations. Several conditions for the addition and removal of reactivity were included.

Interactions of Subcritical Assemblies

An investigation of the interaction between spatially distinct multiplying systems has been started. This work is an extension of work done here some years ago by G. W. Stuart, Journal of Appl. Physics, 28, 677 (1957). By using the Roussopoulous variational principle discussed by D. S. Selengut in the Quarterly Report for October-December, 1958 (HW-59126), an alternate derivation of the Stuart interaction formulas to the multigroup diffusion equations is being examined.

Mass Spectrometry

Isotopic analyses were provided on two plutonium samples for Critical Mass Physics and three uranium samples for Reactor Lattice Physics. Further difficulty was encountered in the operation of the source vacuum interlock. Work is in progress to attempt to improve the reliability of the interlock system. A new mounting for the ion source designed to improve the mechanical stability and lessen electrical breakdown was completed. The performance of the new design has not been evaluated as yet.

NEUTRON CROSS SECTION PROGRAM

The crystal spectrometer at 105-DR which is used in many of the measurements of this program was not operative during the month because of a faulty beam shutter. During a reactor outage at the end of the month the beam shutter shielding was disassembled and the beam shutter was inspected and replaced. The primary difficulty with the shutter was determined to be rust and galling of the front steel sleeve bearing. Some surface smoothing was done and the bearing surfaces regreased. The drive motor for the shutter was also replaced. The shutter is apparently operating satisfactorily at present. This shutter has been in operation for 4-1/2 years and this was the first breakdown which required disassembly to make the shutter operative.

Slow Neutron Scattering Cross Sections

The measurements of the scattering of 0.147 ev neutrons from a room temperature water sample were terminated when the aluminum crystals used as the analyzer monochromator were found to be out of alignment following a reactor outage. Since the spectrometer area was heavily populated with IPD work forces during the outage, it is assumed that the crystals were bumped at that time. Because of a lack of confidence in ability to restore the crystals to alignment identical to that previously used, the measurements under this condition were terminated. Most of the useful measurements at this energy had been obtained at the time.

The 0.147 ev measurements gave useful data only on the "bound elastic" component of the water scattering. In order to study the "gas scattering" component provisions will have to be made to obtain a higher intensity at energies below the bound elastic component. This can be done by using worse collimation on the analyzing spectrometer for this region where the resolution can be much worse without bothering the interpretation of the results.

The analysis of the bound elastic component of the scattering has been essentially completed. The data were of sufficiently good quality that it was possible to unfold the (assumed) Lorentz shape of this component from the (measured) gaussian resolution function shape. A fairly good measure was obtained for the broadening

of this component with scattering angle and the angular distribution was also obtained.

The scattering of 0.147 ev neutrons was also measured at a scattering angle of 3 degrees using the (0002) reflection of the beryllium crystal previously in use at the DR spectrometer as the analyzing monochromator. An increase in intensity of about 60 percent was obtained using the Be crystal over that obtained with the aluminum crystals with about the same resolution.

Measurements are now in progress on the scattering of neutrons of about 0.25 ev energy from water. A Be crystal in the $(11\bar{2}0)$ reflection is being used as the first monochromator and a Be crystal in the $(10\bar{1}3)$ reflection is in use as the analyzing monochromator. The over-all energy resolution at 0.25 ev is 9 percent as compared with the resolution of 11.5 percent used in the 0.147 ev measurements. The counting rates observed in the bound elastic peak are about a factor of 8 lower, however, so that only a limited amount of data will be obtainable.

Design was started on equipment necessary to make slow neutron scattering cross section measurements by time-of-flight techniques using the rotating crystal method of beam pulsing. Time-of-flight techniques will be necessary for taking data at scattering angles greater than 90 degrees because of the restricted range of the detector arms of the KE spectrometer.

Slow Neutron Fission Cross Sections

No measurements have been made on this program during the month. The results of a multilevel resonance theory fit to the MTR total cross section data and Hanford fission cross section data on Pu^{241} have been received from O. D. Simpson of Phillips Petroleum Company. The fit to the fission data deviates significantly in the region of the important 6 ev resonance such that the theoretical fit is probably not adequate for practical application.

Subthreshold Fission

Measurements in progress on the U^{235} fission cross section necessary to subtract this contribution from the data obtained near the 5.5 ev resonance in U^{236} were stopped when the DR crystal spectrometer beam shutter became inoperative. This is the only measurement necessary to complete the planned program of measurements on available samples.

The results of the Hanford measurements on this program were compiled and submitted to Professor J. A. Wheeler for inclusion in an article to be published in the Handbuch der Physik.

Fast Neutron Reactions

The effort on this program has been devoted to preparation for the studies of fast neutron total cross sections by pulsed continuous spectrum time-of-flight techniques. The development of a system for evaporating thick lithium targets in situ has been essentially completed. The shells of the slit boxes for the Van de Graaff have been completed. Work is in progress on the preparation and procurement of samples for this measurements program and a procedure for casting sulfur, phosphorus and alkali metals has been developed. The literature on

neutron total cross sections between 2 and 20 Mev has been reviewed. Both of the compilations BNL-325 and UCRL-5226 have been found to be incomplete and to contain misleading information.

PLUTONIUM RECYCLE PROGRAM

Low Exposure Plutonium Lattices

Six normalization irradiations were performed in the PCTR. All of the Pu and U-235 foils planned to be used in future experiments of this series were irradiated, in the sets as they will be used. Previous normalizations had been performed in the TTR internal thermal column where the 1/v CdR $\simeq$ 33. Preliminary analysis indicates that the BF_3 (.040" Cd) CdR at the center of the PCTR core was > 200. It is expected that normalization in this more thermal spectrum will reduce the uncertainties due to corrections for epithermal reactions. The large CdR was obtained without the use of the D_2O calandria by loading the driver elements and leveling slugs with Lucite, and inserting 36 tubes containing D_2O in a square array just inside of the largest driver square.

Critical Facility of the PRP

A rough draft copy of "Proposed Studies for the Critical Facility" has been circulated. The purpose of circulating the draft is two-fold. First, it describes some of the current plans for the facility; and, second, it is hoped that the draft will encourage comments either on the experiments presented or on others which should be conducted in the facility. This draft will be the embryo of a more detailed recommendation for the studies to be conducted during the first year or two of operation.

Comments which concern the requirements of the temperature instrumentation for the PRP-CF have been prepared and forwarded to the personnel of Reactor Technology Development.

Multichannel Analyzer

Apparatus which makes it possible to do gamma-gamma coincidence measurements have been added to the 256 channel analyzer. The equipment is also capable of measuring beta-gamma coincidences provided an anthracene crystal is used in place of one of two NaI(Tl) crystals.

There are two reasons for adding this counting technique to the capabilities of the analyzer. One is to be able to investigate new methods of measuring resonance escape probabilities in U-238 lattices. The other is to investigate the decay schemes of the lutetium isotopes.

The latter investigation is necessary in order to determine the activation cross sections of Lu-175 and LU-176. Coincidence counting has been done on γ-rays from Lu-177 during the month.

Effect of Temperature on Neutron Energy Spectrum

A rough draft of a report has been written describing an analytical and experimental study for evaluating several methods for calculating the thermal neutron spectrum in plutonium fueled - water moderated systems. The objectives of the study are:

1. To make available to HAPO computer codes which can be used to calculate the thermal neutron spectrum for hydrogen and non-hydrogen moderated systems.

2. To compare the spectrum codes with other analytical methods and to evaluate them by correlating with experimental data with the objective being to identify the range of macroscopic absorption cross section over which the various methods are valid for calculating average cross sections.

3. To experimentally determine the spectral characteristics of plutonium - water systems over a range of hydrogen-to-plutonium ratios.

Preliminary calculations have been made utilizing the Sigma Gas and Spectrum codes obtained from General Atomics. These indicate that the range of H:Pu of interest is from 200 to 2500.

Instrumentation and Systems Studies

The pile noise analyzer built by Critical Mass Physics was considered for use in the PRTR neutron lifetime measurements. It was found that the lower frequency limit of this instrument is above the frequencies of interest at PRTR. Therefore, it is not directly applicable. However, it was interesting to note that this noise analyzer used the same rectifying principle being studied by Systems Research Operation. C. E. Cohn, of ANL, reports that this method is valid for random inputs having a Gaussian distribution. Further development of these methods will be delayed until the tape recorder electronics is operational. The noise spectrum of the over-all measuring system will then be determined.

The information necessary to continue the analog computer PRTR Critical Facility Analysis has not as yet become available. Advice was given on the procurement specifications for the Critical Facility.

The final phase of the PCTR controller evaluation is still incomplete. This work will consist of checking the period control characteristics of the controller. The Goodyear computer was used to evaluate the performance of a logarithmic simulation of the reactor kinetics. Two different simulations were constructed and tested. The first used three groups of delayed neutrons, the second used only one group. The results from the one-group model showed a deviation of approximately twenty percent from those of the three-group model. This work led to the conclusion that the logarithmic simulator requires at least three groups of delayed neutrons to give usable results. The work on the Goodyear computer also pointed out the major difficulty in the use of the logarithmic reactor kinetic simulation; namely, that of getting sufficiently good synamic accuracy from the electronic multipliers which must be used. The worst possible conditions under which electronic multipliers may be operated occur when one or both of the variable inputs are at, or near, zero. Since these are the operating conditions with the logarithmic simulator, the use of highly stable electronic multipliers becomes a matter of prime importance. All of the equipment necessary to perform the controller period-control evaluation has been obtained. This includes two ten-amplifier stabilized Donner analog computers, six Donner electronic multipliers, and two Donner diode function generators. Since the Donner electronic multipliers are unstabilized, some difficulty is anticipated with the final simulation. At this

writing, it appears that the on-site portion of the controller evaluation program will be performed in the latter part of August.

Fabrication continued on the PRTR in-reactor process tube dimensional measuring instrumentation (Mark I). An authorization was received to start development on the final model.

Specifications are being written for the purchase of a commercial eddy current instrument to obtain the measurement of the PRTR process-to-shroud-tube gas-gap spacing in-reactor. These are based on the results of experimental tests performed with the Magnaflux FW-400, in use by the Radiographic Testing Operation. It has been determined that this instrument is capable of fulfilling the requirements of the gas gap measurement if it is used in conjunction with a high-sensitivity on-site-fabricated probe unit. Further consideration of this project has led to the development of a dual coil probe which should greatly reduce the instability effects due to radiation, temperature variations, scale buildup in the process tube, and tube-to-tube wall thickness differences. Long term stability requirements are also expected to be reduced since calibration factors will be less dependent on the symmetrical variables mentioned above. Essentially the probe will consist of two coils placed against opposite walls of the process tube, and connected as corresponding elements in an alternating current bridge circuit. Symmetrical environment variations affect corresponding bridge elements equally, and the probe assembly becomes, to a large extent, self-compensating.

The water tank for use in testing PRTR Gas Gap Probes was completed and received from Tech Shops. Design was completed on the test supports for the water tank and given to Tech Shops for fabrication by early August. Two Starrett dial gages were received. The water tank test setup will be complete when a decision is made on the internal diameter size of the phenolic process tube holders. The design of the probe itself has been started. The probe will be contained in a stainless steel shell which slips into a stainless steel sleeve which connects to the other probes. The design of the cell has been completed except for electrical connectors.

NONDESTRUCTIVE TESTING RESEARCH

The study of the use of orthogonalized exponentials in signal analysis has been continued, and preliminary work has been done investigating their possible application to the reading out of information contained in the response functions of broadband or pulsed eddy current and similar tests. The work of Professor W. H. Huggins, of Johns Hopkins University, who has been instrumental in interpreting and greatly extending the original works in this field, has been the guide for this initial effort.

Experimental work has involved the setting up of "orthonormal filters" for a three coordinate system. The orthonormal functions, in this case the first three Laguerre functions, were generated, and simple waveforms were resolved into their three coordinates. These tests have yielded qualitative information on the number of coordinates required for accurately representing various functions, and on coordinate time scaling relative to duration of the function being analyzed.

This method shows promise of providing an index of waveform in the form of numerics which may be recorded by any standard voltage-sensitive device. It is

very possible that these numerics will prove to possess a sensitivity to waveform variations which is missing in visual comparisons.

It would be very convenient in analyzing response functions if one could assume a certain minimal set of exponentials as coordinates and describe the function by the component of the function along each coordinate to achieve a good fit a given set of exponentials to a given curve because the weighting of any one exponential affects the weighting which must be assigned to every other component. The method under study avoids this difficulty by choosing as coordinates, not the individual single exponents in a set, but rather linear combinations of the exponents which form an orthonormal set of coordinates along which to measure the function. This is analogous to the location of a point in a plane described in rectangular coordinates compared to oblique coordinates. In the former, small inaccuracies in locating a point near one axis will have little effect on measurements along the other, whereas in the latter this same inaccuracy could create large errors along both axes.

Relatively simple circuits are known which will generate an orthonormal set of functions from any given set of exponentials. These functions may be individually read from a set of terminals in response to a single impulse at the input terminal. This same set of terminals will yield the components of the given function when the time reversed function is the input to the circuit. If the orthonormal functions form a "complete" set, the function will be reproduced with zero error if all terms, usually an infinite number, are used. A finite set will provide the most accurate curve fit on a least-squares basis. The number of coordinates necessary for a good fit depends on the nature of the curve to be fitted. Fortunately, the curves arising from pulse testing tend to approach their axes asymptotically, and such curves may generally be fitted to a prescribed accuracy with a small number of exponential functions, whereas curves which have discontinuities at their trailing edge, such as the square pulse, will require an infinite number.

The final design of a device for rotating and translating fuel elements during thermal bond tests has been completed. This design was based on a prototype built in the laboratory.

Attempts to shield the infrared radiometer head against stray pickup from the intense magnetic fields generated by induction heaters have not been successful thus far. Part of this problem has resulted from having the radiometer too close to the induction coil. A maximum separation of only six inches was possible with the original instrument. Modifications of the optics are now being made to allow up to four feet separation between the radiometer and test piece by using a reflecting system rather than an arsenic trisulphide lens.

Analytical solution of time transient two dimensional heat flow problems is not generally practical. Even most of the simplest cases, in which a highly idealized model is assumed, are complex enough to require several months to solve, and three-dimensional heat flow problems are much more difficult. Since the effect of various sub-surface defects on surface temperatures during external heating must be evaluated to allow interpretation of thermal bond testing data, it will be necessary to solve a number of time transient heat flow problems. The most powerful method of studying time transient heat flow problems is analog simulation. Because of the simplicity with which even relatively complex transient problems can be solved by analog simulation, feasibility of applying this method to thermal bond studies is being investigated.

An inductive thermometer using a single vacuum tube as a self-excited oscillator and a semiconductor diode as a detector is being developed for use in the heat transfer studies. The inductive thermometer gives an indication of metal temperature by using an eddy current test method to monitor changes in electrical conductivity of the metal. Since the electrical conductivity varies with temperature, such a device can be calibrated and used to indicate temperature. Maximum sensitivity obtained with the single tube device using a test probe coil about one-quarter inch in diameter has been approximately 18 millivolts per degree Centigrade. The greatest source of instability has been found to be due to temperature changes in the test probe. A water-cooled probe was built and was found to be much more stable on a long term basis, although probe noise increased due to internal vibrations caused by the flow of water. Tests are being continued temporarily with an uncooled probe, and the method will be evaluated for detection of unbonded areas in fuel elements.

A preliminary review was completed on the current state-of-the-art and needed advances in the nondestructive testing of thin walled tubing for fuel sheaths. A study is being made of possible techniques for measuring zirconium hydride buildup in in-reactor components.

GAS COOLED REACTOR PROGRAM

Lattice Parameter Measurements

Satisfactory isotopic and chemical analyses have been obtained on the uranium foils which were irradiated in the PCTR to obtain fast flux data in the EGCR lattice. This data has been included in the report on the k_∞ and f measurements for the 2.6 w/o fuel.

The customer report on the PCTR measurement of the EGCR control rod worth has been completed and is being prepared for distribution.

In addition, the customer report on the PCTR measurement of the reactivity effect of a stainless steel loop tube in the EGCR lattice has been completed.

Lattice Parameter Measurements

Analysis of the PCTR experiment with the 2.6 w/o enriched UO_2 fuel in the EGCR lattice has been completed. The results of the k_∞ and f measurement are:

EGCR LATTICE - 2.6 W/O ENRICHMENT

$$k_\infty = 1.267 \pm 0.008$$

$$f = 0.850 \pm 0.005$$

A customer report has been completed and will appear as HW-66182.

Variation of Doppler Coefficient with S/M Ratio -

A series of experiments had been planned to measure the change in the U-238 resonance broadening or Doppler coefficient resulting from a change in the fuel surface to mass ratio. Prior to cancellation of the Gas Cooled Reactor Program funds, measurements were begun in the PCTR to determine the values for k_∞ and f

in a 6-1/2-inch, graphite lattice fueled with solid, 0.925-inch diameter, natural uranium rods. The rods were air cooled and consequently there were no end caps on the fuel cladding. A 5 by 5 array of the 6-1/2-inch cells, surrounded by a layer of hole bars, required the large cavity of the PCTR.

With this lattice spacing it was assumed that the spectrum would be too fast and each hole bar contained a column of D_2O. In addition, all of the hollow driving and leveling fuel was filled with Lucite and the 60- and 70-cm fuel positions were loaded before drivers were added in the square holes surrounding the cavity. Based on an estimate made prior to the start of the experiment, each fuel column was poisoned with about 192 grams of copper.

With this arrangement of fuel and copper the lattice was 1.2 percent overpoisoned; and the cadmium ratio at the first buffer was 0.1 percent below the central test cell whereas at the second buffer it was 0.8 percent above. However, in the extreme corner buffers the cadmium ratio was 2.6 percent below the test cell.

Mechanical difficulties with the BF_3 tube traverse mechanism prevented a detailed mapping of the cadmium ratio longitudinally along the test column. Nevertheless, over the 20-inch test portion of the central column a variation of about 3 percent was detected using gold foils at seven positions along the cell boundary. Repositioning of the leveling rings would have reduced this variation had the experiment continued. However, at this point the k_∞ and f measurements were interrupted and the experimental apparatus that was to be used in obtaining the Doppler coefficient for this fuel size was tested in the PCTR.

The apparatus consisted of a nichrome heater on the surface of a 20-inch long, 0.925-inch diameter fuel piece all enclosed in an evacuated quartz tube. Iron-constantan thermocouples monitored the test fuel and the surrounding graphite temperatures.

Five heating runs were made which differed only in the maximum temperature obtained and the time required to reach this temperature. The 47-minute final run reached a maximum fuel temperature of 773°C before the nichrome heating element failed. An analysis of the data will be made to determine the loss in reactivity with increasing fuel temperature and to obtain the increase in graphite temperature throughout the lattice.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Calibration of the phosphorescence method of assaying the amount of ZnS tracer material on membrane filters was completed. A correction factor to be applied to the mass determinations on samples containing dust or other impurities was found to be a linear fuction of the colorimeter reading. The mass calibration curves for the Rankin counters were determined from a regression analysis of paired readings of Rankin counts and mass determinations from Tri-Carb counts. Mathematical expressions for the calibration curves and confidence intervals on these curves were derived.

Recounting was completed of all of the dust obscured samples of Zn65 tracer material collected on membrane filters at distances of 8 and 16 miles from the source during the summer 1959 atmospheric dispersion and transport studies. Reassaying of these filters was started last month following a decision that a practical limit in the development of the technique had been reached. The new data were transcribed on cards in preparation for reduction on the IBM-709 computer. Programming was in progress at month end.

Field activities in the atmospheric dispersion and transport studies were resumed following the extensive break in the series occasioned by the reassay of the "Green Glow" samples. Four field experiments were performed during the month. These experiments were designed to measure the dispersion of tracer material released from a source near ground level during both stable and unstable vertical density gradients. Three were successful and one failed when the meteorological conditions predicted failed to materialize. Dosage data were obtained to a distance of 3200 meters from a ground-level source, utilizing both the horizontal and vertical sampling grids.

A meeting was held between Professor A. Nelson Dingle and personnel of Atmospheric Physics Operation on July 26 and 27, 1960, to discuss coordination of our precipitation scavenging studies with those at the University of Michigan conducted under contract to the Atomic Energy Commission. Methods of utilizing the raindrop spectrometer and sorter developed at the University of Michigan in our field studies were explored. It was agreed that the first step was to prepare a climatological summary of precipitation for the Hanford Area. This step is to be followed by design of field experiments utilizing the existing sampling grid and the fluorescent pigment technique to determine rain scavenging processes, and to ascertain the feasibility of conducting such experiments.

Consultation service was rendered on meteorological and climatological aspects of 1) reactor accidents, 2) background variations in the 108-F counting rooms, and 3) release of uranium during a filter test in 200 East Area.

DOSIMETRY

Except for two emergency cases the Whole Body Counter was shut down for the month for maintenance work on the analyzer and for the installation of the tape-punch recorder and the spectrum stripper. The recorder was installed and operates satisfactorily. Installation of the spectrum stripper is almost complete.

A satisfactory mechanical system was completed that moves the large scintillation crystal of the Whole Body Counter when it is being used for scanning. Tests showed that the sensitivity of a scanning counter to sources at different body positions was about 20%. In the present arrangement where the subject sits in a chair there is a variation by about a factor of 2. (A factor of 20 if the possibility of a source in the foot is included.) The chair position was initially adopted because tests at Argonne National Laboratory showed that the counter would respond to the K^{40} and Cs^{137} in normal people with very little dependence on the size of the person. Apparatus is being fabricated to try scanning the subject from below in place of, or in addition to, scanning from above.

It was found that reducing the voltage between the anode and the last dynode of a photomultiplier tube helped considerably in reducing the height of background

noise pulses relative to the pulses due to X-rays. The noise pulses are produced by very short bursts of high current. Reducing the voltage between the anode and last dynode causes space charge limitation of the current.

The positive ion Van de Graaff was in operation about one-half of the month. A failure to keep sufficient liquid nitrogen in one of the traps resulted in mercury contamination of the vacuum system and three days loss in use of the accelerator. Later in the month the vacuum system was completely overhauled. It was found that most of the mercury in one stage of the main diffusion pump had distilled over into the other stage.

Some results on the comparison of different precision long counters are now becoming available. Two counters made independently at Hanford differ by 1.2%. One of the Hanford counters differs by only 0.2% from a counter made at the National Bureau of Standards.

An odd aging effect has taken place in some of the BF_3 counters that were specially made for the precision long counter. This effect has improved the already good operation of these counters. It has produced a clear resolution between the two groups of alpha particles that are produced when slow neutrons are absorbed by boron.

The Perlow neutron spectrometer was used to study the spectra of low energy fast neutrons from several plutonium-beryllium sources. Observation of some low energy neutrons was expected. All of the sources showed a peak in the spectrum at 300 kev. Difficulties with electrical transients have interferred with these spectrum measurements so this result cannot yet be considered firm.

An attempt was made to use semi-conductor diodes for fast neutron detection. 18 Mev neutrons could be detected by placing polyethylene radiators in front of both RCA and Hughes diodes. The voltage pulses observed were smaller than expected. It is believed that this was due to a non-optimum choice of the voltages used with the diodes.

The improved gamma ray calorimeter was used to complete the measurement of the source strength of a standard Cobalt-60 source owned by the National Bureau of Standards. During the measurements control of the calorimeter was within 0.0003°C. It was frequently better than one-half of this. The results of three separate measurements were within 0.66, 1.26, and 0.98% of the value determined by the National Bureau of Standards. The Bureau had used a coincidence counting technique for which they expected an accuracy of 1%. Our measurements can be considered an excellent confirmation of their calibration.

INSTRUMENTATION

Experimental circuitry was tested for the digital-readout version of the coincidence type alpha air monitor which has a calculated alarm sensitivity (no false alarms) of 2×10^{-10} μc/cc (continuous level) in three minutes. Experiments are also continuing on the analog readout method.

An experimental tunnel diode logarithmic voltage quantizer was partly completed. The circuit will be used as a voltage comparator device in range-extension application for a multichannel analyzer. Present experimental operation extends over 30 db. If the circuit is successful, the analyzer (any multichannel type) can

display a much wider range of gamma energies without the necessity of the presently-required multi-step successive data taking.

Work continued on the P-N surface barrier diodes with ten more diodes, varying in area from 1.0 mm^2 to 1.0 cm^2, nickel plated, potted, and lapped. They are now ready for etching and gold plating to complete them. Diodes completed to date have proved to be very successful for Pu^{239} alpha-particle detection. A developed six-stage transistor amplifier and headphone driving circuit for use with the larger area (0.75 inch diameter) diodes is now being fabricated (2 complete prototype units). These will provide extremely small (palm-of-hand) alpha monitoring instruments.

A portion of the experimental circuitry, in final form, has been fabricated for the Van De Graaff (electron) ion beam deflection system. The 60 KV, 5.0 ma power supply is now being tested.

The experimental servo-controlled accurate logarithmic scintillation area monitor was successfully bench-tested. The expected logarithmic range will extend from about 1.0 mr/hr to 10 r/hr. Full servo motor stall torque was used for two weeks without difficulty or temperature rise.

Seven final-form, cast plastic, 2-inch-by-4-inch effective area, experimental alpha scintillation probes were very nearly completed for extensive field test usage. Experiments were conducted comparing the use of equivalent type RCA and DuMont phototubes in the probes with RCA 6199 tubes determined, on the average, to be nearly twice as good, in all considered respects, to their DuMont counterparts. With the RCA tubes, and a 10 percent alpha geometry (discriminator setting determined), the probes produced less than two C/M in a 4.5 r/hr Ra gamma field. Complete neutron-caused background increase in the alpha probes remains to be evaluated; however, for the same alpha geometry as stated, a fast neutron field (1.4 Mev) dose rate of about 30 mrem/hr produces about one C/M background with the new probes. This effect can be reduced by changing the discriminator setting with a small reduction of Pu^{239} alpha geometry capabilities.

A special scintillation detector head was designed for use in monitoring Ca^{45} uptake (from water) in fish at the Biology Operation. The Ca^{45} solution is passed directly through a terphenyl-in-polyvinyltoluene detector. The detector has been assembled and tested in a preliminary fashion to date.

A special Pu^{239} 17 Kev X-ray detecting scintillation probe was designed for use at the Biology Operation. The probe will be used to measure the stated X-rays from a Pu^{239} solution injected under the skin of experimental animals.

An accurate determination of the alpha particle to beta-gamma counting rate ratio was made for natural airborne emitters deposited on a filter with an air flow rate of 3 CFM. This information will be used in future air monitoring development work.

Further experiments were conducted with the miniature ion-chamber, selectable-level, alarming personnel dosimeter using the very sensitive 0.2 and 0.5 microampere contact relays. The relays are somewhat sensitive to position resulting in inaccuracies of alarming (false alarms). The light level for, and the position of, the CdSe cell will be changed to provide a larger signal which will

permit desensitizing of the alarm relay. If necessary, a two-stage transistor amplifier will be incorporated.

Investigations were started, in cooperation with the Industrial Hygiene Operation, concerning measurements of filter efficiencies using a special 0.3 micron particle size aerosol. It is possible, using commercial instrumentation, to measure about 700 particles/cc of the stated size; however, this sensitivity is inadequate. It is believed that proper circuitry and detector modifications in the commercial unit will improve operation to the degree desired. If successful, proper filter effectiveness evaluation studies can be made.

Continued experimental progress was made covering the miniature thermoluminescent dosimeters. It should be pointed out that although the term thermoluminescent is applied to the dosimeters, several other methods, besides thermal activation, of obtaining readout will be investigated. Present work is of the thermal-activation type for readout. One fabricated CaF_2:Mn dosimeter was successfully tested and read out after activation in a Ra^{226} gamma field to dose levels of 200 mr, 500 mr, and 1.0 r. The irradiation rate was 1.0 r/hr. A successful "recipe" for preparing the CaF_2:Mn was thus obtained and proven. Experiments will continue at an accelerated pace. At present, an induction heater is being used to heat the dosimeters. The released light is phototube-amplified, and the readout is obtained on a chart-recorder to provide a legible record. The dosimeters can, of course, be used over and over again with no change in characteristics. A special dosimeter design is partly completed to permit improvement of the exposure-dose gamma energy response curve. The results, thus far, are exceptionally promising.

Development continued on the carriage mechanism for the Robot Monitor. Devices were fabricated and tested for determining the location of the mechanism.

WASHINGTON DESIGNATED PROGRAM

The mass spectrometer for this program operated routinely throughout the month without loss of time from operational difficulty. The operating characteristics of the triple filament source for thorium samples was studied.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month on a 2- and 3-shift basis. There were three unscheduled shutdowns due to electronic failure.

The experiment using 2-1/2-inch natural uranium fuel for k_∞, f, p, and ϵ wet and dry was completed during the month.

A trial experiment was run to check the techniques and equipment design to be used in the NPR fuel temperature measurement. Using 0.926-inch fuel, temperatures to 770 C were successfully obtained.

The 3% enriched uranyl nitrate-H_2O experiment for k_∞ at H/U = 8 was started during the month.

It is planned to provide additional fuel channels in the PCTR. This will allow placing the fuel farther from the edge of the test lattice. Better flux matching can thus be made for large lattices. A work order has been written and forwarded

for cost estimates on this job.

The TTR facilities were used by Critical Mass Physics all month with the exception of three days. These three days were used to make cadmium ratio measurements of lutetium to determine some resonance integrals.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	85.4
24-Hour General	62	89.1
Special	129	86.0

July was the hottest month in 49 years of record for the Hanford Area. The average temperature, 81.8, compared with 81.2 for July of 1958, the previous hottest month. The extreme high of 110, observed on two days of the past month, was the highest recorded in the area since July of 1941.

In spite of considerable cloudiness on several days after the 24th, practically clear skies continuously up to then resulted in the lowest average sky cover and the highest average solar radiation of any month on record. There were a few occurrences of rain after the 25th, but there was no measurable amount at any time.

Instrumentation and Systems Studies

Part of the tests were completed on the specially-designed in-cell beta-gamma monitor for the Chemical Research Operation, HLO.

Two newly-designed scintillation beta-gamma shoe counter probes will be fabricated for the previously designed Beta-Gamma Transistorized Clothing and Shoe Monitor for the Chemical Research Operation, HLO. The new probe design will be used since the older probes incorporated a phototube suddenly declared obsolete, and out of production, by RCA.

Fabrication was completed on a special air filter monitor (for hot cell filter use) for the Chemical Research Operation, HLO.

Fabrication continues on 13 linear 0-200 mr/hr 614 Building (Area) Monitors of the scintillation type. These units are being built for Radiation Protection Operation, HLO.

Most of the work, except for some machining and final testing, is completed on a Pu^{239} wound probe monitor for Records and Standards Operation, HLO. The work was temporarily held up by lack of machine shop time. It is hoped to complete the probe within two or three weeks. The work has now extended one month past scheduled delivery date because of the non-delivery of the special 4-inch-diameter, 3-mm-thick NaI crystal. This crystal finally arrived.

Cooperative effort continued with the Calibrations Operation, HLO, and the Drafting Operation, HLO, concerning several types of portable radiation detection

instrument drawings, and concerning hand and shoe counter drawings for the alpha and alpha-beta-gamma hand and shoe counters. The Calibrations Operation has gone out on bid for layout work and fabrication of a number of our "Sentinel" two-range, scintillation, portable alarming (settable-level) approximate dose-rate meters. This action of obtaining offsite instrument layout-design and subsequent fabrication work should accelerate the obtaining of field instruments.

During the month, revisions were made to specifications and drawings for the NPR Building Radiation Monitoring System and to the specifications for the Zone Temperature Monitor in assistance to CE&UO Instrumentation Design Operation.

Work continued on the development of a system for calibrating transducers intended for use in in-reactor metallurgy creep measurements. The reference system, for calibrating the Schaevitz DRS-100 micro-displacement system, has been fabricated, assembled, and all operational tests satisfactorily completed. The reference system has been checked for compatibility with the DRS-100 and was found to provide smooth and positive repositioning of the LVDT core. The displacement amplifiers (differential rollers) are both operational and produce magnification factors of approximately 12 and 90, respectively. It is expected that operation at elevated temperatures will be examined during August in addition to a more comprehensive calibration of the complete reference system. Further work with the DRS-100 confirms earlier suspicions that alignment of the instrument involves a somewhat intricate, painstaking process, and an intimate knowledge of the procedure is required if alignment is to be accomplished within a reasonable time.

The CPD calciner temperature control system was simulated on the GEDA computer. The results of the simulation were compared with transient data obtained on the actual process. It was found that the simulated time constants were considerably different than those indicated by actual measurement, but that the general shape of the curves representing the response to a step change in heat input were comparable. The degree of control difficulty should, therefore, be comparable for both cases. A three-mode controller was simulated to close the loop and study the control characteristics of the process. The results of this study are summarized in Systems Research Memorandum No. 60-29. Further study is planned to determine the factors causing the errors in the time constants of the simulated process.

A problem concerning the determination of the characteristics of a baffled dissolver for the Chemical Research and Development Operation was completed. The results were quite satisfactory. A memorandum report on this work will be issued.

Optics

Development of Radiation-Ratio Pyrometer techniques continued towards applications by FPD and HLO Metallurgy. A new filter wheel has been fabricated and mechanical changes have been made to eliminate sensitivity to the varying size of the object. A preliminary calibration run was made and demonstrated the ability of the pyrometer to cover the 500 to 1000°C temperature range with a ± 10°C sensitivity.

Analog Computer Facility Operations

The major problems on the analog computers this month were: Reactor Kinetics Test problem, PRTR Period Measurement, Sub-Critical Monitors for Old Reactors,

Calciner Control problem, and the Reactor Lithium Loss study.

For the reliability improvement program, three power supplies and all necessary connectors have been ordered for the amplifier testing device. An attempt will be made to utilize the EASE amplifier tester with the Goodyear amplifiers. It will be necessary to purchase or construct spare amplifiers for both computers if a routine maintenance program is to be undertaken. A recent letter from the Sylvania Company reported considerable success with a similar program on their Goodyear computer. At present, three amplifiers in the EASE computer are disabled. Considerable trouble is encountered in trying to repair these amplifiers since there is no way to furnish power to them. The amplifier testing device should provide such power.

The computer operating times were as follows:

GEDA	-	115 hours up
		32 hours scheduled downtime
		13 hours unscheduled downtime
		160 hours total
EASE	-	126 hours up
		34 hours scheduled downtime
		0 hours unscheduled downtime
		160 hours total

The control digital computer study continued. The results of the study with recommendations were prepared in rough draft for comments by members of the study group. The final report is being prepared at the present time.

Instrument Evaluation

1. Acceptance tests were completed on 35 or 65 C-P type dose-rate meters.

2. All tests were completed on the last three of the first group of ten 614 Building Radiation Monitors (0-200 mr/hr) including proper multiplier phototube aging.

3. Three logarithmic (5 mr/hr to 5 r/hr) Scintillation Area Monitors were satisfactorily test-completed. These units, which need only meter-scale remarking before delivery, were designed and fabricated for elevator monitoring use for IPD.

4. Two scintillation probes from the multi-range linear scintillation area monitor, designed by Instrument Design and using our developed circuits and detection methods, were returned from the Idaho ETR installation. The two probes were found to be in perfect operating condition, and they calibrated correctly. The true cause of the supposed malfunctioning of the area monitor at the ETR site thus remains unknown. It is possible that the system was incorrectly used at the ETR site. Several probe design changes were suggested, by letter, to further guarantee reliable operation. We have yet to have an RCA phototube and terphenyl-in-polyvinyltoluene detector probe assembly fail in any of our many and varied HAPO area monitoring and criticality monitoring applications.

5. Calibration procedures were devised and written for the portable transistorized alpha and alpha-beta-gamma radiation detection instruments.

6. Tests were satisfactorily completed on the original, experimental-prototype logarithmic (5 mr/hr to 5 r/hr) scintillation area monitor employing the inexpensive compact high voltage, high current (1200 VDC at 3.0 MA) power supply.

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Decontamination of Reactor Components

In a previous report (February 1960) it was stated that test coupons exposed in the KER-3 loop did not decontaminate as well as other coupons during the APACE process. Residual activity was due to Ag-110 and Sb-124 whose presence was unexplained. A group of coupons recently removed from the KER-2 loop had a small amount of Ag-110 in their activity spectrum; this also was not well removed by APACE procedures. Source of the silver has been traced to silver solder used in strainer repairs. These results indicate that the use of silver solder or other silver containing alloys in the NPR primary loop might result in decreased decontamination efficiency.

Further decontamination tests in which acetic and lactic acid were substituted for citric acid in the APACE process confirmed that decontamination is not as effective as with citric acid. However, decontamination with acetic and lactic acid was good enough to warrant further study of their use because they are less expensive than citric acid. Tested variations in the composition of the alkaline permanganate solution used in the APACE process produced only minor variations in removal of activated corrosion products from stainless and carbon steels.

Corrosion of sections of unused stainless steel pigtails by the solution proposed for rear-face decontamination of present reactors (0.9 M H_2SO_4 - 0.9 M $H_2C_2O_4$ - 1 g/l phenylthiourea) was more severe than previously observed for polished coupon test specimens. Even the higher rates are considered acceptable on a weight loss basis. However, some pitting attack was noted on the pigtail samples.

Uranium Oxidation and Fission Product Volatilization Studies

A single fission product release test was made at a temperature of 1215 C in an air atmosphere for 24 minutes. The uranium specimen had been irradiated to about 5×10^{17} nvt. Analytical work was completed on I^{131}, Sr and Xe^{133}. The data confirm the previously reported finding that the release of the volatile fission products is dependent upon the irradiation level while the release of the non-volatile is not affected. Iodine and xenon release was 95 percent while strontium was less than 0.2 percent.

NPR Effluents

Laboratory experiments were continued to study the settling of precipitates in mixed decontaminating solutions and rinses proposed for NPR. In duplicate samples, the mixtures were allowed to settle naturally in the one case and were centrifuged (but without separation of solid and solution) in the other. Settling of solids continued for periods up to 48 days after mixing. By the end of 48 days the mixtures that were initially centrifuged were indistinguishable from those that were allowed to settle. The decontamination factor finally achieved was about 10^3. Laboratory experiments that measure the decontamination of these solutions by scavenging with precipitates in which the solids are centrifuged from solution give initial decontamination factors about 40 percent higher than those attained by natural settling.

Experiments were started to study the possibility of a treatment of a commercial phosphoric acid decontaminating agent (Turco 4512) to reduce its concentration of radioactive material before disposal. The material is another candidate for decontaminating the NPR loop. Investigation of a neutralization with lime and filtration of the calcium phosphate precipitate by soil was examined.

A study of available ground water data was made to develop information to assist with design evaluation of a waste crib for the NPR facility. Estimates were made of the aquifer characteristics beneath the proposed NPR waste disposal area from the observed response of water levels in nearby wells to changes in the river level. The field permeability of the aquifer was estimated to be 156 gal/ft^2/day on unit gradient. From the calculated gradient established beneath the proposed crib a minimum travel time for water to flow to the river as short as 12 hours was predicted. From an assumed conformation of this trench it was determined that the water table might flood the bottom under the dual influence of large waste flow and high river levels. Under these conditions, there is some risk indicated that the proposed crib would be too small to handle the required flow.

Reactor Effluent Treatment

The pilot scale facility for aluminum bed decontamination studies was operated in a preliminary way near month end; some pump difficulties were met and some adjustment of the slope of the tank to compensate for head loss was required. Instrumentation for recording temperature and flow rate was readied. The procedures developed for planing aluminum bars into packing rings to give the proper density permitted a final production rate of about 70 pounds of uniform packing per hour. The goal packing density of 20 pounds per cu.ft. was achieved within close limits with some mechanical compaction.

A review of rupture frequency and extrapolation to year end indicated a very significant increase in total ruptures over those in 1959. The advances which can be achieved in more reliable and quantitative monitoring were reviewed, with the anticipation of possible need for more sensitive monitoring and control of fission products released to the Columbia River.

Spectrographic Analysis of Graphite

HW-66219 will describe an emission spectrographic method for the determination of impurities in nuclear grade graphite. The method is being used in NPR work. A modification of fluoride volatilization allowed direct determination of most impurities.

Analysis of New Corrosion Inhibitor

Concentration of inhibitor, Quachrom Glucosate®, in reactor test loops was controlled by chromium analysis. The commercial material reacts with diphenylcarbazide, in acid solution, to give the characteristic reddish-violet chromium complex. Results are easily reproduced. The color is stable for more than an hour. Fuming the material with sulfuric acid prior to applying the diphenylcarbazide procedure produced a 20 percent larger chromium value. Thus, two methods are required to determine effective and total chromium.

SEPARATIONS PROCESSES
Purex Decontamination Studies

An unusual aspect of the recent decontamination difficulties in the Purex plant has been the failure of the plant first cycle solvent to decontaminate effectively in the alkaline permanganate solvent treatment step, even when this is applied in laboratory equipment under supposedly ideal conditions. In the course of scouting studies to ascertain means of furthering decontaminating Purex plant solvent, the following solvent washing procedures were tested in ten minute contacts with Purex 100, with the indicated result in removing zirconium-niobium fission product activity (which represents the major activity in Purex plant solvent).

	Wash Procedure	Zr-Nb DF
1.	0.05 M $KMnO_4$ - 0.5 M Na_2CO_3 + 0.3 M HNO_3 + 0.5 M Na_2CO_3 (Purex plant procedure)	2.1
2.	0.5 M Na_2CO_3	1.1
3.	Centrifugation	1.02
4.	3 M HNO_3 - 0.1 M $Cr_2O_7^=$ + H_2O + 0.5 M Na_2CO_3	5.7
5.	3 M HNO_3 + H_2O + 0.5 M Na_2CO_3	2.7
6.	As in 5. except 3 M HNO_3 contained 20 g/l sulfamic acid	2.7
7.	2.5 M NaOH	6.4
8.	Activated alumina bed	5.0
9.	3 M HNO_3 - 10 g/l hydroquinone + 0.5 M Na_2CO_3	1.5

From these data it is apparent that three rather radically different solvent treatments (an acid oxidizing wash, a strong caustic wash, and a treatment with a solid adsorbent) yield approximately equivalent removal of zirconium-niobium from this solvent. Which, if any of these procedures likewise results in removal of the organic compounds ("do bads") responsible for the high retention of zirconium-niobium in the plant solvent remains to be ascertained.

On the supposition that the backcycled waste concentrate (3WB) might be responsible for the tendency toward high fission product retention by the solvent and the slightly sub-standard decontamination performance observed in the Purex plant over past months, some brief exploratory experiments were performed with Purex plant 3WB. No unusual effects were seen. Specifically, filtration of the 3WB through packed glass-wool resulted in a decontamination factor of 1.35 for zirconium-niobium. Although indicative of solids or easily adsorbed fission product species, such

behavior is not unusual and indeed is typical of Purex 3WB, even in periods when decontamination performance has been satisfactory. Likewise contact of 3WB with kerosene diluent resulted in only very slight "extraction" of zirconium-niobium activity, corresponding to a distribution coefficient (E_a^o) of the order of 10^{-5}.

A batch extraction of 3WB (diluted three-fold with water) followed by three successive batch scrubs with 2 M HNO_3 likewise disclosed nothing especially untoward as regards the extractability of zirconium-niobium activity present in the 3WB. Zirconium-niobium distribution coefficients were 0.016 in the extraction step and 0.03, 0.042, and 0.18, respectively, in the three successive scrubs. This ascending distribution coefficient on exhaustive scrubbing is customary. After the three scrubs the zirconium-niobium activity in the organic extract had been reduced to 4×10^{-5} that of the initial (diluted) 3WB feed.

Thus, these experiments fail to pinpoint the 3WB as a particular source of the plant decontamination problems. However, it must be recognized that plant decontamination performance is only slightly sub-standard (e.g., first cycle decontamination low by a factor of perhaps 5) and that effects of this magnitude might easily escape notice in experiments of this nature.

The sample of 3WB used in these experiments did contain visible solids. These have been isolated and submitted for spectrographic analysis.

Feed Preparation - NPR Fuels

Instantaneous dissolution rate measurements were made on several uranium alloys which have been proposed as possible NPR fuels. These included uranium-zirconium alloys having zirconium contents ranging from two to 0.045 percent and an uranium-300 ppm silicon-200 ppm iron alloy. Test solutions contained nitric acid ranging from 15.7 to zero molar and uranyl nitrate ranging from zero to two molar. They represented various solution compositions expected in the normal dissolution of uranium metal in nitric acid.

Uranium alloys containing one and two weight percent zirconium dissolved at significantly lower rates than ingot uranium; with 0.38 and 0.045 percent zirconium present, dissolution behavior was comparable to that for ingot uranium. At high acidities (>10 M) the uranium-iron-silicon alloy dissolved a little more rapidly than ingot uranium.

Observation Wells

The Hatch Drilling Company contract for wells on Projects CAH-885, CGI-791 and CAC-843 was about 14 percent complete. Two wells in the 100-F Area and one in the 200 West Area were completed.

Data obtained from the drilling of wells on the current contract are being used to prepare plans for the FY 1961 program. A large part of that program evidently will be the rehabilitation and redevelopment of existing wells.

New maps were prepared which show the contours on the water table beneath Hanford Works. Minor changes in the shape of the 200 West ground water mound were introduced as a result of elevation data obtained from new observation wells in the area. Other changes in the shape of the countours near the river result from the normal response to seasonal fluctuations in the level of the river.

Noticeable changes were evident in the movement of contaminated ground water under 200 East Area during this month. A definite eastward movement of contaminants from the 216-BY scavenged waste disposal facilities is reflected by increases in beta-emitter concentrations in wells east and southeast of this disposal site. Heretofore the indicated direction of movement was predominantly southward. A logical explanation for this shift is the decrease in the level of the B-Swamp ground water mound. Although the water level in the swamp is almost the same as it has been in the past, the rate of waste water addition necessary to maintain the level has decreased appreciably. Addition rates during the past nine months were less than when B-Plant was in operation. It is not unlikely that windblown silt and vegetation growth have measurably decreased the percolation capacity of the swamp.

Analytical results of depth samples from nine of eleven sampled wells located in the north-central and central sections of 200 East Area showed increased concentrations of radioisotopes with depth. The maximum gross-beta concentration difference noted was 1000-fold in well E28-2. Other wells showed increased concentrations at depths varying by factors of two to 30. The bottom samples from well E28-2 contained Co^{60} at a concentration of 1.1×10^{-5} uc/cc. This is the farthest south (2500 feet) of the 216-BY cribs that this radioisotope has been detected. Correlation of these results with geologic and hydrologic data was planned to define the cause and extent of the variation of radioisotope distribution with depth in this locale.

Disposal to Ground

Work on sinking well points near the 106-TY underground tank was abandoned due to the inability to drive the points to the required depth of 60-70 feet. Soil conditions are such that maximum depths of penetration on three attempts were 35', 25' and 20'. The possibility of extending the present well-drilling contract to provide shallow wells in place of the drive points as a method for determining the contamination status of the soils near the tank bottom is being investigated.

Recommendations for the location of a replacement Recuplex CAW waste crib (216-Z-9) and attendant monitoring well requirements were forwarded to the Chemical Processing Department. The recommended location was 120 feet directly south of the existing disposal facility.

Waste condensate from the 216-SX tank farm was used as influent for two soil columns to test the soil decontamination of this waste. Soil samples from a well near the crib were used to pack the columns. The columns were run at 0.87 $gal/ft^2/hr$ and received 121 and 147 column volumes of waste, respectively. No detectable breakthrough of Cs^{137} or Sr^{90} was evident during these tests. The tank farm condensate is discharged to the 216-S-21 crib at a rate of about 2.4 column volumes per year and has discharged a total of about 17.7 column volumes to date.

WASTE TREATMENT

Fluid-Bed Waste Calciner Prototype

Four runs with a simulated Purex waste containing a high-acid and a moderately-high sulfate were completed during the month using the extended-tip feed nozzle. The mole ratio of sulfate to salt nitrate was 1.1 and the mole ratio of sodium to the collective quantities of chromium, iron, and aluminum was 2.8. As expected,

the increase in the sulfate ratio from the previous 0.48 to 1.1 imparted a greater fusing tendency to the calcine. Hence, scaling on the electrical heaters occurred at 600 to 650 C as compared to near 800 C with previous low-sulfate feed. The scale on the heaters limited the overall heat transfer coefficients to 30 to 40 Btu/hr ft^2 °F. A value of 50 to 70 has been normal during previous operations without scale. In two of the runs with steam fluidization, heat transfer was improved 15 to 30 percent over air fluidization at the same gas velocity. This is expected because of the higher specific heat and lower viscosity of steam compared to that of air.

An initial test with simultaneous steam atomization and steam fluidization was successful and encouraging. Calciner operation appeared normal. However, some increase in the agglomerate formation was noted with near two percent of the calcine agglomerated versus 0.1 to 1.0 percent at comparable weight flow rates of atomizing gas of 12 lb/hr. Increasing the atomizing steam rates and/or reducing the superheat of the steam from the 300 F of the last test is expected to reduce the agglomerate formation.

Total solids entrainment in the calciner off-gas remained at 1 to 5 weight percent of the product rate. Spot checks indicate approximately 0.03 weight percent nitrate in the final calcine.

Laboratory Batch Calcination Studies

Five laboratory-scale studies of the calcination of Purex wastes in an unagitated 3-inch diameter by 7-inch high pot were made during the month. In one run, the simulated Purex waste composition was similar to that used in ORNL pilot plant studies of the batch calcination process. Calcium was present in the feed to suppress sulfate volatilization and the sulfate to salt nitrate ratio was 0.5. As expected, no melt formed and the appearance of the deposited solids were similar to those formed at Oak Ridge. However, foaming was less of a problem in comparison to other laboratory studies made at Hanford.

A second run was made to determine the effect of a high calcium content on melt formation. The feed contained equimolar concentrations of calcium and sodium (0.83 M), a sulfate to salt nitrate ratio of 1.48 and a calcium plus sodium to iron plus aluminum ratio of 1.5. No melt formed at 860 C and the final solids were porous with specific gravity of 0.95. Evidently calcium and sodium compounds do not form a low-melting eutectic in a Purex calcined waste. In previous tests, melts have been formed at 850 C with the above parameters but with additional sodium substituted for the calcium.

In a third test, the feed was a simulated Purex neutralized IWW. Pertinent observations were: (1) the solids were porous and hard, (2) the specific gravity was 1.26, (3) the solids were not hygroscopic despite the presence of sodium hydroxide in the feed, (4) pot corrosion was negligible, (5) an average thermal conductivity of 0.2 Btu/(hr)(sq.ft.) (F/ft) was measured.

In a fourth test, the calcination of the simulated underground waste from an interim storage tank was studied. The alkaline feed contained both sodium carbonate and potassium permanganate from solvent washes. During the run, the solid deposition was not uniform. A porous calcine formed on the pot wall and a slurry high in caustic accumulated in the center. During the calcination portion of the run, the pot foamed over when the internal temperature reached 850 C (possibly from carbonate decomposition). Sectioning of the pot revealed the following:

1. The central 5/16 inch, 30 mil wall stainless steel tube used to house a heater for thermal conductivity measurements was dissolved as were the thermocouples.

2. The pot interior walls appeared to be free of corrosion.

3. The pot exterior wall was attacked where contacted by the overflow of foam.

4. The bottom inch of solids was dense and hygroscopic.

5. The remainder of the solids was porous and not hygroscopic.

6. The average specific gravity was 1.05.

The feed solution to the fifth run was a portion of the simulated underground waste used in the fourth run, but acidified with sulfuric acid. As in the previous run, the solids did not deposit uniformly. In the lower portion of the pot, a melt formed at 900 C without foaming. No corrosion of the pot internals was noted. The average specific gravity was 1.8.

A comparison of the last two runs indicates two distinct advantages of acidifying the underground waste with sulfuric acid prior to calcination: (1) a lower volume of solids per ton of uranium can be obtained, and (2) a melt is formed which undoubtedly improves the thermal conductivity.

Based on previous studies, it is probable the same advantages could be obtained by a similar pretreatment of neutralized IWW.

Semiworks Batch Waste Calciner

The fabrication of the pilot-scale batch calcination facility has been completed and functional testing is underway.

Waste Stability

Study has continued on the post-calcination gas evolution and weight loss behavior of various spray calciner products. These studies are intended to simulate storage conditions (radioactive decay heating) or remelting (for volume reduction). Evolution of SO_2 and SO_3 from a normal, high-sulfate, spray-calcined powder was found to be very rapid at 950 C, gas evolution ceasing and constant weight being attained in less than five minutes. At lower temperatures, reaction is much less rapid. For instance, weight loss and gas evolution as a function of temperature and for constant heating times of 30 minutes were as follow:

Temp.	Percent Weight Loss	SO_2	SO_2 and SO_3
600 C	14.0	0.614 meq/g	1.09 meq/g
700 C	34.3	4.39	5.86
800 C	29.6	3.84	4.75
900 C	41.5	6.28	7.69
950 C	41.8	6.49	7.77

The anomaly at 800 C is probably due to melting or sintering, which interferes with escape of gas.

[redacted]

Another series explored the effect of varying the ratio of sodium to sulfate. These experiments showed sodium to be about as effective as calcium in decreasing the extent of sulfate decomposition. When the number of equivalents of sodium or calcium equaled or exceeded the concentration of sulfate, the weight loss was decreased from a value of 40 percent to a value of 3 to 4 percent, a factor of about ten.

Cobalt-60 irradiations of simulated, formaldehyde-killed 1WW suggest that destruction of nitrate during interim acidic storage may be severe; however, the dosage used (2.8×10^8 R) was insufficient to give conclusive results. The dramatic decrease in pH of an irradiated ammonia neutralized solution, which was reported earlier, was found to be due to distillation of ammonia rather than to irradiation.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Hot Cell Operations

B-Cell was started up the end of June, and one month of successful, full-level operation was logged during July. All equipment performed satisfactorily except for the in-cell pH meter, which gave considerable difficulty early in the month, and the dilution sampler, which does not function adequately (all samples must therefore be submitted to the Analytical Laboratories Operation without dilution). The first run, with one liter of Purex plant 1WW, was designed to pilot the run plan which will be used in the next Purex plant test (aimed at demonstrating the isolation of cerium and trivalent rare earth concentrates in forms suitable for shipment). The run also served to test the peroxy-acetate precipitation with radioactive solutions, the first time this has been done with full-level material. The run consisted of two consecutive double sulfate precipitations followed by a peroxy-acetate precipitation. Preliminary analytical data and visual observation (Cherenkov glow and radiation darkening of glassware) indicate that the run was successful.

A strontium recovery run is now in progress. This run is designed to test the process, described last month, for isolating a crude strontium-90 concentrate from Purex 1WW in the Purex head-end equipment. Analysis of the recovered strontium will also help to define what subsequent purification will be needed. It is assumed that the crude strontium will be contaminated with significant quantities of fission product rare earths plus chemical calcium, barium, and lead and that rather extensive additional decontamination and purification will be required.

A third run was made this month in the resin column battery in A-Cell, this time with promethium-147 tracer added to the feed. Flow rate was increased from the 3 - 3.5 $ml/min/cm^2$ used in the earlier runs to a value of 5 $ml/min/cm^2$ in the present run. This flow rate was found to be too high and resulted in operational instability which forced termination of the run. Apparently 3.5 $ml/min/cm^2$ is about the limit that can be safely used with the present system.

Strontium Absorption Studies

It is desired to ship strontium crude from Purex to the F3P plant at Oak Ridge as dry strontium carbonate in the filter cask which has been designed for cerium shipment. However, this cask will not be available in time to alleviate the immediate interim shipment problem. Therefore, the same scheme which has been

tentatively adopted for similar shipment of cesium-137 is under consideration, i.e., absorption on a bed of inorganic ion exchange resin contained in an existing 500 gallon ORNL Shielded Transfer Tank (STT). Laboratory measurements were accordingly made to evaluate the proposal. The results indicate the idea to be feasible.

Two absorbers were used, Decalso YG (a strontium specific inorganic ion exchanger made by Permutit) and Linde 4A Molecular Sieve. The experiments simulated filling, washing, and elution of a cask. A strontium-bearing solution was passed at a rate of one bed volume per hour through a shallow bed of absorbent. After loading, the bed was washed with water and then eluted with 8 M NH_4NO_3. Both absorbents exhibited surprisingly high capacity for strontium. The Decalso YG loaded, at 50 percent breakthrough, to about 50 gms Sr/liter of resin. This is equivalent to 4000 curies of strontium-90 per liter of resin or to over six megacuries per STT. The capacity of the Linde Molecular Sieve is even higher. However, kinetics of absorption were poorer than with Decalso, and there was some tendency towards production of fines. Water washing to the Decalso bed indicated an equilibrium solubility of < 0.00001 gm Sr/l. Subsequent elution with NH_4NO_3 removed most of the strontium in the first two bed volumes. Spectrographic analysis of both as-received absorbents indicated only trace contents of natural strontium, calcium and barium, concentrations too low to seriously contaminate the strontium crude.

From the above results, it is evident that capacity is not a limitation in determining how many curies of strontium-90 can be shipped per STT. Rather, heat transfer and shielding will doubtless be controlling.

Strontium Isotopic Purity

The isotopic composition of strontium recovered from Purex waste is of crucial importance to possible use in strontium-90 powered thermoelectric power units since this application can tolerate only very slight dilution with inert chemical strontium (or other impurities). Earlier isotopic analysis of the strontium in the 103 A Purex waste tank showed gross contamination with natural strontium. There was accordingly considerable interest in determining the isotopic analysis of the strontium which would be recovered directly from current Purex 1WW. This has now been done, and the results are tabulated below:

Mass No.	Atomic Percent	Precision (95 percent C.L.)
86	0.93	± 0.13
87	0.68	± 0.11
88	42.2	± 1.2
90	56.2	± 1.2

From these results it is apparent that strontium in 1WW is > 90 percent of fission product origin and quite suitable for the projected uses.

Recovery of Neptunium in Redox

The several flowsheets presently being considered for recovery of neptunium in the Redox plant could be simplified if a means were found to maintain extractable neptunium(VI) in acid-deficient solutions. However, no workable scheme has yet been developed. Only about 80 percent of the neptunium can be oxidized to neptunium(VI) in 0.2 molar acid-deficient feeds containing 1.35 M ANN, 0.005 M persulfate and 0.001 M Ag^+ catalyst.

Likewise, persulfate does not serve to hold neptunium(VI) when an acidic neptunium(VI) solution is made acid-deficient. Solvent extraction studies with such solutions indicated that about 20 percent of the neptunium reverted to inextractable species when an acid ANN solution was oxidized with dichromate, persulfate added and the solution then made 0.2 molar acid-deficient.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

In-Cell Gamma Spectrometer

Preliminary calibrations of the gamma spectrometer in A-Cell of the 325-A Building have been completed. The resolution obtained is very good and the height of the Compton continuum (for cesium-137) is less than 25 percent that of the photopeak. The effective range of the spectrometer is estimated to be 10^{-4} to 2 curies per sample. (When calibration is completed, it should prove extremely valuable in monitoring progress of the fission product recovery runs.)

EQUIPMENT AND MATERIALS

Z Plant Centrifuge Test

Vibration of the six-inch continuous centrifuge has been reduced by adding mass and rigidity to the mounting, but has not yet been brought within satisfactory limits for operation of 6000 rpm (3000 G).

A process test at 4000 rpm (1500 G) with a slurry of cerous oxalate (stand-in for plutonium oxalate) was not satisfactory, the effluent liquid contained considerable solids, and the discharged solids were a semi-fluid paste rather than the desired semi-dry, free-flowing stream. A short process test at 6000 rpm resulted in improved separation, but the vibration was excessive. Further improvements are being made in the mounting to reduce vibration at 6000 rpm.

Plutonium Reclamation Facility Pulser

A crank driven piston pulser was operated for 240 hours, pulsing water in a simulated solvent extraction column, to demonstrate the feasibility of U-column pulse system for the Plutonium Reclamation Facility. In the U-column system the pulse leg is as high or higher than the column. Piston leakage accumulates in the upper pulse leg until the back pressure equilizes the mean effective pressure across the piston. When this condition is achieved, the effective leakage becomes zero and the system operates in equilibrium. Tests showed that equilibrium was sustained over a wide range of pulsing conditions.

Corrosion of 304-L in Alkaline Purex 1WW

After 2600 hours exposure to boiling synthetic Purex 1WW at pH 10.5 samples of 304-L stainless steel continue to show corrosion rates of less than 0.01 mil/mo in either the liquid or the vapor phase.

Corrosion of A55 Titanium in HNO_3-HF-$Al(NO_3)_3$ Solutions

As noted last month these tests were made to determine the effect corrosionwise of inadvertent admission of ion exchange column flush into the titanium product concentrator at Purex. After total exposures of 336 hours, corrosion rates for all the samples were within the range 0.1 to 0.3 mil/mo. Accelerated attack was not evident in the vapor phase or at the interface.

Non-Metallic Materials

An "O" ring, identified as #6 Butyl 9078-D, from a "Swagelok" fitting was tested by static immersion at room temperature. This material failed after 24 hours in both Purex HAX and Recuplex CAX, swelled approximately 3 percent and became tacky after 37 days in 60 percent nitric acid. It swelled 42 percent in carbon tetrachloride and 4 percent in hexone. Immersion in caustic soda for 37 days left the material virtually unaffected.

Three different gloves were tested for possible use in Recuplex and Purex:

1. An all vinyl glove manufactured by W.A. Snyder Company bleached after 37 days in 60 percent nitric acid, Recuplex CAX, Purex HAX. The solutions did not, however, penetrate the glove. Hexone and carbon tetrachloride both caused failure after 90 minutes. Samples in 60 percent nitric acid, Recuplex CAX and Purex HAX exhibited only minor dimensional changes with 37 days exposure. The sample in carbon tetrachloride shrank 7 percent while hexone caused gross swelling.

2. A second all vinyl glove manufactured by the Charleston Rubber Company was tested in the same manner. This glove was said by the manufacturer to be 100 percent vinyl chloride, however some plasticizer was used since the material was flexible. Recuplex CAX, Purex HAX and 60 percent nitric acid penetrated the glove within 16 days. It failed in hexone after 4 hours and was slightly penetrated by carbon tetrachloride after one day. Twenty-four hours in 60 percent nitric acid caused some embrittlement while the same exposure to carbon tetrachloride caused severe hardening. Shrinkage of 8 percent was noted after 21 days in Purex HAX and swelling of 14 percent was noted after 21 days in Recuplex CAX.

3. The third glove was a double dipped vinyl plastisol coated cloth glove manufactured by Jo-Mac. For this test the fingers were removed and inverted. The test solutions were poured into the sac thus formed. After 6 days the 60 percent nitric acid was detected on the outside of the sac. Sixteen days were required for a detectable amount of Recuplex CAX to penetrate. Hexone was seen after one day and the carbon tetrachloride appeared after more than one but less than six days.

PROCESS CONTROL DEVELOPMENT

IC Column Facility and Studies

Eight runs using the test facility were made during the month. Data from these runs were recorded by the data logging system and processed with the IBM 709 Data Reduction Code. These runs were carried out to investigate the performance of the mid-column uranium photometer. While the results are not yet entirely conclusive they do show that unequilibrated aqueous phase analyses are being obtained when the sample flow through the photometer is greater than 20 ml per minute.

The design of a new Data Scanning Programmer has been completed. Additional instrumentation which will be incorporated on the C-Column necessitated a new Programmer with larger scanning capacity. Some 50 pieces of data can be scanned with the new Programmer upon installation. New features include: (1) Provisions for reading up

to 40 sample ports on the C-Column and up to 40 sample ports on a future A-Column in series with the C-Column, (2) an abbreviated scan which takes only one value of read and standardize on the Mid-Column-Photometer to be used in future transient behavior studies; (3) adaptation of the logic circuitry for operation with either an Electro Instruments Digital Voltmeter or a Kintel DVM; operation with the former will allow the scanning of 50 data points in ten seconds; (4) a digital display of the channel identification code; (5) automatic printout of 5 blank spaces between scans.

Calciner Furnace Control System

The calciner furnace heat transfer equations have been simulated on the GEDA analog computer and preliminary open-loop and closed-loop data obtained. The open-loop computer data indicate that the system transfer function is essentially made up of two time constants which agree with actual measured data on the calciner. The longer of the two time constants obtained on the computer solution was approximately four times the corresponding time constant measured on the calciner (about 100 minutes compared with about 25 minutes, respectively). Further modification of the system constants used in the computer solution will be required to obtain closer correlation with actual measured data.

Closed-loop data were obtained using a simulated three mode controller to study calciner furnace shell temperature variations for start-up conditions, a ramp function input of 70 F/hr and heater power fluctuations of ± 15 percent. Controlled operation was good for all of the above system variables and controller settings were determined which gave minimum system error and minimum calciner shell temperature overshoot for all transient conditions mentioned above.

After system constants have been more accurately determined, controller settings will be further refined on the analog computer prior to verification on the calciner furnace control systems.

Control System and Instrumentation for New Plutonium Reclamation Facility

A preliminary study of the chemical and physical variables involved in the present Recuplex Facility served as a basis to scope instrumentation requirements proposed for control of the solvent extraction batteries in the new Plutonium Reclamation Facility. A proposed control scheme and associated instrumentation has been submitted to Research and Engineering personnel for comment. The scheme proposed is based primarily on measuring plutonium concentration at some predetermined points in the CA and CC columns.

Redox 3BP Plutonium Summation System

Results obtained with the plutonium summation system agree to within 4 percent of results obtained by sampling methods. Work is being done to improve the system sensitivity and precision by increasing the counting rate of the 3BP neutron counter. The neutron detector holder will be changed from stainless steel to zirconium and the holdup tank diameter enlarged from 6 in. to 8 in. These two changes are expected to increase the counting rate by a factor of 4 to 5.

Flowmeter Tests

Investigation of the transient response of the Potter Turbine flowmeter has shown that it has an effective first order time constant of 0.1 second; therefore, it

would not be suitable for measuring sinusoidal variations in flow occurring at a frequency of 50 cycles per minute because the response of the instrument would be only 90 percent of the true amplitude and about 30 degrees out of phase.

A Fischer-Porter magnetic flowmeter has been checked to verify the factory calibration. A scheme has been devised whereby the existing error amplifier in the F-P recorder can be used separately from the recorder and in conjunction with a Sanborn recorder and thereby improve the transient response of the magnetic flowmeter system. It is anticipated that an effective time constant of 20 msec will be achieved with this flow measuring system.

In-Tank Boron Monitors

Further work is necessary on the F-2 and F-5 evaporator applications. A neutron multiplication monitor rather than a boron monitor will be necessary for the F-5 evaporator since present plans call for boron removal before the F-5 evaporator. A series of theoretical calculations have been made predicting neutron counting rates versus both uranium concentration and U-235 enrichment. Experimental data are necessary to establish working curves.

pH Standardization

A sample cup with valve stand and drain piping was designed and fabricated for use in the Gilmont Sampler located in the Purex E-3 sample station. This circuit will be used for standardization of the E-3 in-tank pH probe.

Gamma Monitor for Purex HAP Stream

Design drawings are being completed for both a scintillation detector and ion chamber to be mounted on the HS column framework. These monitors will measure the gamma activity of the HAP stream as it flows from the HA to HS column.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

Transient Shear Measurements - Some transient velocity, position and cylinder pressure measurements have been made on the NPFR shear. Cylinder pressure varied from peak values of about 600 to 700 psig for accumulator pressures of 400 to 600 psig to about 2000 psig at accumulator pressures of about 1000 psig. Peak shear blade velocity was about 6.5 ft/sec. Further tests may be necessary to determine true pressures since the Sanborn recorder is limited to a maximum of 60 cps. An oscillograph or Hughes Memoscope may be required to determine actual peak pressures and frequencies of the pressure wave.

Feed Preparation

Zirflex Process - Statistical treatment of data obtained on the dissolution of Zircaloy-2 in Zirflex decladding solutions led to the equation:

$$\text{Log Dissolution Rate} = A + B \log (H^+) + C \log (F^-)^*$$

where $A = 3.606 \pm 0.036$

$B = 0.457 \pm 0.025$

$C = 2.017 \pm 0.034$

*Defined as total fluoride minus six times zirconium concentration.

This model has a 95 percent confidence interval for the expected value by log D.R. of ± 9 percent. The model is considered adequate for use in a computer program to describe the dissolution of Zircaloy-2 in Zirflex decladding solutions.

Materials of Construction

Screening corrosion tests on four alloys selected as the most promising of the 24 experimental heats prepared by BMI, for use in the HAPO non-production fuels dissolver were continued. The tests show no major advantage, corrosionwise, of any one of these four alloys. Fifty-pound heats of the four alloys have been received from BMI. It is planned to fabricate laboratory-scale dissolvers from portions of these heats and to perform long-term corrosion tests in them.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Reprocessing PRTR Spike Fuel Elements

Further experiments were performed to determine the attack by Zirflex decladding solutions on Al-Pu-Ni-Si alloy PRTR spike fuel cores. Core pieces were exposed for a period of about eleven hours in decladding solutions while Zircaloy-2 was being dissolved and for an additional period of about five hours in the terminal decladding solution. Maximum plutonium losses observed (calculated on the basis of radial penetration of the cores) were 2-3 percent. These losses were for a two percent nickel alloy exposed to a decladding solution initially 2 M NH_4F - 0.17 M NH_4NO_3. Plutonium losses were somewhat lower for a one percent nickel - one percent silicon alloy under the same conditions and for both alloys when exposed to a decladding solution initially 6 M NH_4F - 0.5 M NH_4NO_3. In these experiments, exposure of the cores to decladding solution was greater timewise than would be expected in actual decladding and the core losses quoted are probably considerably higher than would occur in practice.

A large number of experiments has been performed in an effort to understand the dissolution of various Al-Pu-Ni-Si alloys in mercuric-nitrate-catalyzed nitric acid. These have involved dissolution rates of activated samples and conditions for activation of samples as a function of nitric acid, mercuric nitrate, uranyl nitrate and aluminum nitrate. In general, alloys proposed for PRTR spike elements, once activated, dissolve in HNO_3-$Hg(NO_3)_2$ solutions at rates two to three times those found for 2S aluminum. For most concentrations of nitric acid, the rates are sufficiently high that the heat removal capacity of the Redox multipurpose dissolver and condenser will be exceeded if a full charge of eight assemblies is made and these are completely immersed in dissolvent. Means of moderating the dissolving rate by controlled acid concentration, the presence of nickel nitrate and controlled activation are under study.

Further studies on the evolution of hydrogen during HNO_3-$Hg(NO_3)_2$ dissolution of proposed PRTR fuels were made. These confirmed preliminary results which indicated less hydrogen evolved in the dissolution of Al - 1.8 percent Pu - 2 percent Ni alloy than in dissolution of Al - 1.8 percent Pu - 1 percent Ni - 1 percent Si alloy.

Continuous Ion Exchange Contactor Development

Adsorption Kinetics for Thorium Nitrate Complex - Kinetics of the adsorption of thorium nitrate complex ions on Permutit SK anion exchanger were studied. The data are desired as a basis for using thorium nitrate as a stand-in for plutonium nitrate during evaluation of operating characteristics of continuous ion exchange contactors.

Data have been obtained for adsorption of thorium at room temperature from solutions containing: (a) 7.0 M HNO_3 - 2.34 g/l Th, and (b) 6.0 M HNO_3 - 2.03 g/l Th. The resin used was 20-50 mesh. The data fit very well a postulated model for adsorption in which it is assumed that the rate determining process is the diffusion of the thorium nitrate complex within the resin beads. It is further assumed that the outermost layer of a given bead comes to equilibrium with the surrounding solution almost instantaneously and remains at equilibrium with it during the adsorption. The diffusion coefficient for the thorium nitrate complex is assumed to remain constant and interaction between adsorbed thorium nitrate ions does not occur. Equations expressing resin loading as a function of time for this model are identical with those for heat flow in a similar model. Equilibrium loading and diffusion coefficients calculated for solution (a) are 122 g Th/g dry resin and 9.7×10^{-9} cm^2/sec; for solution (b) they are 87 g Th/g dry resin and 9×10^{-9} cm^2/sec.

Further studies will involve different solution compositions, effects of temperature and desorption kinetics.

Jiggler Contactor - Tests to evaluate the stability of the semi-fluidized moving bed of the jiggler contactor were continued. One requirement for stable, steady state operation of the jiggler is a constant rate of resin removal from the bottom of the "A" column. Continual removal of resin permits additional resin to settle into the recycle cone during the relaxation stroke of the pulser. The resin is then forced through the recycle line by the compression stroke of the pulser.

A small D.C. drive centrifugal pump was used this month in place of an air lift to transfer resin to the top of the "C" column. The pump successfully transported wet settled resin (not pulsed) at a controlled constant rate through five feet of 3/8-inch tubing against a head of two feet. The flow range was from 297 ml/min to 1243 ml/min.

In other tests, the resin slurry was transported to the top of the "C" section by a centrifugal pump with the injection of 30 to 50 ml/min of wash water between the pump effluent line and the column. At a column feed flow rate of 120 ml/min and scrub of 114 ml/min in a 4-in. column, an average resin rate of 467 ml/min was pumped. Pulser frequency was 6 cpm. The amplitude was changed from an initial displacement of 200 ml to 300 ml. A second test at about the same aqueous stream flows was conducted with a resin pumping rate of 338 ml/min. Test duration was from two to three hours.

The gross "entrainment" of slip acid with the recycle resin suggests the possible need for a vacuum-type dewatering device. The use of the dewatering device, in turn, presents the possibility of using the vacuum along with pulsing to lift the resin slurry to the top of the "C" column. In scouting tests stability in the column was not achieved using vacuum transfer. However, with the resin recycle

line valve alternately turned on and off (manually) in three tests of about 15 minutes duration each, the range of resin flow obtained was from 75 ml/min to 500 ml/min. The slurry obtained was more than 50 percent wet settled resin by volume.

Visual observations indicate that the one-half foot scrub section was probably too short and was contributing to excessive fluidization at the bottom of the "A" column. It was replaced by a three-foot section which now gives the apparatus a more realistic 1 to 1 ratio - "A" section to scrub section.

Equipment is currently being fabricated to test the effectiveness of a simple hydraulic ram within a two-foot section of 4 in. glass pipe, for overcoming fluidization at higher flow rates in packed moving bed exchangers.

Salt Cycle Process

Pilot Plant Quantities of Electrolytic UO_2 - Attempts to operate the 20 liter electrolytic NaCl-KCl cell by charging $UO_2Cl_2.H_2O$ and sparging with chlorine to remove water or charging UO_3 and sparging with chlorine to dissolve the UO_3 have been unsuccessful to date because of low gas rates and poor gas-liquid or gas-solid contact. Subsequent electrolysis required 2.5 to 4.0 volts, resulting in extreme corrosion of the graphite cathode with a plate-like product grossly contaminated with graphite.

Electrolysis of charges of $UO_2Cl_2.H_2O$ which have been sparged with HCl gas and air have been more successful. Approximately 5 lb of $UO_2Cl_2.H_2O$ was charged into 15 liters of molten salt and sparged vigorously for four hours with HCl gas and then for 15 minutes with air. The solution was then electrolyzed at 1.5-1.7 volts and 80 amperes (about 9 amp/dm^2 nominal current density) for 2.5 hours at about 735 C to produce approximately 35 percent of the charge (uranium basis) as UO_2 at a 60 percent current efficiency. No corrosion of the graphite cathode was noted. The product, consisting of agglomerates of fine particles, was easily removed from the cathode. Approximately 40 percent of the agglomerates were in the -6 +14 mesh range. The oxygen to uranium ratio was 2.0217.

The remaining salt was allowed to stand for 14 hours and sparged with HCl gas for one hour and with air for 15 minutes. Subsequent electrolysis under the above conditions at about 725 C gave a current efficiency of 80 percent. The agglomerates were less coarse and constant voltage and current were maintained until at least 90 percent of the uranium had been removed from salt solution. The oxygen to uranium ratio was 2.0546.

Non-Metallic Materials - Screening tests have continued in search for ceramic materials for containing a sodium-potassium chloride (equal mol percentages) melt at 750 C. Silicon carbide crucibles have been found to be porous and leak as soon as the salt melts. On the other hand, zirconia crucibles withstand the molten salt for about 48 hours before leakage occurs.

Metallic Materials - Samples of Hastelloy B and C, Haynes 25, platinum, 304-L stainless steel and 10 percent Ta - 90 percent W alloy were exposed 20 hours in an HCl - sparged NaCl - KCl melt at 750-800 C. Corrosion rates calculated on total weight loss were 84, 195, 507, 3, 350 and 350 mils/mo, respectively. All samples showed accelerated interface and/or vapor phase attack.

Dissolution of Uranium Oxides in Molten Chlorides - Dissolution rates for UO_2 and UO_3 with Cl_2 were measured in several molten chloride mixtures. Dissolving rates measured in various systems under identical conditions are shown in the accompanying tabulation.

Perhaps the most noteworthy aspects of these results are the lower rates of dissolution of UO_3 in these salts (0.2 to 1.2 g U/hr vice about 9 g U/hr in NaCl-KCl at 700 C in the same equipment) and the very rapid rate of dissolution of UO_2 in the thallous chloride mixtures, the relatively minor effect of temperature on the dissolution rate (1.1 g U/hr at 500 C vice 1.2 g U/hr at 600 C in $PbCl_2$-KCl), and the substantial effect of chloride activity on the dissolution (0.08 g U/hr in $ZnCl_2$ at 700 C vice 0.88 g U/hr for $ZnCl_2$-KCl at 700 C).

The very rapid rate of dissolution of UO_2 with chlorine into TlCl-KCl mixtures is presumed to arise from a catalytic process in which thallium(I) is converted to thallium(III) by the chlorine sparge and the thallium(III) then reacts with solid UO_2 to yield uranyl ion and thallium(I). Aside from being thermodynamically favored, this mechanism is suggested by the fact that the reaction rate apparently is not greatly dependent on thallium chloride concentration and the fact that a much lower dissolving rate was observed when hydrogen chloride was used as the dissolvent. A contributing factor may also be the unusually high dielectric constant of thallium chloride and its high activity in molten KCl (a reported mean ionic activity coefficient of 1.0 for TlCl as compared with less than 0.01 for $ZnCl_2$).

Salt System	Mole Ratio	Sample	Temp., °C	Time, Min.	U Dissolved, g/hr
$ZnCl_2$-KCl	1/1	UO_3*	300	30	0.14
$ZnCl_2$-KCl	1/1	UO_2**	300	120	0.008
$ZnCl_2$-KCl	1/1	UO_3	500	30	0.54
$ZnCl_2$-KCl	1/1	U_3O_8***	500	30	0.32
$ZnCl_2$-KCl	1/1	UO_2	500	120	0.016
$ZnCl_2$-KCl	1/1	UO_3	700	30	0.88
$ZnCl_2$ only		UO_3	700	30	0.08
$HgCl_2$-KCl	0.68/0.32	UO_3	200	30	0.22
$CdCl_2$-KCl	1/1	UO_3	500	30	0.50
$PbCl_2$-KCl	0.52/0.48	UO_3	500	30	1.1
$PbCl_2$-KCl	0.52/0.48	UO_3	600	30	1.2
$NaNO_3$-KNO_3	1/1	UO_2	300	900	< 0.00006
TlCl-KCl	1/1	UO_2	650	1.25	> 42
TlCl-KCl	1/3	UO_2	650	1.25	> 42

* UO_3 = Pot-type, 325 - 100 mesh.
** UO_2 = Spencer arc-fused, 325 - 100 mesh, O/U = 2.0008
*** U_3O_8 = Made from above UO_3.

In further dissolution studies in the NaCl-KCl system the effect of a mixture of oxygen and chlorine gases was studied. It had been supposed that inclusion of oxygen in the chlorine sparge gas might expedite the dissolution of UO_2 by enabling UO_2 to be converted in situ to U_3O_8 which is known to dissolve more rapidly. However, a chlorine sparge gas containing ten volume percent oxygen yielded a dissolution rate identical with that obtained with pure chlorine.

Recrystallization of UO_2 in NaCl-KCl - "Aging" of solid UO_2 in KCl-NaCl - 12 w/o UO_2Cl_2 for six hours at 800 C under argon resulted in an increase in the chloride content of the UO_2 from an initial 80 ppm to 170 ppm, and an increase in the O/U ratio from 2.0233 to 2.1716. Thermal decomposition of uranyl chloride is suspected as contributing to both these effects and prompts an increased interest in molten chloride systems melting lower than NaCl-KCl.

Other "aging" tests showed a slight increase (from 2.1782 to 2.1911) in the O/U ratio when UO_2 was aged under NaCl-KCl in the presence of a chlorine sparge. Simple equilibration for 16 hours with NaCl-KCl at 800 C resulted in reduction of the O/U ratio from 2.1782 to 2.0193, while "aging" under NaCl-KCl in the presence of a hydrogen chloride sparge resulted in reduction of the O/U ratio from 2.1782 to 2.0396 in the residual UO_2.

X-ray diffraction studies indicate the 111 planes (cutting diagonally across all three axes of the original cube) are emphasized in the flat plates which form when UO_2 is equilibrated with NaCl-KCl-UO_2Cl_2. This is consistent with a more rapid dissolution rate at the corners of the initial cubic crystals.

Behavior of Rare Earths in Molten NaCl-KCl

Studies with non-radioactive rare earth compounds have been initiated to obtain advance information on the probable behavior of rare earth fission products prior to hot cell experiments. Studies completed to date indicate that rare earths oxides are dissolved by chlorine at about the same rate as is UO_2 and that exposure of the resultant solution to air results in precipitation of a rare earth compound. X-ray diffraction pattern indicates the material precipitated is definitely not the rare earth oxide. Precipitation of the oxychlorides (MOCl) is suspected and will be tested by synthesis of these materials and measurement of their diffraction patterns.

Immiscible Salt Systems

The previously reported formation of two liquid phases in quaternary halide systems containing LiCl and $AlCl_3$ also has been observed in the $AlCl_3$-KCl-LiCl ternary system. No detailed examination of the system has been undertaken but preliminary experiments indicate that the lighter phase is rich in $KAlCl_4$ while the heavier phase is rich in LiCl. The reason for the two phase formation is not completely understood, but it is believed that the potassium aluminum chloride exists as a fairly stable quasi lattice of $AlCl_4^-$ with interstitial K^+ ions. Reason for formation of the second phase when lithium is present (but not sodium) is possibly the formation of ionic aggregates which because of size considerations cannot penetrate the $AlCl_4^-$ lattice.

RADIOACTIVE RESIDUE PROCESSING DEVELOPMENT

Radiant-Heat Spray Calcination

The spray calciner has been out of service for repair during the month due to the Inconel corrosion failure which followed the Zirflex waste run. It appears that special materials of construction would probably be required to spray calcine Zirflex wastes.

Experiments on the pressing of several previously produced powders showed that densities were readily attained which approach those obtained by sintering or remelting. Pressing may be an attractive alternate way to obtain higher density and better thermal conductivity.

Radioactive Residue Fixation

Mineral Reactions - An experiment was performed in which diluted high-level Purex waste was passed through three short columns of clinoptilolite in series. The original waste was diluted with synthetic high-level waste solution to reduce the radiation levels and the mixture was then further diluted 20:1 with distilled water to provide feed for the mineral column. A 50% breakthrough of cesium was achieved after passage of 540 bed volumes of diluted waste through the first mineral bed and an additional 700 bed volumes through the second bed. This indicates a cesium capacity of 27 and 35 bed volumes of undiluted waste respectively. A surprisingly high adsorption of radiostrontium was also achieved by the mineral; no radiostrontium was detected in the effluent until the last sample collected from the first bed. Thus, the mineral's capacity for decontaminating Purex waste with respect to strontium is even higher than that for cesium. This rather unexpected result was also observed for coating waste earlier. It is postulated that a reaction between phosphate ion in the waste and a calcite or gypsum impurity in the mineral may be responsible for the high strontium removal. It thus appears that the long lived isotopes in Purex waste may be converted to a more compact solid by the use of a mineral bed than by calcination of the whole waste.

Diluted decladding waste that was found to give good radiostrontium decontamination when passed through clinoptilolite was analyzed and found to contain 1.2×10^{-3} M phosphate. This concentration is somewhat lower than is needed for satisfactory calcite-phosphate reactions. However, experiments with synthetic decladding solutions containing this concentration of phosphate gave strontium decontamination factors of 200 with mixed beds of calcite and gypsum, while a D.F. of only 2 was achieved without the phosphate. Thus, the possibility of some such mineral reaction being responsible for strontium removal by clinoptilolite or an impurity in it still exists.

The effect of dilution of high-sodium waste solutions on the capacity of clinoptilolite for cesium was measured by performing a column experiment with high level Purex waste diluted to 28 percent of its original salt concentration. In this case a cesium capacity of 7.6 bed volumes of undiluted waste was determined. This may be compared with the 27 to 35 bed volumes obtained when the waste was diluted to 5 percent of its original salt concentration. Thus, the cesium capacity of the mineral can be significantly improved by this dilution technique.

Lead corrosion products were found to contain 98 percent of the ruthenium in a bed of lead granules which had received a 0.01 M $NaNO_3$ solution containing Ru^{106} at pH 8. A similar experiment with iron granules provided little quantitative data because of the difficulty of completely separating the iron from its corrosion products. However, the iron corrosion products that were obtained had a high ruthenium concentration. A solution of sodium nitrate containing complexed ruthenium was passed through beds of lead, iron, and Amberlite-120 (a cation exchange resin) to determine the relative effectiveness of these materials for adsorbing complexed ruthenium. The metal beds have a ruthenium D.F. of about 10^3 compared to a D.F. of about 2 for the exchange resin.

Further equilibrium distribution coefficients were obtained to study the influence of gamma irradiation dosages on cesium adsorption by clinoptilolite. Previous findings indicated a possible effect of 10^9 R on the temperature influence of this adsorption mechanism. The accumulation of additional data covering a broader range of irradiation dosages does not support this original conclusion. The K_d values measured earlier appear anomalous in view of the later results, even though they represented averages of several determinations. The results tend to suggest some differences in the mineral specimens used in the experiments.

Condensate Streams

Studies on the decontamination of Purex Tank Farm Condensate in the 271-CR Building Micro Pilot Plant were continued. Two runs were made during the month; one was made using a particle size of clinoptilolite of 0.9 to 1.0 mm, and the other was made using synthetic apatite.

Before placing the clinoptilolite in the column it was pretreated by boiling twice for 20 to 30 minutes in 5 g/l sodium hydroxide solution. Before and after each caustic treatment the mineral was backwashed with water. This technique proved to be quite satisfactory for removing a large fraction of fines associated with the mineral. The waste, prior to entering the clinoptilolite column, was decontaminated of organic material by an activated carbon column. At flow rates of 16 to 40 ml/min/cm^2 the decontamination factor for cesium remained at values between 200 and 300. At lower flow rates the decontamination factor increased and, based on incomplete analytical results, may have approached 2500 to 3000 at 1 ml/min/cm^2. This was quite similar to decontamination factors found before where the particle size of clinoptilolite was smaller. The improved decontamination with larger particles is believed to be a result of the caustic pretreatment given the clinoptilolite.

The second experiment explored the decontamination ability of an apatite formed by passage of a solution of sodium phosphate over calcite at 70 to 80 C before passage of waste through it. Analytical results are incomplete, but very little removal of strontium was exhibited except during the very early part of the run.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

Well 699-15-15, at the Hanford wye, encountered the surface of the "blue clays" part of the Ringold formation and the lowermost clay bed of that formation within 10 feet of the predicted altitudes. However, the materials encountered between those two altitudes were gravelly clays, quite unlike the cemented sands and gravels encountered at comparable altitudes in well 699-26-15. Lateral (facies) changes are evident in those beds in patterns not yet resolved. Determination of these patterns is necessary before meaningful interpretations can be made of the potential of waste movement at depth in the Ringold formation.

A study was made of the influence of a small stream of high-density solution, such as high salt waste, on the flow pattern of the material in the ground water. The conditions assumed included a stream of sodium nitrate solution of much smaller volume than the total flow of ground water beneath the site. It was found that

the ratio of density to viscosity for sodium nitrate solutions is nearly constant over a rather wide range of concentrations, permitting considerable simplification of the partial differential equation describing this flow. A laboratory experiment in which a small source of sodium nitrate solution was injected into a model of a ground water mound produced flow patterns that were consistent with this simplified flow equation.

The computer program for numerical analysis of unsaturated flow patterns was revised for application to the imbibition cycle. The previous program was designed for calculating the moisture content during the draining cycle. The major difference between the two cycles is the abrupt wetted front in the imbibing cycle (unsaturated flow of water into dry soil). These abrupt changes are difficult to handle by finite differences. The possibility of obtaining special hydraulic measurement on samples of Hanford Works soils by the Irrigation Department of the University of California is being examined. The needed measurements involve capillary conductivities and capillary pressures for the imbibition cycle.

Special measurements were made of the piezometric heads at different depths in a well currently under construction. The measurements were made by observing the recovery of the water levels following vigorous bailing by the driller as the well drilling reached the respective depths. Measurements made when the well reached 182 feet and 455 feet indicated a piezometric head difference of 0.53 feet of water, the lower head being measured at the 455 foot depth. The measurements indicate the potential for vertical flow in the well when the casing is perforated. This may have a strong influence on the utility of water samples from the well for measuring ground water contamination and the possible uncertainty in the piezometric head measured by the water level elevation.

Ground Waste Investigations

It was possible to compare the cation exchange capacity of soils measured under saturated conditions with that obtained from unsaturated flow experiments. The capacities were obtained from the 50 percent C/C_o breakthrough point for column experiments using a radiostrontium tracer. From these results the ratio of cation exchange capacity at 64.5 percent saturation to that at complete saturation was determined to be 0.33. The ratio of cation exchange capacity at 48 percent saturation to that at complete saturation was determined to be 1.5. The inconsistency of these results reflects the difficulties encountered in unsaturated flow adsorption experiments. Several determinations at each condition are needed to establish any real differences.

Soil column experiments were performed to measure the soil adsorption of fission products in effluent from a clinoptilolite column used to fix high level wastes. The experiment involved effluent from a mineral column decontaminating diluted (20:1) actual Redox high level waste. The Y^{90} in this high-salt effluent moved readily through the soil without adsorption, but no radiostrontium broke through the soil column until 60 column volumes of diluted waste had been added. No radiocesium was detected in 158 column volumes of effluent. This is equivalent to 3 and 8 column volumes of actual Redox waste for strontium and cesium respectively.

Soil Chemistry and Geochemistry

Study of the cation exchange properties of the natural zeolites continued in an effort to determine the cause of some apparent similarities in zeolitic cation exchange properties that do not fit accepted explanations for selective adsorption. The cation sieve properties of chabazite are under study at present for comparison with mordenite in later work.

Both chabazite and mordenite are less cation-selective than either erionite or clinoptilolite. That is, the two cation replacement series

$$Li^+ < Na^+ < K^+ < Rb^+ < Cs^+ \quad \text{and} \quad Mg^{+2} < Ca^{+2} < Sr^{+2} < Ba^{+2}$$

are common to all four of the zeolites but the selectivity is much stronger in clinoptilolite than in erionite which in turn is much more selective than chabazite or mordenite. All evidence obtained to date points to the conclusion that where any selectivity is exhibited by a zeolite, the above replacement series prevail. Differences between such zeolites are apparently of degree or intensity rather than of replacement order. This is true even though the four zeolites are not all morphologically similar. This behavior suggests that some general property of cations in aqueous solutions, such as radii of the hydrated ions, is operative. It is felt that identification of the reasons for the cation selectivity of these zeolites might assist with the selection of those that best fit the requirements of waste treatment.

The chemical composition of waste solutions and the chemical form of radioactive ions in these wastes has a major influence on the adsorption of radioactive material by soils. Study was continued to evaluate the relative effect of the chemical nature of several Hanford wastes on rare earth adsorption. The removal by soils of radionuclides from Purex caustic scrubber waste solution was determined as part of this study. This waste solution was found to contain 4.6×10^{-2} uc/cc of Ce^{144}, representing nearly half the total radioactivity in the waste. Studies with this waste showed little change in rare earth removal from pH 8.5 to 11.8. The rare earths in the waste together with added Ce^{144}, Pm^{147}, and Eu^{152} were more than 95 percent removed by soil over that pH range.

Field Apparatus Development

Further field testing of the seven-unit multi-depth well sampler pointed out the need for more reliable electrical connectors for the conditions in the well.

Submerged scintillator monitoring of water in wells was tested and found to give further promise as a routine method. Scintillation counter response was determined as a function of laboratory-measured concentrations of ruthenium-106 in six wells. Although the response was not linear with concentration, the calibration appeared to be promising and direct measurement with the submerged scintillator may prove satisfactory for many situations. The lower limit is estimated at about 3 to 5 $\times 10^{-7}$ uc/cc. Wells containing as much as 3×10^{-2} uc/ml were also monitored with this instrument. Areas for improvement were noted, that of temperature-dependence of background rate being particularly troublesome on the hot days during these tests.

Micromeritics

Deposition velocities of lycopodium spores were extended into the range of Reynolds Numbers 8000 to 25,600. The results were in satisfactory agreement with the correlation function determined from similar measurements with particles of greatly different diameters and density. The data continue to support the correlation which predicts the deposition velocity in conduits as a function of the ratio of stopping distance of a particle to the thickness of the viscuous (sub-laminar) layer at the duct wall. The internal surfaces of the pipe used in these tests with 30 u particles were treated with a silicone fluid to insure retention.

Entrainment was studied of the 30 u particles after turbulent deposition in one-inch lines. The time to remove as many particles as could be removed by a given flow rate appeared to be a function of the flow rate. A notable observation was that there is no critical velocity below which particles are retained and above which they are airborne. There is a velocity at which one or a few particles will be released from the wall, and to increase the number requires a higher velocity, until a velocity is reached at which virtually all particles are released. This observation is in contrast to theory which postulates a critical velocity at which particles are released. The statistical nature of the release is shown by the linear plot which results when the percent of the original deposit which remains is plotted against flow rate on logarithmic-probability paper. The theoretical explanation of this observation is under study.

First tests with the recently designed moving wall elutriator gave promise that a significant decrease in the size range of a given "cut" of particles sized by gravity settling will be achieved as compared with the conventional stationary wall elutriator. The improvement results from virtual elimination of a velocity gradient across the elutriator and consequent smearing of particle sizes settled at the average elutriator velocity.

Origin of Isotopes in Reactor Effluent Water

Fast neutron reactions on titanium isotopes were found to contribute less than eight percent of the Sc^{46} formed in aluminum and less than 20 percent of the Sc^{46} formed in the process water. These results were obtained by gamma spectrometric analysis of the 3.34 Mev photopeak from Sc^{48} arising from three gamma rays in cascade. Sc^{48} cannot be made from Sc^{45} by neutron reaction but could come from fast neutron reactions on titanium. This confirms the results reported in May from the aluminum process tubing which showed that the Sc^{46} in aluminum was formed by slow neutrons.

Dry residue from evaporated reactor effluent water was examined with the Electron Paramagnetic Spectrometer and was found to exhibit a complex spectrum. In the 0-3500 gauss region significant absorption is observed which is probably due to ferric iron and other transition elements. In the region from 3500 to 5500 gauss a very sharp absorption peak was observed superimposed on a broad band characteristic of the isolated electron. This absorption is perhaps due to crystal defect structures induced in the microcrystalline solids by irradiation as they pass through the reactor.

Bioassay Method for Neptunium-237

Preliminary studies show that the standard Np^{239} separation procedure with minor modifications can be applied as a bioassay separation method for Np^{237}. Yields

of about 90 percent were obtained which can probably be improved. With the application of nuclear track counting a suitable sensitivity should be obtained.

Radiation Protection and Chemical Dosimetry Studies

Protection indices were determined for barbituric acid (0.037), uric acid (0.44), d-tryptophan (0.59), and l-tryptophan (0.65). With the statistical deviations the latter two values overlap indicating equal effectiveness of free-radical attack on these stereoisomers. Calculated values for the energies of the highest occupied molecular orbitals in the above four compounds were examined for correlation with their protection indices but a simple correlation was not found.

W. H. Reas

Acting Manager
Chemical Research and Development

WH Reas:cf

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

Dr. Edwin Uyeki joined the Metabolism Operation.
J. F. Cline began a one year leave of absence to fulfill an appointment by the International Atomic Energy Agency in Tunisia.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

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

Location	μc/g Wet Thyroid Average	μc/g Wet Thyroid Maximum	Trend Factor
4 mi SW Redox	8×10^{-4}	1×10^{-3}	+4
Prosser Barricade	6×10^{-4}	9×10^{-4}	+3
Wahluke Slope	3×10^{-4}	3×10^{-4}	+3

Columbia River Contamination

Concentrations of gross beta emitters in Columbia River organisms collected at Hanford were approximately nine times greater than those observed one year ago. Values follow:

Location	Organisms	μc/g Wet Weight Average	μc/g Wet Weight Maximum	Trend Factor
Hanford	Minnows (entire)	9×10^{-3}	1×10^{-2}	--

Fallout Contamination

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

Sample Type	Total Beta Avg. μc/g Wet Material	Trend Factor
Bone	2×10^{-5}	-3
Muscle	6×10^{-6}	--
Liver	5×10^{-6}	--
Feces	5×10^{-6}	-2

Effect of Reactor Effluent on Aquatic Organisms

No test was under way in this category during the month pending modification of the equipment for a new study designed to test the toxicity of effluent passed through a bed of aluminum turnings.

The transition of vegetative cells to microcysts has been followed microscopically and photographically during the transition stages. It appears that the vegetative cells develop a globular end and this globular structure simply receives the contents of the vegetative cell. In some instances where cells were in chains, the individual microcyst formed coalesced to produce a larger microcyst. There is still no evidence that the microcyst can produce a new colony of cells.

Infection by columnaris has been noticed in two troughs in the Aquatic Biology building and both trout and salmon have been affected. Samples of water that were taken from the inlet have failed to show any columnaris organisms coming into the troughs. Similar samples taken from the outlet have shown an average of 15 organisms per ml which with a water velocity of four gallons per minute indicates that something on the order of 10^{11} organisms are flowing back to the river from these troughs each 24 hours.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Zinc

The critical organs for the internal deposition of most of the radionuclides as reported in Handbook 69 were determined primarily on the basis of the organ showing the greatest concentration of the specific radionuclide and the most sensitive organ. The total body is listed as an "organ of reference" and is, in some instances, the critical organ. The values listed in Handbook 69 for the smallest maximum permissible body burdens, therefore, require that the true dose (internal dose plus external contribution due to radionuclide in surrounding tissue) to the more radiosensitive organs (gonads, ovaries, and fetuses) shall not be greater than the integrated body dose.

In the case of dominant gamma emitting radionuclides such as Zn^{65} it is possible that the external gamma contribution may assume significance. Therefore, direct measurements using Victoreen pocket dosimeters were taken of the dose rates in a number of the major tissues of a pregnant ewe after 15 daily feedings of 1 mc/day of Zn^{65}. The measurements were made in situ before and after excision of the gastrointestinal tract and in the excised organs in order to evaluate properly the true dose rates together with the percentage of external contribution from the radiozinc in the gastrointestinal tract and other surrounding tissues. The body dose was estimated using the nomogram by Bertinchamps and Cotzias.

The radiation dose to the various organs expressed in mrad/day ranged from a low of 120 in the brain to 1400 in the rectum. The dose to the liver was over 800 mrad/day while the dose to the ovaries, kidney, lung and fetus was in the range of 400 to 500 mrads/day. The dose rates to the ovaries and the two fetuses of the ewe were nearly equal to the body dose, thus agreeing with the values for the smallest maximum permissible body burdens suggested in Handbook 69. However, there was evidence that the external contribution to the tissues should be considered when ranking them in order of importance.

Following parturition of three ewes, the initial concentration of radiozinc in the colostrum was 20 to 30 times that in plasma after which there was a progressive decline for two days to a final steady concentration of 10 times that in plasma for the milk. (Samples of the milk are being saved for analyses of stable zinc and other minerals so that possible significance of the initial high concentration may be determined.)

In order to extend some preliminary observations on Zn^{65} retention in plasma and blood, studies were performed on the blood of the ewes given Zn^{65}. In an earlier investigation with rams, a slow progressive uptake of radiozinc in the blood cells relative to plasma was observed. Because of this slow rate of uptake and a high retention, it was considered to be of importance to determine what fraction of the zinc in the blood cells was freely exchangeable. There appeared to be no appreciable exchange of zinc between the red blood cells and plasma in refrigerated blood from ewes over a two-day period. Blood from three ewes fed Zn^{65} maintained the 4 to 1 ratio of red cell to plasma zinc and in another study there appeared to be no detectable uptake of *in vitro* added Zn^{65} into the blood cells of chilled blood from a control ewe for a similar period. Further studies are indicated since most of the zinc in the red blood cells has been recognized as a component of the enzyme carbonic anhydrase and information concerning the rate of formation and turnover of this enzyme may be obtainable. It may also be possible to develop a new technique for determining the viability of red blood cells utilizing radiozinc.

Strontium

Oral administration of Sr^{90}-Y^{90} to trout was continued through the 21st week. At the end of this time, mortality was being experienced among the fish receiving the greatest amount of isotope (0.5 μc/day/g of body weight). It was also inferred from statistical treatment that the fish which received this level of isotope did not maintain as rapid a growth rate as did the fish in other groups. Isotope feeding was discontinued in order that a few specimens from each isotope feeding level could be sacrificed for radiochemical and histopathological study. Surviving fish in the control, low and medium level groups will be retained for further study.

Encouraging results have been obtained in the development of a gastric fistula technique for future study of assimilation of isotopes by trout.

No significant changes were observed this month in the blood constituents nor the clinical condition of the miniature swine fed 1, 5 or 25 μc/day of Sr^{90}. New pellet holders now under construction will facilitate spiking, monitoring and feeding of the Sr^{90} pellets to the swine.

Preliminary to determining the effect of high dietary calcium on the comparative binding of calcium and strontium by plasma protein, an *in vitro* study was performed. Plasma obtained from sheep receiving normal levels of dietary calcium was spiked with Ca^{45} and Sr^{90}-Y^{90}. Portions of this spiked plasma were then enriched with $CaCl_2$, providing samples ranging in plasma calcium concentrations from 4.5 to 13 milliequivalents per liter. Ultrafiltration of these samples was conducted using standard Visking "Nojax" tubing. Radiochemical

data for the diffusibility of Ca^{45} and Sr^{90}-Y^{90} are not completed at this time. The following preliminary results were obtained:

1. Absolute concentrations of diffusible calcium essentially doubled (in mEq/L) when the total plasma calcium level was increased to three times normal (to 13 mEq/L). With a similar increase in plasma calcium level, the percent diffusibility of plasma inorganic phosphate was reduced to one-half the normal value of nearly 100 per cent.

2. The increased diffusibility of plasma calcium with increase in total calcium concentration was much less than expected on the basis of mass action equilibrium relationships. The formation of a non-diffusible calcium phosphate complex may at least partially explain the reduced percentage of diffusibility with high levels of calcium.

Experiments were initiated studying the interrelationships of calcium and strontium in the absorption of these elements from the perfused intestine of anesthetized rats. No data are as yet available.

In cooperative experiments with Dr. Biddulph of Washington State University, it was observed that strontium behaves in plants nearly identically with calcium. Some differentiation was observed with the plant. The rate of ascent in short-term periods was more rapid for strontium than calcium. This resulted in a DF value which was high in leaves and relatively low in stems. Since this was in contrast to results of long-term experiments previously conducted in our laboratories, the time intervals were extended to 16 days' post exposure to the tracers. It was observed that the DF in stems and leaves reversed at approximately four days post exposure at which time the DF value in leaves became lower than that in stems. It appears possible that the difference between short term and long term exposures may be due to a more rapid rate of calcium exchange with pre-existing calcium in the stem as compared with strontium exchange in the stem. Thus in short term experiments the labeled calcium introduced would replace existing calcium; it in turn would move on up the stem giving the appearance of a more rapid movement of strontium than calcium.

Iodine

At the request of the Division of Biology and Medicine, a study was made to determine the availability of I^{131} to lambs given sheep milk labeled either in vivo or in vitro. A total of eleven lambs, one to twelve weeks old, were given either single feedings of I^{131} in vivo or in vitro - labeled milk and thyroid uptake was followed by external monitoring. After a period of two weeks the experiment was repeated except that the manner of administration was reversed from the previous I^{131} feedings in order that each lamb would have received both in vivo and in vitro I^{131}-labeled milk. As expected, the percentage uptake of I^{131} by the lamb's thyroid and the effective half-life of the thyroidal I^{131} appeared to be independent of the manner of radioiodine administration. The maximum uptake expressed in percentage of administered dose per gram of thyroid was ten per cent and the effective half-life was seven days.

Neptunium

Some preliminary data were obtained following the intravenous injection of Np^{237} in rats. It appears that tissue Np^{237} content can be satisfactorily assayed by either direct alpha counting or by measurement in the gamma ray spectrometer. The gamma ray spectrometer measurements also will indicate the tissue content of the Pa^{233} daughter of Np^{237}. It appears that the protactinium is less efficiently excreted than the neptunium.

Plutonium

The use of chelating agents in the decontamination of wounds was further evaluated in an experiment in which plutonium was added to the wound as the nitrate, as the EDTA chelate, or as the DTPA chelate. These conditions should optimize the enhanced absorption due to the chelating agent. All wounds were decontaminated by thorough water rinsing fifteen minutes after exposure. Deposition of plutonium in the liver was increased an average of four-fold by chelation with EDTA and six-fold by chelation with DTPA. Deposition in the femur was increased an average of eight-fold by chelation with EDTA and twelve-fold by chelation with DTPA. Urinary excretion the first day was increased an average of four-fold by chelation with EDTA and nine-fold by chelation with DTPA.

One month following multiple intradermal injections of plutonium nitrate at levels of 0.0016 to 5 μc per site, a white miniature pig continued to exhibit scab formation which was most pronounced at the 5 μc sites. Two scabs which were surgically removed contained 90 per cent of the plutonium estimated to be at the injection site. All signs of erythema have disappeared. External monitoring of the various sites indicates that up to 30 per cent of the plutonium present five days after injection has disappeared.

Glove boxes and exposure chambers were assembled for exposing dogs and rats to cerium oxide and neptunium aerosols. A study of the acute toxicity of inhaled plutonium dioxide in dogs is nearing completion with the examination of histological preparations and tabulation of analytical data. A limited program to breed beagle dogs was initiated with the selection of breeding stock and successful mating of four bitches. This apparently is the only way we can be assured of having a reliable, healthy, parasite-free dog colony for inhalation studies.

Gastrointestinal Irradiation Injury

An experiment was initiated in which rats were exposed to repeated doses of whole body irradiation at rates of 100 r per day, 250 r twice per week, and 250 r once per week. Following the delivery of total doses in the range from 1200 to 1900 r, the animals are being tested to determine the effect of radiation on absorption from the gastrointestinal tract. Results are not yet available.

Xylose, when given intragastrically or when injected directly into the intestine, is absorbed and excreted via the urine in normal rats. X-ray doses of 600 to 900 r were shown to reduce the urinary excretion of xylose (and therefore presumably its absorption from the intestine) by a factor of five or more.

The ability to absorb xylose has been used as a diagnostic test in human malabsorption studies, and may have value in diagnosing radiation injury to the gastrointestinal tract.

Reduction in glucose absorption from the rat intestine caused by exposure to 900 r X-radiation was prevented by the prior administration of 200 mg/kg of AET.

Microbiological Studies

Permeability effects in yeast cells were studied using uranium in addition to the work previously done with mercury. The tentative data obtained suggest that uranium causes rather different effects when used in conjunction with X-ray than previously observed with mercury. The data have not as yet been fully evaluated and final conclusions cannot be made as yet.

Project Chariot

Sorting and analyses of samples of aquatic organisms and terrestrial invertebrates collected at Chariot site for ecological studies were initiated.

HA Kornberg /es
BIOLOGY OPERATION

HA Kornberg:es

C. Lectures

a. Papers Presented at Meetings

None

b. Off-Site Seminars

H. E. Dziuk, "Animal Care Procedures at Hanford," and the "Hanford Biology Program," USAF-AEC Conference of Supervisors - Long-Term Experimental Animal Colonies, Aerospace Medical Center, Brooks Air Force Base, Texas, and Radiobiological Laboratory, University of Texas, Austin, Texas.

F. P. Hungate, "Biological Implications from Radiation," Summer Institutes at University of Washington, Seattle; Oregon State College, Corvallis; and Portland State College, July 20-22, 25 and 26, 1960.

R. H. Schiffman, "Life Support and Other Biological Problems of Space Travel," Oregon Air and Space Workshop for Teachers, Portland, Oregon, July 13, 1960.

L. A. George, Jr., "Radiation Protective Mechanisms," Summer Institute, University of Washington, Seattle, 7/25/60.

L. K. Bustad, "Cellular, Biochemical and Physiological Response to Radiation," Summer Institute, Univ. of Washington, July 13, 14 and 15 (three series).

c. Seminars (Biology)

None

d. Seminars (local)

L. A. George, "Biology Orientation," IPD Secretaries, 100-F Area, July 8, 1960.

F. P. Hungate, "Effects of Radiation," Medical-Dental Group, Richland, July 13.

R. F. Foster, "Columbia River Fish," YMCA Day Camp Resource Leadership Program, Columbia Park, Richland, July 8.

P. A. Olson, "Columbia River Fish," YMCA Day Camp Resource Leadership Program, Columbia Park, Richland, July 19.

W. J. Bair, "Biology Research at Hanford," General Engineering Laboratory visiting personnel from Schenectady, N.Y., July 21.

L. A. George, "Whole Body Radiation Syndrome," AEC Physics Fellows, 300 Area, 7/11/60.

D. Publications

a. HW Publications

Cline, J.F., "Potassium, Cesium-137 and Rubidium-86 Relationships in Plant Uptake, Soil Diffusion Rates and Irrigation Practices;" Document HW-62037, May 24, 1960, (Unclassified).

b. Open Literature

None

OPERATIONS RESEARCH AND SYNTHESIS OPERATIONS
MONTHLY REPORT - JULY, 1960

ORGANIZATION AND PERSONNEL

Effective July 29, Kitty Scott was placed on pregnancy leave and replaced by Margaret M. Wood.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

A preliminary analysis was completed of post-irradiation data from 48 tubes discharged under the quality certification program. Pertinent results were transmitted informally to interested personnel. Issuance of a report is being deferred until the final stages of the IBM processing of the data are completed.

Fuel Element Failures

Some problems associated with the design of production tests involving ruptures were considered. Specifically, a determination was made of the exposure to which a given number of tubes must be irradiated without rupture before it can be stated with a given confidence that the rupture rate at some given exposure does not exceed a given value. The power of such a test was also considered, and the dangers in not utilizing controls were pointed out.

Optimization of Reactor Operations

Work continued on the problem of determining a supplemental crew size optimum with respect to minimizing total annual expected costs. A general expression was found which gives the probability that N reactors will be "down" during a given shift, and that n of these will be performing charge-discharge work. This expression gives results which agree very well with available data, and is basic to the problem of determining an optimum supplemental crew size.

In determining this optimum, two cases have thus far been considered. In the first case, the assumption is made that all of the overtime required can be supplied. In the second case, a limit is placed on this, with the result that part of the cost is due to increased reactor downtime. The general expression used in determining the optimum will be programmed for IBM calculations to permit varying certain constants of interest and determining the effects.

Process Tube Leaks

Primary attention was directed toward the problem of predicting internal tube wall corrosion as opposed to external corrosion. The present method of predicting this has proven to be unsatisfactory. In approaching the problem, it was hyopthesized that the internal corrosion rate is not constant, as is presently assumed, but is rather a decreasing function of time due to the fact that as the tube corrodes more coolant water flows through the tube. In using this approach for several tubes from B reactor good results were achieved. The method will be re-tested and defined on a broader scale using data from all reactors.

Z Plant Information Study

The Z Plant information system study was reorganized on the basis that information needed to define the future production system will be obtained directly from technical personnel responsible for each phase of the systems design and operation as opposed to the past practice of study meetings. The organization of the computer program logic diagrams (the basis for computer coding) is currently in process. Close liaison with Z Plant personnel is being maintained to obtain the most reliable description of the process, process criteria and production equipment organization that will be implemented for future production operations.

The specifications for modifying existing production line weight and density balances to permit direct input signals to the computer were received from the G. E. Computer Department the week of August 1, 1960. The required modification to the balance(s) will depend upon the scope of the test which will in turn be dependent upon the computer's memory capacity and production system complexity.

Reliability Studies

Work continued on the problem of giving mathematical and probabilistic expressions for reliability of a control system. Current efforts are directed toward deriving the probability law for simultaneous failures of any fixed number of devices out of a given number of identical independent devices.

Work continued on statistical evaluation of a proposed NPR GM tube type fuel rupture monitor. This study is nearing completion, and a rough draft of a document encompassing the study has been prepared. This will be issued in the near future as a formal HW document.

Work continued on an evaluation and comparison of reliabilities of existing and proposed panellit systems for the NPR.

Redox Dissolver Study

Study of the chemistry of the dissolution process was continued. It is believed that enough is now understood about the process so that the main problem of increasing dissolution rates can be solved by chemical means. However, study of the chemistry has continued in order to postulate an actual kinetic mechanism.

A mathematical model that can be tested with currently available Redox dissolver data is almost completed. A set of simultaneous differential equations which express the instantaneous interactions among the various materials in the dissolver as a function of time has been completely formulated. The integrated form of this model can be tested with available boundary condition data, which includes pre-cut information defining initial conditions within the reactor vessel and post-cut data defining the vessel at shutdown. Integration of the system of equations is equivalent to the solution of a first order nonlinear differential equation, the solution of which is currently being considered. The basic problem here is not the solution of the equation, but the expression of the solution in a form which allows parameter estimation using standard statistical techniques.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Data were analyzed from an experiment previously designed to evaluate the amount of uncertainty associated with grain size measurements made by the Heyn line intercept method.

The relationship was examined between cooling rates after heat treating co-extruded tubes, and growth indices computed from X-ray diffraction data.

Analysis was completed of data from two additional tests conducted in the pilot plant concerned with the effects on fuel element bond integrity of different vibrators and of vibration frequencies and amplitudes. In one test, the porosity of the bond was measured by total count on the canned fuel element; in the other, component wettability was measured using visual ratings of the aluminum components. Large between run differences were noted in the second experiment.

Irradiation Processing Department

Assistance was given in the design of a production test which will further evaluate the effectiveness of nickel plating fuel elements.

A study is being made of reactivity values measured in the 305 test reactor. The primary purpose of this study is to establish specifications for reactivity. Additional results of interest are being found, such as within lot variability and a comparison of reactivity of bare uranium cores with that of the canned fuel elements where both are sampled from the same lot.

Reports were written summarizing the results of analyses of data from two production tests. Production test IP-219A was primarily concerned with evaluating the sonic orientation resonance tester (SORT) with respect to its ability to predict in-reactor dimensional distortion. The other, IP-280A, was designed to evaluate the performance of alloyed low-hydrogen dingot uranium.

Chemical Processing Department

A statistical review is being made of the BPID's experienced in CPD during fiscal year 1960. This will assist in the definition of problem areas and provide additional control guides.

The rough draft proposal for conversion from a tolerance statement to part-by-part acceptance of final product parts from a chemical purity standpoint is still being reviewed by CPD personnel. Indications are that the proposal will be accepted. A close watch is being kept on current production to aid in establishing test limits for this acceptance procedure.

The study on methods of numerically evaluating complex mathematical expressions which arise in certain shielding calculations continues.

[redacted]

A simplified method of completing contour descriptions has been devised, and is under study to determine its accuracy and smoothness characteristics.

Construction Engineering & Utilities

Additional data has been received and is being used to evaluate more precisely the relationship between fair cost estimates and lowest bid.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Chemical Development

The statistical analysis of zirflex data was completed. A model was constructed which appropriately defined the dissolution rate of zirconium as a function of solution pH and fluoride ion concentration.

A mathematical model of a poly-stage chemical process was constructed, a solution obtained, and its properties discussed with a member of Programming Operation.

A mathematical model for the diffusion (loading) of thorium in solution to immersed resin spheres was constructed and the solution obtained. The parameters of the model were determined from operational data, and have subsequently been tested by additional experiments which confirm the fact that the model adequately describes the physical processes involved. It is now planned to enlarge the model so as to study the time variation of sphere density during alternate loading and unloading.

Fuels Development

Extensive discussions were held with a member of Physical Measurements, Instrument Research and Development Operation on the feasibility of constructing mathematical models for and obtaining solutions to certain heat-transfer problems within fuel elements. More specifically, it was desired to develop a theoretical treatment of the types of signals to be expected from the inductive heating nondestructive fuel element test. Several simplified models were constructed, but due to extremely varied conditions in mixed geometrics solutions are, in general, unobtainable. Possible methods of analogue simulation were also discussed.

Technical assistance is being given to the mathematical theory of the metallurgically-idealized continuously dislocated crystal. The analysis is somewhat unusual in that it employs as its major tool the pure mathematical discipline of generalized tensor calculus for non-Riemannian geometry.

4000 Program

Swelling Studies

Work continued on the evaluation of the increase in precision due to calculating void density and void fractions for uranium samples from true interface dimensions instead of observed diameters on the micrographs.

Plutonium Recycle

Mathematical aid was given in devising a surveying scheme capable of detecting and accurately measuring small displacements and rotations of the PRTR top shield.

A mathematical treatment of the ideally elastic-plastic solid shaft proved that the additional allowable torque that can be obtained by the process of prestressing cannot exceed that of the unstressed shaft by more than one third.

6000 Program

Atmospheric Diffusion Studies

Statistical consultation continued in connection with the calibration of zinc sulfide particle detector to be used to analyze the sample filters employed in last summer's diffusion and deposition study.

General

Instrumentation

Work continued on a statistical method for constructing joint confidence regions for a multiple gamma energy spectra. A rough draft of the work has been completed and a formal report will be issued in the near future.

Formulas were developed to quantify the drift characteristics of multi-channel gamma energy spectrometers from test data using a "noisy pulse generator."

Work Sampling

A six-day schedule for the observation of Analytical Laboratories salaried personnel has been completed and will be used for a work sampling pilot study to be carried out in the near future. Analysis of the results of this study should indicate whether changes are needed prior to the full scale study to be conducted this fall.

Division of Research Programs

Statistical studies continued to determine the best method of estimating background for a high energy anti-coincident type gas sample counting instrument. Further analysis of existing data demands the use of the GCL IBM program. Current efforts are directed toward revising the dimensions of this program so that it can handle several hundred observations on a comparatively few variables. Compilation of this modification has been achieved and data analysis should commense in the near future.

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:mw

PROGRAMMING OPERATION
JULY 1960

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. The cross-section library of the RBU code was debugged during the month by use of the input code. The input code itself appears to be almost completely debugged and is being recompiled for incorporation into the rest of the system. Further changes in the Monte Carlo and Diffusion codes were made to improve efficiency. In particular, the time required to establish equilibrium before tallying in the Monte Carlo has been greatly reduced.

A first-order perturbation solution of Wilkins' differential equation for the thermal spectrum in a homogeneous medium with 1/v absorption may be used as a convenient and reasonably accurate one-parameter expression for the averaging of cross sections. A short code has been written to generate the Maxwellian and non-Maxwellian functions required. It is expected that the averaged cross sections using these functions will be superior to those currently in use, particularly for plutonium isotopes.

The Multiple-Hole Fuel Element program was changed to accommodate the calculation of large diameter fuel pieces. Previously, some of the terms in the program were evaluated by use of a series expansion which overran the capacity of the IBM-709 when calculations were made for large diameter fuel elements.

The GPR code has previously been revised so that the cross section treatment is consistent with that used in the Meleager code. In addition, an improved method of calculating short exposure cases has now been devised and incorporated into the code.

Fuel Cycle Analysis. A few highly successful calculations have been made in an initial attempt at finding a Phoenix (long-burning) fuel for the Advanced Pressurized Water Reactor. Some earlier work based on the Yankee reactor suggested that a Pu-240 to Pu-239 ratio of two or three to one should give an optimum exposure. Fuels containing Pu-240 to Pu-239 atom ratios of 2, 2.5, 3.0, 3.5, 4 and 5 to 1 were calculated using the Meleager MK-II code. All cases were initialized to k = 1.0 at equilibrium xenon. Depleted uranium or aluminum was used as a diluent. The longest exposure case within a reactivity peaking limit of 58 mk had a composition of 7.5 atom per cent Pu-239, 15 per cent Pu-240, with a balance depleted uranium. This particular fuel composition ran to 62,300 MWD/T with an associated reactivity peak

of 53 mk. For comparison, the base 3 per cent enriched U-235 case with boron poisoning will run to about 12,000 MWD/T with a reactivity peak of 58 mk. The exposures calculated for the foregoing Phoenix fuels are likely to be in error by a considerable amount (i.e., 25 per cent), but they still offer a firm basis for the belief that plutonium compositions can be calculated which will indeed show extremely long exposures.

Other Activities

The Plutonium Recycle Program Ten Year Program Report was revised and issued for comment. A complete description of the Critical Tests for the PRTR was published. The PRP annual report final draft was completed except for one section.

Concurrently with the establishment of nickel as the alloying agent for Pu-Al fuel rods for PRTR, a revised specification for the elemental composition of this fuel was developed.

(1) In order to allow for plutonium of varying Pu-240 content the specification requires 258 ± 13 grams of fissionable plutonium isotopes per assembly (Mark I). This will result in an alloy varying from 1.8 to 2.9 per cent plutonium depending on isotopic composition.

(2) For corrosion resistance ten parts of nickel to nine parts by weight of total plutonium has been specified.

The study of non-aqueous separations processes continues to show that there appear to be economic prospects for those processes from which uranium of less than natural enrichment can be discarded and with which remote refabrication of the partially decontaminated plutonium can be realized. Because of the need for effective decontamination in order to provide acceptable feed for the diffusion cascade, and also to minimize the economic penalties of blending for re-enrichment, these processes are less advantageous in cases where partially enriched uranium must be recovered.

Because of unsolved corrosion problems the volatility (UF_6) processes show extremely high waste ratios - ten kilograms of salt waste per kilogram of uranium processed. The Al-$AlCl_3$ process, from an optimistic view, may produce as low as one kilogram of waste per kilogram of uranium processed.

Activities in support of PRTR startup included review and analysis of process specifications, coolant system operating procedures, and power tests. Of the 45 planned process specifications Startup Council has reviewed 95 per cent and approved 87 per cent.

2. SPECIFIC FUEL CYCLE ANALYSIS

The necessary physics calculations for the study covering plutonium enriched fuel cycles in the Advanced Pressurized Water Reactor (APWR) are nearly completed. An outline of the method of operation is as follows: For the

first cycle, U-235 enrichments (in U-238) were selected by the Meleager code to give four different initial reactivities, which are 1.08, 1.116, 1.17, and 1.25. All cases are irradiated in identical reactors (APWR) until the reactivity drops to 1.0168 (the amount necessary to overcome equilibrium xenon). The plutonium formed during the irradiation is then recycled batchwise, to the same reactor (i.e., same initial k_{∞}) for the following cycle. This amount of plutonium (mixed with depleted uranium) is not enough to bring the initial reactivity up to the correct value. Two methods are used to raise the reactivity; one, by adding U-235, the other, by adding more plutonium of the same composition as that recycled. Allowances are made for a 3 per cent process loss and for a one year decay period for the Pu-241.

A series of steps will be calculated until the plutonium compositions closely approach an equilibrium plutonium recycle case. To date, four steps (32 cases) have been calculated on the IBM-709. It is expected that 6-10 steps will be required.

The final equations to be used for the Advanced Pressurized Water Reactor economics study have been completed. These equations are now suitable for hand calculation and have been considerably simplified from the more general and elaborate economics code which is being developed for the IBM-709 computer.

The fuel cycle costs for the first irradiation step (a U-235 enriched case) have been completed with the following results:

APWR Total Fuel Costs

Assigned Plutonium Value $/g	Fuel Cost mils/kwh
15	3.36
10	3.61
5	3.87

The fuel cost reported in TID-8502 (Advanced Pressurized Water Reactor Study, Phase I Report) for a similar uranium cycle is 2.91 mils/kwh with an assumed plutonium credit of twelve dollars per gram. The difference in calculated fuel costs of about a half mil per kilowatt hour reflects slight differences in the economic treatment of the two cases.

By assuming a variation in the allowable initial reactivity (from 1.08 to 1.25), calculated fuel costs have ranged from 3.15 mils/kwh to a maximum of about 4.5 mils/kwh for this particular reactor..

B. BIOLOGY AND MEDICINE - 6000 PROGRAM

1. RADIOLOGICAL CONSULTATION

Consultation was provided on the consequences of reactor accidents, exhaust monitors in the 325 Building, environmental monitoring procedures, and criteria for leakage from the confinement of NPR.

C. OTHER ACTIVITIES

Irradiation space requirements and scheduling of HAPO experiments in the MTR, ETR, GETR, and WTR were reviewed for fiscal years 1960 and 1961.

All 4000 program activities were reviewed for the benefit of F. K. Pittman, head of the AEC Division of Reactor Development, and other senior Division of Reactor Development personnel. Extensive facility tours and technical discussions on plutonium fuel fabrication technology were arranged for the benefit of senior Division of Reactor Development personnel plus nine visitors from the United Kingdom.

Assistance was rendered in arranging 13 tours (involving 86 people) through HLO and HAPO facilities. Of special interest were visits by Professor Dunstan of the Washington State University Department of Sanitary Engineering, Professor Pickering of the University of Oregon Medical School, and three senior members of the General Engineering Laboratory.

Manager, Programming

LH McEwen:dl

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF JULY, 1960

A. ORGANIZATION AND PERSONNEL

Virginia A. Warford transferred from Laboratory Auxiliaries to Exposure Evaluation and Records on July 11, 1960. The force of the Radiation Protection Operation totals 134.

B. ACTIVITIES

One case of plutonium deposition was confirmed during the month. The total number of deposition cases that have occurred at Hanford is 257 of which 188 are currently employed. One CPD employee received a plutonium puncture wound during the installation of equipment in the 234-5 Building. Whole Body Counter surveys indicated 1.1×10^{-3} μc of plutonium remaining in the wound area. Initial bioassay results indicate plutonium body deposition would probably amount to less than 10 per cent of the maximum permissible body burden.

Except for whole body monitoring of three special plutonium contamination cases and eight Radiological Physics Fellowship Students, the Whole Body Counter (WBC) was shut down throughout the month for maintenance work on the analyzer and installation of the tape punch recorder and spectrum stripper. Actual counting time for July amounted to eight per cent. The year-to-date total of people counted in the WBC is now 583.

A satisfactory mechanical system was completed to move the large scintillation crystal for personnel scanning in the WBC. Tests have shown that the response of a scanning counter to sources at different positions of the body varies by about 20 per cent. In the present arrangement where the subject sits in a chair, there is a variation of about a factor of two. A new safety device was installed on the door of the WBC to provide an immediate reversal of the door motor whenever the safety device comes in contact with any object.

A dose rate of 10 rads/hr was obtained from a Sr^{90} solution that had leaked from the pellet spiking mechanism at the Aquatic Biology facility. All areas were cleaned with a maximum dose rate to personnel of 3 rads/hr.

Improved radiological conditions have been established with the completion of a shielded X-ray room for radiographing examinations at White Bluffs. In addition to increased use of shielding materials the entrance doors are equipped with interlocks that will prevent operation of the X-ray unit unless all doors are closed and locked.

The introduction of a lww sample into B-cell marked the startup of the High-Level Radiochemistry Facility in 325-A Building. The maximum dose rate received during this operation was 200 mr/hr. A minor spill of Pm^{147} in the controlled area was the only case of uncontrolled contamination in this facility during the month.

Gross plutonium contamination was detected in the waste storage room of the 325 Building. The origin was a leaking waste barrel. Readings to 3000 d/m were measured over areas approximately 12 square feet in Room 4-7C and also in the basement.

Design work and fabrication of the automatic film densitometer continued. Preliminary use of this densitometer was made in comparing the radium gamma dose response of Du Pont films 502, 508, and 555. The preliminary results indicated that the 508 and the 555 films were several times as sensitive as 502 film for radium gamma doses below 200 mr. Du Pont films 834 and 1290 were exposed to Co^{60} gamma doses as high as 2000 r. The standard 3705 Building photometers could be used to evaluate doses to about 1000 r with these films.

Hanford Drawing H-4-39169, "Personnel Film Dosimeter" was completed and fabrication of five prototype badge dosimeters was ordered from the 328 Shops. Studies of gamma energy discrimination systems for use in film dosimeters have continued with encouraging results.

With the advent of warmer weather the Victoreen Model 362 ionization chamber pencils, used in part of the Environmental Monitoring Program, have been giving increasing dose rate readings. The Victoreen Stray Radiation Chambers positioned adjacent to the Model 362 chambers have maintained about their same level of performance. For recent atmospheric conditions, the Model 362 pencils are reading about a factor of three greater than the Stray Radiation Chambers. The difference in chamber performance appears to be a property of the electrode insulator material.

Special vegetation and milk samples were obtained following the release of approximately 54 curies of I^{131} from the Redox Plant during a 10-day period. No abnormal I^{131} activity was found in milk from the surrounding areas. Release of the iodine has been attributed to a partial failure of the silver reactors. Approximately 0.08 curie of activity, principally Te^{132} and I^{132}, was emitted from the 105-KW reactor stack as the result of the partial burnup of a ruptured fuel element during discharging. Ground surveys in the vicinity of the 105-KW Building disclosed that no appreciable contamination occurred. Initiation of the fog-spray system prior to discharge of the ruptured fuel element apparently prevented extensive contamination.

Liaison with the U. S. Geological Survey personnel established the fact that they will soon discontinue aerial monitoring by contract with the AEC. The AEC will obtain a new contractor for this work throughout the country and is arranging a test at Nevada whereby various aircrafts and detecting equipment will fly over known sources of radiation. The potential advantages of local participation in these Nevada tests are under consideration.

C. EMPLOYEE RELATIONS

One suggestion was submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to 22. One suggestion was evaluated and rejected. Six suggestions submitted by RPO personnel are pending evaluation.

There were two medical treatment injuries during the month for a frequency of 1.02. No security violations occurred during July.

Radiation protection training included: Two 2-hour orientation talks presented to Plutonium Metallurgy and Biology Research personnel; orientation lectures presented to one group of new employees and two groups of construction personnel assigned to Project CGH-860; a lecture on portable instruments including demonstrations to Chemical Effluents Technology personnel tours were provided of the 327, 309, 308, and 325 Buildings to several groups of personnel; and the first of a series of ten lectures was presented to nonexempt personnel prior to their assignment to PRTR.

D. SIGNIFICANT REPORTS

HW-64371 "Evaluation of Radiological Conditions in the Vicinity of Hanford for 1959" by Radiological Evaluation staff.

HW-64892 "A Wrist Badge Dosimeter for Hand Dose Measurement" by P. E. Bramson.

HW-66009 "Analysis of Radiological Data for the Month of June, 1960" by R. L. Junkins.

HW-66147 "Estimated Residual Curies of Beta Emitters Discharged to Cribs and Trenches at HAPO Chemical Processing Department Facilities Since Startup in 1945 Through 1959" by G. D. Brown and M. W. McConiga.

HW-66172 "Plutonium in Puncture Wounds" by J. W. Vanderbeek.

HW-66280 "Monthly Report - July, 1960, Radiation Monitoring Operation" by A. J. Stevens.

Report of Invention: "A dosimeter for Measuring Radiation Doses to the Human Hand" by L. G. Faust.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-June 1960 - Mid-July 1960)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.3	% MPC_{GI}*
Separations Areas	Gross Beta	8.6×10^{-8}	µc/cc
Pasco	Isotopic	< 2.1	% MPC_{GI}**
Kennewick	Isotopic	< 0.9	% MPC_{GI}**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	8.0×10^{-9}***	µc/cc
100-F Area	Isotopic	0.4	% MPC_{GI}*
Hanford	Isotopic	0.8	% MPC_{GI}*
Pasco	Isotopic	< 5.4	% MPC_{GI}**
McNary Dam	Gross Beta	8.0×10^{-7}	µc/cc
Vancouver, Washington	Isotopic	< 0.6	% MPC_{GI}**
Atmosphere			
I^{131} Separations Areas	I^{131}	1.3×10^{-12}	µc/cc
I^{131} Separations Stacks	I^{131}	2.7	Combined curies/day
Active Particles - Project	--	1.1	ptle/100 m^3
Active Particles - Environs	--	0.2	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	3.4×10^{-6}	µc/gm
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 occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

**The % MPC_{GI} is the percent of the maximum permissible concentrations for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

***This location is now sampled quarterly. The most recent result is tabled.

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
July	0	0
1960 to Date	1	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
July	10,992	158	3	0
1960 to Date	112,520	1,477	22	7

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)	mr(s)
July	11,169	812	102	35	163	9.39	14.7
1960 to Date	80,621	6,324	1,099	283	438	10.30	18.02

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
July	0	0	0	0	0
1960 to Date	6,745	2	0	0	26
Fast Neutron					
July	0	0	0	0	0
1960 to Date	1,074	73	29	0	21

Bioassay

	July	1960 to Date
Plutonium: Samples Assayed	534	4,839
Results above 2.2×10^{-8} µc/sample	41	298
Fission Products: Samples Assayed	560	4,735
Results above 3.1×10^{-5} µc FP/sample	0	3
Uranium: Samples Assayed	250	2,020
Confirmed Plutonium Deposition Cases	1	13*

Whole Body Counter

	Male	Female	June	1960 to Date
GE Employees				
Routine	0	0	0	533
Special	2	1	3	17
Terminal	0	0	0	1
Nonemployees	8	0	8	27
Pre-employment	0	0	0	5
Total	10	1	11	583

*This brings the total number of plutonium deposition cases which have occurred at Hanford to 257.

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	14	3.7	58	8.3	3.1	53
Fuels Preparation*	0	0	0	0	0	0
Hanford Laboratories	19	6.9	23	21	4.2	25
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	490	16	43	57	4.7	41
Chemical Processing*	97	39	3	0	0	0
Special Incidents	0	0	0	0	0	0
Random	2.0	1.7	4	0	0	0

*Samples taken prior to and after a specific job during work week.

Thyroid Checks	July	1960 to Date
Checks Taken	0	160
Checks above Detection Limit	0	3
Hand Checks		
Checks Taken - Alpha	34,243	222,364
Beta-gamma	53,054	322,532
Skin Contamination		
Plutonium	22	149
Fission Products	40	271
Uranium	4	35

CALIBRATIONS

	Number of Units Calibrated July	1960 to Date
Portable Instruments		
CP Meter	852	6,301
Juno	246	2,086
GM	736	5,471
Other	164	1,276
Total	1,998	15,134
Personnel Meters		
Badge Film	1,352	9,502
Pencils	-	1,912
Other	368	2,912
Total	1,720	14,326
Miscellaneous Special Services	811	3,593
Total Number of Calibrations	4,529	33,053

Earl M. Unruh
for the Manager
Radiation Protection

AR Keene:CMU:kc

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - JULY, 1960

GENERAL

Security performance for the Operation was satisfactory with no violations during the month.

There were no major injuries; the minor injury frequency rate was 4.60, which is considered above average experience for safety performance.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 17,917 hours. This includes 12,862 hours performed in the Technical Shops, 2,307 assigned to Minor Construction, 163 hours assigned to other project shops, and 2,585 hours assigned to off-site vendors. Total shop backlog is 18,226 hours, of which 60% is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 8-1/2% (1,843.1 hours) of the total available hours.

Distribution of time was as follows:

	Man hours	% of Total
Fuels Preparation Department	2,824	15.8
Irradiation Processing Department	983	5.5
Chemical Processing Department	378	2.1
Hanford Laboratories Operation	13,503	75.4
Construction Engineering & Utilities	131	.7
Miscellaneous	98	.5

Requests for emergency service remained at a higher than average level, requiring an overtime rate of 8.5%. Total backlog decreased approximately 10%, but the short range nature of the requests will require the continued use of subcontractors at an accelerated rate.

Two Machinists were added to the shop force and one Instrument Maker deleted, due to the death of John Brady on July 1st. Candidates are being considered to fill two additional requisitions filed for Journeyman Machinists. A candidate is being considered for a Sheetmetal Journeyman position which will be vacant in the near future, due to the transfer of a senior employee to another department.

The procedure, as outlined in a communication to personnel in the Machinist classification, for the selection of Instrument Makers, dated June 8th, 1960 and signed by L. J. Lucas, has been placed in effect. To date, all candidates have passed the written examination and are now being evaluated under actual shop conditions.

RADIOGRAPHIC TESTING OPERATION

A total of 4,388 tests were made of which 1,279 were radiographic (including x-ray and gamma-ray) and 3,109 were supplementary tests. Out of a total of 2,907 man hours, 959 (33.0%) were in connection with radiographic tests, and 1,948 (67.0%) were used on supplementary tests. The supplementary test work included: penetrant (fluorescent O.D. and I.D.); strain gage; surface treatment (alkaline cleaning, passivation, steam detergent cleaning, and vapor degreasing); and ultrasonic (flaw detection, core integrity, bond testing, and thickness measurement).

The number of pieces handled this month totaled 3,911 items. The feet of material represented by these items amounted to 47,569 feet. Work on tubular components continued to account for a large percentage of the footage of material tested.

Work was done for 20 different organizational components representing most of the operating departmens and service organizations. A total of 39 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 41 different occasions for advice and information on general testing theory and applications for other than the jobs tabulated in Part II - Testing Statistics.

Building modifications at C-25, White Bluffs has been completed. Equipment modifications and installation is going forward but progress is slow and some items are still not available for use in testing. Installation of the ultrasonic flaw detection equipment is complete and the unit is in operation. The ultrasonic wall thickness measurement facility is installed and testing will begin when material handling facilities for this station are complete. The autoclaves are installed and preliminary testing of the unit has been initiated. The pickling station pumps are on-site but the heat exchanger to cool the acid solution has not been ordered. Piping modifications are progressing slowly. The borescope stands for the penetrant testing station and autoclave film examination are being fabricated.

Productive testing has been sharply curtailed because of the lack of tubes to be tested and because of the construction activity which has required shutdown of certain equipment items. In the interim, use is being made of the available time for testing equipment alignment and for training of testing personnel.

Field work is proceeding routinely. Extensive strain gage work is being performed on F-reactor crossheaders. Instrumentation is being prepared for a similar job at 105-DR.

In the 300 Area, radiographic and ultrasonic work on TPU fuel rods increased during the month. Completion of the 306-A facilities is still set at August 1, 1960. The OX-250 X-ray is installed in 306-A and operable. Increased activity is being experienced in sheath tube testing. The increase in test demands and adjustment of the emphasis placed on particular phases of testing is creating man power and equipment problems in that this work was planned originally to extend over a considerably greater period of time. The man power problem will be partially solved by some overtime work and reassignment of personnel from the tube shop. Also, it is hoped that consolidation of the testing facilities can be achieved in the 314 building which will help alleviate the problem.

Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces	Description
CE & U	755	251	755	Film interpretation of radiographs by Weld - X Corp of Calif.at the PRTR; Radiograph 14 jumper welds at the PRTR (s/s 1-1/2" sch 10 pipe).
CPD	9	9	9	Radiograph welds of H-4 vessel.
HLO	2,865	43,376	2,943	Electro magnets; Radiograp two electro magnets to determine thickness of top and bottom plate; Alumina cylinder with T.C.; Lead zircaloy clad fuel rods; Zr-2 clad UO2 in al. insert; Co-extruded U-zr-2; Thermocouples; Audio-radiograph five elements I.D. and O.D. 1-3/8" O.D. x 12-1/2" long; NaK swelling samples; Unfinished TPU fuel rods; finished TPU fuel rods; Extruded al.rods; Radiograph fuel rods; Palm fabrication and development program; Perform 0.680" I.D., zr-4 tubing; 0.505" I.D., zr-4 tubing; 0.495" I.D., zr-4 tubing; PRTR dummy fuel rods; Pinion gears & rack pins; various lengths of hastaloy, inconel, pyrex and s/s tubes.

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces	Description
IPD	759	3,933	204	X-ray 57' 6" long NPR zirc tubes; Radiograph front face nozzles for 105-C area; Radiograph A & B position of welds on lug rings from 105-C reactor; Radiograph pipe welds on DT-1026 NPR mock-up in 189-D; 4" sch 160 + 2-1/2" sch 80 pipe; Radiograph welds on check valve (1-1/2" sch 80) Two at Ball 3X room 105-KE; Radiograph six lug rings (ss cost); Fluorescent penetrant test front face 105-C Area; Perform strain gage measurements at 105-F reactor rear face; 43' long "C" type alum. tubes.
Total	4,388	47,569	3,911	

CONSTRUCTION OPERATION

There were 56 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $186,659. Thirty new orders, 7 supplements and adjustments for underruns amounted to $58,527. Expenditures during the month on HLO work were $67,119. (Includes C.O. Cost). Total J. A. Jones backlog at month's end was $178,067.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	52	$ 173,410	2	$ 13,249
Issued during the month (Inc.Sup.& Adj.)	30	$ 58,527	0	0
J. A. Jones Expenditures during Month (Inc.C.O. Cost)		$ 62,950		$ 4,169
Balance at month's end	48	$ 168,987	2	$ 9,080
Orders closed during month	36	$ 210,614*	0	0

* Face Value of Orders Closed

FACILITIES ENGINEERING OPERATION

Projects

There were 16 authorized projects at month's end with total authorized funds of $5,071,265. The total estimated cost of these projects is $7,032,000. There were no new projects authorized, no new project proposals submitted to the Commission and no projects completed this month.

The following summarized the status of HLO project activity:

Number of authorized projects at month's end:	16
Number of new projects authorized during month:	0
Projects completed during the month:	0
New project proposals submitted to AEC during month:	0
New projects awaiting AEC approval:	4

CGH-832, Full Scale Physical Constants Testing Reactor
CGH-874, Consolidation of Plutonium Metallurgy Facilities
CAH-901, Structural Material Irradiation Test Equipment
CGH-902, Uranium Scrap Burning Facility

The attached project report details the status of individual projects.

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals.

Title	Status
329 Building Ventilation Mod.	Work is schedule for completion during August.
Pressure Vessel and Code Piping-Engineering & Inspection Service	This is a continuing work program for HLO vessels, pressure systems and related safety devices.
Coaxial Cable Between 325 and 329 Buildings	Field work to be completed during August.
Additional Improvements to Air Supply Rooms 204 and 206 - 3706 Building	Work completed.
Laboratory Furnace Installation Room 39-B, 326 Building	Engineering complete. Field work 40% complete.
Glove Boxes, 325 Building	Fabrication is complete and appurtenances are being installed.

Title	Status
Equipment for Critical Mass Studies	Materials on order. Detail design is about 75% complete.
Fire Detection System - 314 Building	Installation work 60% complete.
Criticality Alarm - 300 Area	Installation work about 65% complete.
Reactor Effluent Filter - Pilot Test Facility - 100-D	Field work essentially complete.
Improvement to Animal Waste Disposal System	Engineering work in progress. Field work has started.
Electrified Fenced Animal Pens and Pasture	Field work essentially complete.
Air Conditioner - Room 40-C, 326 Building	Work is being postponed to future.
Horizontal Control Rod & Drive for Tamper Tank	Engineering work has started.
Study 325 Building Ventilation System	Work has been initiated to determine ultimate capacity of system.
Ventilation Improvements to 325 Basement Mezzanine	Engineering work has started.

Drafting and Design Services

Work load in central drafting room (3706 Bldg.) is constant with heavy backlog. Branch offices in 306 and 308 Buildings have steady work loads.

Major design and drafting work in progress includes the following:

1. High Level Utility Cell - 327 Building - Special Tools (40% complete).
2. PRTR Fuel Element Rupture Facility - Special design work of miscellaneous type.
3. PRP Critical Facility - Detail of in-cell piping, ventilation, instrumentation and electrical work (20% complete).
4. Physical and Mechanical Properties Test Cell - 327 Building - Special equipment design (35 drawings - 35% complete).
5. Extrusion Tools for 700 Ton Press (8 drawings required - work completed).
6. Irradiation Studies Test Loop - "C" or "K" Reactor (12 drawings required - 98% complete).

7. Remote T.V. Inspection of Process Tubes (8 drawings required - 100% complete).
8. Periscope Viewer - Reactor & Fuels (4 drawings - 100% complete).
9. Structural Materials Irradiation Test Facility - Scope design - (25 drawings required - 30% complete).
10. Loading Dock Enclosure - 321 Building (3 drawings - 90% complete).

In addition to the above work, miscellaneous small design-drafting jobs are in progress.

Approximately 145 drawings including sketches, work sheets, and formal drawings were completed during the month of July.

HLO Plant Maintenance and Operation

Costs

	June	Total FY-60	% of Forecast
Building Maintenance	$ 12,234	$ 238,276	88.5
Mach. Maintenance	7,028	83,107	102.0
Improvement Maintenance	34,468	183,835	108.1
General Maintenance	4,479	54,302	95.9
Total Maintenance	$ 58,209	$ 559,520	97.0
Janitor Service	$ 10,005	$ 182,659	96.7
Power Operators	12,270	154,599	104.5
Utilities - Steam	15,685	293,754	96.0
- Electrical	7,297	83,443	100.5
- Other	20,283	166,473	112.5
Total Utilities	$ 43,265	$ 543,670	101.2
Engineering Services & As-Blts.	$ 5,810	$ 45,245	116.8
Administration	$ 3,000	$ 36,000	100.0
TOTAL	$ 132,559	$1,521,693	99.7

Budget = $1,525,700
Underrun = 4,007

Analysis of Costs

At year's end, the costs were 99.7% of the budget. The initial FY-1960 budget was $1,572,700. This was reduced to $1,457,000 in October, 1959, as part of the economy program. The budget was adjusted in April, 1960, to $1,525,700. In May, FPD returned $30,000 rebate from over-liquidation of steam charges. In June, they allowed a $8,000 rebate for over-liquidation of janitor charges. Despite these fluctuations and last minute rebates, the expenditures were controlled to within 0.3% of the FY-1960 Maintenance and Operation Budget.

Improvement Maintenance

Item	June	FYTD
HV Correction	$ 5,302	$ 73,020
Reloc. & Alteration	12,094	45,908
Paint	1,884	13,620
Crane Installation	3,338	31,754
Shielding	8,701	8,701
Miscellaneous	3,149	10,832
Total	$ 34,468	$ 183,835

Miscellaneous

Approximately 25,200 square feet of prints were reproduced during the month.

The total estimated value of the 13 requisitions issued during the month was $5,000.

Installation of six replacement hoods began this month at 747 Building, Bio-Assay Laboratory.

Power operator coverage was provided during this month on a minimal basis for 306 Addition, and 306 Buildings.

Remotely operable dampers have been provided in the 314 Building roof monitor.

Lead lining of the X-ray room at C-25 Building was completed.

A major rearrangement of offices on the first floor of 3760 Building was completed.

A construction health badge self-service badge house was constructed outside of 300 Area just west of 301 Building.

TECHNICAL INFORMATION OPERATION

A revised OPG on the transmittal of unclassified technical information to foreign nations has been written. It reflects a change in Commission policy made some months ago which permits exchange of technical information with certain Iron Curtain countries. These exchanges may be made by individual scientists or by individual contractors but not "by or in the name of the Atomic Energy Commission". It is planned to have it issued as a plant-wide Relations OPG. A popularly written brochure, based on the revised OPG, has also been written and will be distributed as soon as the new OPG becomes official.

A review of Hanford reports in the now out-moded categories C-66, C-67 and C-68 has been completed and a final report made to the Commission. The Commission has also been supplied with a microfilm of the review sheets for future reference if needed.

The details of the new document access system proposed to the Commission some months ago received considerable attention during the month. A working draft of the new system has been written and will be sent to both HOO and HAPO personnel concerned with the problem for comment.

AEC approval to use HW-63726 "Proposed Guide to Atomic Weapon Data at Hanford" for weapon data identification was received. This completes approval of the guide for use at Hanford for both classification guidance and weapon data identification. The guide is being readied for HAPO distribution.

Work was again started on the declassification review of older Hanford documents contained in Files. This program had been dropped because of the many problems which arose in connection with the Hanford Classification Guide. Although certain areas of the Guide still need to be revised, it is felt that declassification review of the older Hanford documents is a more timely project because of the microfilming program which Files plans for the near future.

The automation of the Classified Files issuance and routing procedures is getting down to the details of practical operation. A representative of IBM spent some days in the Operation doing initial programming. On July 27, IBM demonstrated the proposed system at the Kaiser Aluminum Plant in Spokane, where similar equipment is in use. A number of other vendors have had an opportunity to work on the problem, but this is the first demonstration of a workable system. Prospects are that a well worked out system can increase efficiency and reduce costs.

Work Volume Statistics

	June	July
Document Distribution and Files		
Documents routed and discharged (copies)	15,361	14,515
Documents issued (copies)	9,272	11,818
Documents sent offsite (copies)	3,776	6,687
Document reserves filled (copies)	736	634
Documents picked up and delivered	18,423	17,933
Document Accountability		
Holders of classified documents whose files were inventoried	438	642
Documents inventoried in Files (copies)	0	16,789
Documents destroyed or retired (copies)	3,340	2,967
Documents revised (copies)	1,407	1,441
Documents pulled and documents filed (copies)	11,697	9,476
Documents reclassified	428	545
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents onsite	214,393	214,807

Reference and Publication	June	July
Books cataloged (new titles)	113	85
Books added to the collection (volumes)	164	230
Ready reference questions answered by professional staff	80	150
Literature searches by professional staff	81	90
Reports abstracted (titles)	272	207
Formal reports prepared (titles)	7	12
Offsite requests for HAPO reports (copies)	499	324
Reports released to CAP (titles)	56	28

Library Acquisitions and Circulation		
Books ordered (volumes)	251	446
Periodicals ordered	91	25
Books circulated (volumes)	2,240	1,704
Periodicals circulated (issues)	3,607	3,015
Inter-Library loans	173	84
Films borrowed or rented	8	11
Industrial film showings	78	61
Bound periodicals added to the collection	122	201

Library Collection

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	29,752	8,422	1,624	2,015	41,813
No. of bound periodicals	14,008	5	1,522	97	15,632
	43,760	8,427	3,146	2,112	57,445

Classification and Declassification	June	July
Documents, including drawings and photographs reviewed for downgrading or declassification	8	252
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	39	12
Documents submitted to Declassification Branch, Oak Ridge	5	8

J. L. Boyd
Manager
Laboratory Auxiliaries

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

SEMI- MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
			AMOUNT	DESIGN SCHED.	CONST. SCHED.	DESIGN	DESIGN	DESIGN
			DATE	DESIGN ACTUAL	CONST. ACTUAL	CONST.	CONST.	CONST.
CG-731	Critical Mass Laboratory		$1,000,000	100	100	5-22-58	---	2-26-59
		$990,000	3-23-59	100	100*	6-4-59	6-30-60	6-30-60
		USING COMPONENT Reactor & Fuels R & D				FEO ENGINEER Project Engineer DS Jackson DL Ballard		

REMARKS:
The project was physically completed, with exceptions on June 30, 1960, Physical Completion Notice dated June 30, 1960, has been issued. Work by J. A. Jones forces is continuing on hoods and miscellaneous clean-up items. Final assembly of the reactor control system has not yet been completed by the vendor. Shipment of their equipment is expected around the middle of August.

* With exceptions

Cost & Commitments to 6-26-60 $949,150

CA-744	Metallurgical Development Facility 306 Building		2,685,000	100	*	6-30-58	---	9-30-59
		$2,650,000	11-5-58	100	**	3-20-59	9-1-60	9-1-60***
		USING COMPONENT Reactor & Fuels R & D				FEO ENGINEER Project Engineer JT Lloyd KA Clark		

REMARKS: The Frank Lohse contract was extended from July 26, to August 12, 1960, because the tanks were not delivered as indicated in the contract. The Jensen-Rasmussen contract is complete with exceptions, which should be eliminated by August 15. Equipment installation is complete. Start up testing of the arc melt furnace and the vacuum tube annealing furnace is scheduled for August 2, 1960.
* Total Project 96%; Jensen-Rasmussen 100%; J.A. Jones 90%; Frank Lohse 100%; Government Scheduled Material 100%
** " 99%; " 100%; " 99%; " 90%; " " 100%
***The offices were accepted on July 5, 1960, & occupied on July 13, 1960.

Cost & Commitments to 7/17/60 $1,195,918

CGH-790	High Level Radioactive Receiving and Storage Addition - 327 Building		$345,000	100	100	6-23-58	---	12-31-59
		$344,991	4-23-59	100	100	10-9-58	6-1-60	6-1-60*
		USING COMPONENT Reactor & Fuels R & D				FEO ENGINEER JJ Peterson		

REMARKS:

All exceptions have been completed except for painting the old basin. This project will not again be reported.

* With exceptions

Cost & Commitments to 6-26-60 $344,124

BUDGET CLASSIFICATION: Plutonium Fabrication Pilot Plant - 58-e-1

SEMI-MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

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.
CA-747	Plutonium Fabrication Pilot Plant	$4,230,000	$4,230,000	100	---	8-1-57	---	11-25-59
				100	100	3-6-58	3-1-61	7-24-60

USING COMPONENT: Reactor & Fuels R & D

HLO ENGINEER: HE Hanthorn

REMARKS:

Project complete and closed out as of July 24, 1960. A Physical Completion Notice is being prepared.

Plutonium Recycle Test Reactor Facilities
58-e-15

Cost & Commitments to 7-17-60 $1,633,720

CAH-822	Pressurized Gas Cooled Facility	$995,000	$995,000	100	NS	8-19-59	---	4-29-60
				100	6*		7-31-60	NS

USING COMPONENT: Reactor & Fuels R & D

HLO ENGINEER: JF Fletcher

REMARKS: Completed fixed price contractor modifications to the PRTR costing $44,087, were transferred from Project AEC-167 to Project CAH-822. This work includes 1) "B" Cell Structural Mods. by JP Hopkins Co. on Contract AT(45-1)-1253, $4,176; 2) Control Room Mods. by Hoffman Construction Co., Contract AT(45-1)-1280, $1,444; 3) "B" Cell Painting and Equipment Mods. by Shaw and Estes, Contract AT(45-1)-1410, $18,155; and 4) Stack Modifications by Custodis Construction Co. Contract AT(45-1)-1477, $20,312. A project proposal revision is being studied to extend the project completion to a date compatible with completion of Project AEC -167.

* Fixed Price contractor work transferred from AEC-167

Cost & Commitments to 7-17-60 $791,301

CAH-841	High Pressure Loop	$1,175,000	$50,000*	0	0	4-22-59*	---	NS
				0	0	NS	None	None

USING COMPONENT: Reactor & Fuels R & D

HLO Engineer: JC Fox

REMARKS:

A revised project proposal is being held up pending a program review. A stop-charge notice was issued, for all work on this project, on March 27, 1960. All costs of $30,385, incurred against this project were transferred to expense.

* Title I only.

Cost & Commitments to 6-30-60 $ 0

BUDGET CLASSIFICATION Plutonium Recycle Test Reactor Facilities - 58-e-15

SEMI- MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
			AMOUNT	DESIGN SCHED.	CONST. SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CAH-842	Critical Reactivity Measuring Facility	$360,000	$360,000	NS	NS	11-17-59		11-18-60
				52	0		4-30-61	4-30-61

USING COMPONENT

HLO ENGINEER WS Kelly

REMARKS:

The fuel transfer lock bids exceeded the available funds. A re-bid has been requested with chemically resistant painted carbon steel substituted for the originally specified stainless steel.

The bid opening date for the building was extended from 7/27/60 to 8/16/60.

Cost & Commitments to 7-17-60 $42,385

CAH-867	Fuel Element Rupture Test Loop	$1,500,000	$130,000	0	0	7-1-60		2-1-61
			6-30-60	0	0	Not Authorized		

USING COMPONENT: Reactor & Fuels R & D

HLO ENGINEER: PC Walkup

REMARKS:

Preliminary design was completed on 3-15-60. AEC Work Authority No. CAH-867, dated 6-30-60, authorized the General Electric Company $130,000 for design and related management services. Design of Annex Building completed. Annex Building to be added to Maintenance and Mockup Facility bid package as an addendum.

General Plant Projects - FY 1960

Cost & Commitments to 7-17-60 $96,796

CGH-819	Increased Laboratory Waste Facilities 300 Area	$193,000	$193,765	100	NS	2-5-60*	---	5-1-60
			2-19-60	100	110	7-18-60	5-31-61	3-1-61

USING COMPONENT: Chemical R & D

FEO ENGINEER: JJ Peterson

REMARKS:

Ray Britton started construction on July 18, 1960. Excavation work for the steam line has been performed.

* Design started on revised scope.

Cost & Commitments to 7-17-60 $120,213

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

SEMI- MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

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-860	Access for PRTR Fuel Elements - 327 Building	$81,000	$81,000 10-8-59	100 100	99 93	10-19-59 1-4-60	--- 8-15-60	4-1-60 8-1-60

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: JJ Peterson

REMARKS:

Major items of work remaining consists of installation of carbon filters and CO_2 fire protection system.

Cost & Commitments to 7-17-60 $64,689

CAH-864	Shielded Animal Monitoring Station-100 F	$52,000	$52,000 4-18-60	100 100	100 65	10-22-59 5-5-60	--- 7-24-60	2-4-60 8-15-60

USING COMPONENT: Biology

FEO ENGINEER: JT Lloyd

REMARKS:

The walls were "sacked" and cleaned. Soil for berm is being hauled in and leveled. The contract completion date was July 24. The AEC has not extended the contract period.

Cost & Commitments to 7-17-60 $10,146

CGH-874	Consolidation of Plutonium Metallurgical Facilities	$285,000	None None	0 0	0 0	1* 2*	--- ---	5* 11*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: JT Lloyd

REMARKS:

A project proposal requesting authorization of the project, and of total funds in the amount of $285,000 was submitted to HOO-AEC on 10-8-59.

* Months after authorization

Cost & Commitments to 7-17-60 $ 0

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

SEMI-MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

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-877	Pyrochemical Test Facility - 321-A Building		$70,000	100	80	12-8-59	---	4-17-60
		$70,000	11-17-59	100	65*	2-17-60	9-30-60	9-30-60
		USING COMPONENT: Chemical R & D				FEO ENGINEER: RC Ingersoll		

REMARKS:

The 8 x 10 California type hood was shipped from New Jersey 7-13-60. The balance of the hood order was shipped 7-25-60. Footings for the bottle storage were poured 7-15-60.

* Receipt of the hoods about 8-8-60 should put the project back on schedule.

Cost & Commitments to 7-17-60 $57,530

CAH-878	Additional Facilities for Isotope Study on Animals - 141 C Building Addition		$66,000	100	100	12-7-59	---	4-17-60
		$66,000	4-18-60	100	80	5-5-60	7-24-60	9-1-60
		USING COMPONENT: Biology				FEO ENGINEER: JT Lloyd		

REMARKS:

Stanchions and pen partitions and gate have been installed, sewer line has been laid and all concrete work complete. The building components have not arrived. These were due on July 8, then re-scheduled to July 15. The contract completion date was July 24. The AEC has not extended the contract period.

Cost & Commitments to 7-17-60 $5,460

CAH-885	Geological & Hydrological Wells FY-1960		$69,000	100	21	2-15-60	---	4-1-60
		$69,000	2-5-60	100	12	6-8-60	11-15-60	2-15-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: HE Ralph		

REMARKS:

555 feet of hole have been drilled to date. Contractor is currently 9 per cent behind schedule. Promises for a third rig are made each week, but no results.

Cost & Commitments to 7-17-60 $4,891

BUDGET CLASSIFICATION: General Plant Projects - FY-1960

SEMI-MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
				DESIGN SCHED.	CONST. SCHED.	DESIGN	DESIGN	DESIGN
			AMOUNT					
			DATE	DESIGN ACTUAL	CONST. ACTUAL	CONST.	CONST.	CONST.
CGH-896	Stress Rupture Test Facility		$7,500*	0	0	7-29-60	---	12-15-60
		$80,000	6-14-60	0	0	---	---	---

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RK Waldman

REMARKS:

Scope information has been finalized. Based on conclusions reached, CE&UO will start detail design by 7/27/60. HLO design portion will start 8/1/60.

* Interim authorization for design only

Cost & Commitments to 7-17-60 $ 0

CGH-902	Uranium Scrap Burning Facility		None	0	0	2*	---	8*
		$36,000	None	0	0	6*	---	38*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RK Waldman

REMARKS:

This project proposal was submitted to HOO-AEC for authorization on June 16, 1960.
* Weeks after authorization

Improvements to Production and Supporting Facilities - 60-a-1

Cost & Commitments to 7-17-60 $ 0

CAH-866	Shielded Analytical Laboratory 325 Building		$60,000	4	0	6-27-60	NS	11-31-60
		$750,000	5-31-60	4	0	---	---	1-1-62

USING COMPONENT: Chemical R & D

FEO ENGINEER: RW Dascenzo

REMARKS:

Design is proceeding on drawings and Title I report, which is due August 1, 1960.

Cost & Commitments to 7-17-60 $ 8,223

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 60-a-1

SEMI-MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
				DESIGN SCHED.	CONST. SCHED.	DESIGN	DESIGN	DESIGN
			AMOUNT	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CAH-870	Facilities for Recovery of Radioactive Materials - 325 A Building		$486,000	100	14	9-18-59	---	3-1-60
		$486,000	3-22-60	100	15	6-1-60	6-1-61	6-1-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: RW Dascenzo		

REMARKS: 1) Stripped footing forms and compacted fill to elevation 387 ft. 2) Stripped forms for B & C vault lift slabs. 3) Prefabricated wall forms for basement area and poured a partial lift of this wall. 4) Forms were stripped from the wall. 5) East existing basement sandblasted to remove waterproofing. Royal Company, Inc. is approximately 40% complete with fabrication of aluminum pipe and equipment and has started to fabricate vault liner "A".

Installation for Support of Bio-Medical Research - 60-h-1

Cost & Commitments to 7-17-60 $22,075

CAH-888	Biology Laboratory Improvements		$30,000	NS	---	5-3-60*	---	2-1-61**
		$340,000	5-3-60	Des I 100	---	---	---	NS
		USING COMPONENT: Biology				FEO ENGINEER: JT Lloyd		

REMARKS: The design criteria submitted to AEC on June 29, 1960, was returned to Genefal Electric on July 21, 1960, with comments. This was returned to AEC on July 25, and was approved by AEC on this date. The project proposal was revised at the request of AEC to include the third floor and was submitted to GE Contract group on July 18, 1960. General Electric will prepare the design scope of the radiation equipment when it is determined by Biology which type of facility they want. The AEC is negotiating with architect-engineers for the design contract.

* Scope Design ** Estimated

Improvements to Production and Supporting Facilities - 61-a-1

Cost & Commitments to 7-17-60 $6,693

CAH-832	Full Scale Physical Constants Testing Reactor		None	0	0	---	---	---
		$915,000	None	0	0	---	---	---
		USING COMPONENT: Physics & Instruments R & D				FEO ENGINEER: RW Dascenzo		

REMARKS:

No approval has been received from HOO-AEC on the preliminary project proposal requesting preliminary engineering funds.

Cost & Commitments to 7-17-60 $ 0

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

SEMI- MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

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.
CG-785	In-Reactor Studies Equipment 105-K Area		$276,000	100	70**	1-5-59		9-1-60*
		$325,000	12-8-58	100	70	3-22-60	12-31-60	3-1-61*
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H Radow		

REMARKS:
Field progress has slowed somewhat, reflecting the decreased manpower caused by vacations.

The project proposal, Rev. 2, has been submitted to the Commission.

* Estimated total cost and completion dates in revised project proposal.
** Per construction status schedule submitted to the Commission for approval.

Cost & Commitments to 7-17-60 $249,081

CGH-805	High Temperature Tensile Testing Cell - 327 Building		$150,000	100	0	8-26-58	---	6-15-59
		$170,000	2-25-59	100	0	8-20-60	3-1-60	3-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: RW Dascenzo		

REMARKS:
The revised project proposal requesting additional time and funds has not been approved by HOO-AEC. Procurement of plugs, manipulator, cell structure and window is still continuing. The cell structure delivery is scheduled for September.

Equipment Procurement and Fabrication — Orders placed 98% of value; Orders delivered 42% of value.

Cost & Commitments to 7-17-60 $102,974

CGH-834	Modifications & Additions to High Pressure Heat Transfer Apparatus-189-D Building		$700,000	100	81	4-20-59		7-1-60
		$700,000	4-8-59	99*	81	4-22-59	10-15-60	10-15-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H Radow		

REMARKS:
Resumption of field activity, pending receipt of sufficient remaining procurement items to permit completion, is planned for September 1, 1960.

* Final phase of design cannot be completed until vendor's design of the quick-acting valve assembly is finished.

Cost & Commitments to 7-17-60 $665,187

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

SEMI-MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending July 29, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CGH-857	Physical and Mechanical Properties Testing Cell - 327 Building	$500,000	$75,000 / 10-1-59	13 / 13	0 / 0	10-20-59 / NS	--- / ---	12-1-60 / 7-1-63

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RW Dascenzo

REMARKS:
No information has been received from the Budd Company on the requested data for the fatigue testing machines. The Creep, Universal Testing and Impact Testing machines are 95% designed. No work has been done to date on the electrical resistivity or dilatometer machines. The cell structure is approximately 30% designed.

Cost & Commitments to 7-17-60 $14,649

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CGH-858	High Level Utility Cell - 327 Building	$500,000	$70,000 / 10-1-59	25 / 25	0 / 0	10-20-59 / NS	--- / ---	11-1-60 / 11-1-61

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RW Dascenzo

REMARKS:
Equipment design is continuing on schedule for the lathe and milling machine and is about 30% complete on the cell structure.

General Mills Co. has sent a sketch of a proposed manipulator for this cell.

Cost & Commitments to 7-17-60 $14,925

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-901	Structural Material Irradiation Test Equipment - "ETR"	$125,000	None / ---	0 / 0	0 / 0	9-15-60* / 4-15-61*	--- / None	3-1-61* / 10-1-61*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: DS Jackson

REMARKS:
A project proposal requesting authorization of the project, and total funds in the amount of $125,000, was submitted to HOO-AEC on 7-10-60.

* Based on AEC authorization by 9-1-60.

Cost & Commitments to 7-17-60 $ 0

AM-7200-819 (4-60)

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of July 31, 1960, the staff of the Hanford Laboratories totalled 1411 employees, including 690 exempt and 721 weekly salaried. Of the total, 593 possessed technical degrees, including 363 B.S., 125 M.S., and 105 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for July was 1.97 as compared with 1.55 for the preceding month. There were no disabling injuries or serious accidents during the month. There were 6 security violations, bringing the total for the year to date to 17, as compared with 26 for the corresponding period last year.

PROFESSIONAL PLACEMENT

During July 3 Ph.D. candidates visited Richland for interviews. Three offers were extended during the month, and there are currently 3 open offers. For the recruiting year to date, acceptances have been received from 8 Ph.D. candidates.

Twenty new Technical Graduates were added to program rolls, and 8 accepted permanent HAPO assignments during the month. At month's end there were 85 Technical Graduates, including 8 members of the Engineering and Science Program, assigned to this component.

COMPENSATION

John B. Brady, an instrument maker in Technical Shops, died July 1, 1960. All of the Company's affairs relative to Mr. Brady's death have been dispatched.

HLO's contribution to the Annual Northwest Area Wage Survey was completed. Statistics for the Annual Los Alamos National Survey of Professional and Scientific Salaries were prepared and transmitted.

COMMUNICATIONS

Work was initiated on a general purpose recruiting brochure on Hanford technical activities to replace "Career Opportunities at Hanford" and "Adventures in Atomic Energy." The booklet "Your Guide to the Tri-City Area" is in the process of revision.

EMPLOYMENT

Twenty-three weekly salaried vacancies were filled during the month. At month's end there were 9 weekly salaried vacancies in HLO.

TRAINING

Thirteen HLO employees completed the first section of "Technical Report Writing" under the instruction of Professor E. Elliott of the University of Washington.

Manager
Professional Placement
and Relations Practices

TG Marshall:lmh

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	June	July
At end of month	20	22
Cancelled	5	1
Received	28	26
Filled	40	23

Nonexempt Transfer Request	June	July
Active cases at end of mo.	76	79
Cancelled	1	1
New	7	5
Effected	3	1

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to Date

	Cases Considered	Visits to Richland: Invited	Visited	To Visit	Offers*: Extended	Accepted	Open	On the Roll**
Ph.D.	650	152	58	11	29	8	4	6
Exp. BS/MS	518	114	83	4	110	59	10	36
Prog. BS/MS	490	-	-	-	196	83	4	75

*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 and one 1957/58 Ph.D. Carryover.

B. Technical Recruiting Activity - HLO- September 1, 1959 to Date

	Cases Considered	Visits to Richland: Invited	Visited	To Visit	Offers*: Extended	Accepted	Open	On the Roll**
Ph.D.	650	152	58	11	24	7	3	5
Exp. BS/MS	255	38	22	3	26	16	5	14

*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 and one 1957/58 Ph.D. Carryover.

In addition to the above activity, 16 exempt employees have transferred into HLO from other HAPO departments and 24 technical graduates have accepted Off-Program placement in HLO to date.

C - Technical Graduate and Technician Training Program
Month ending July 31, 1960

	TG Program	TT Program
Number of Personnel on Assignment	85	1
(HAPO Tech Grad Program 77		
(Western District E.P. 8		
Distribution of Assignments by Departments		
HLO	26	0
CE&UO	4	0
FPD	14	0
IPD	31	1
CPD	9	0
C&AO	1	0
Distribution of Assignments by Function		
R&D or Engineering	49	1
Other	36	0

FINANCIAL OPERATION MONTHLY REPORT
JULY 1960

Personnel

There were no personnel changes during July.

Activities

GENERAL ACCOUNTING

The following table presents travel statistics for Fiscal Year 1960 as compared with Fiscal Year 1959.

	Number of Trips		Costs (Thousands)	
	FY 1960	FY 1959	FY 1960	FY 1959
Regular Business	986	1 036	$ 233	$ 236
Professional Society Meetings	176*	157	34	27
Interviews, New Hires, Transfers	279	290	110	79
Offsite Courses	12	9	3	3
Billed to Others	92	84	29	32
Dual Purposes Trips	(153)	(192)	____	____
Totals	1 392	1 384	$ 409	$ 377

*Excludes 15 attending local meetings.

Travel during the month of July has been light which compares to patterns established in prior years.

Hanford Laboratories Operation was allocated $64,500 to cover travel for attending professional and trade society meetings in FY 1961. A re-allocation of this amount to HLO Sections was approved by the Manager, Hanford Laboratories and Section Managers were advised of the amount available to them.

The preliminary financial plan covering equipment funds for FY 1961 compared with our FY 1960 expenditures follows:

Program	Allocation	FY 1960 Expenditures
2000	$1 879	$1 514
3000	25	113
4000	805	543
5000	28	37
6000	100	95
Totals	$2 837	$2 302

The funds provided above have been allocated to the Sections participating in these programs. The 5000 and 6000 Program funds appear to be inadequate at this time. A revised proposal is being prepared for Isotopic Analyses, a 5000 Program activity, and if approved, will cover the equipment fund shortage in this program.

(Amounts in Thousands)

Program	6-30-60 Commits	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	6-30-61 Commits
2000	$483	$242	$326	$414	$ 843	$1 825	$1 939
3000	10	10	10	5	-	25	-
4000	89	135	137	293	699	1 264-a)	245
5000	10	4	4	10	10	28	10
6000	6	28	39	87	157	311-b)	5
Total	$598	$419	$516	$809	$1 709	$3 453	$2 199

-a) Includes supplemental programs except for projects.

-b) Expenditure forecast is amount budgeted which includes an expanded dosimetry program.

Reconciliation of the physical inventory of movable cataloged equipment in custody of Reactor and Fuels R&D is complete and a report of results has been issued. Over four thousand items valued at $6,138,584 were physically counted, a net increase of 824 items valued at $972,245 over FY 1959 inventory. Twenty-seven items valued at $6,179 (including 7 items amounting to $846, belonging to UCRL "Whitney") were not located during the inventory. One hundred and twenty-one pieces of equipment were inventoried which were not recorded in property records including six UCRL "Whitney" items and seven RDX items. Considering the size of the inventory, the number of missing items does not appear excessive, however, increased vigilance on the part of custodians and others is needed to improve equipment control.

Reconciliation of the physical inventory of movable cataloged equipment in custody of Chemical R&D is complete. Inventory papers were forwarded to C&AO to update HLO records and review unrecorded equipment with installed equipment records and other HAPO components records. A report of results should be issued in August.

A FY 1961 physical inventory schedule covering movable cataloged equipment was prepared and forwarded to personnel concerned. The large increase in the number of movable cataloged equipment items has made it extremely difficult for the one Financial man assigned to inventories to count and reconcile all HLO equipment on an annual basis. Beginning with FY 1961, physical inventories of movable equipment to be witnessed by Financial will be taken biannually, with exception of portable health instruments which must be inventoried on an annual basis. Components not scheduled for a FY 1961 physical inventory will be provided with a listing of equipment for their review and verification.

The Specialist - Property Accounting, now acting as Central Control Custodian of all HLO Reactor and Other Special Materials, spent considerable effort reconciling the quarterly inventory reports submitted by individual holders and establishing control records to reflect the correct quantity on hand for each holder by kind of material.

Seventy-six items valued at $21,963 were received at the Laboratory Equipment Pool during the month of July. There were 387 items valued at $167,460 located in the storage area at month end. A listing of equipment stored in the Laboratory Equipment Pool will be circulated at the close of August business.

Zirconium (3,882 lbs.) amounting to $5,974 was received in July and seven items valued at $332 were disbursed. At month end, there was a balance on hand of 318 pieces valued at $61,370 including 156 R&D items (442 lbs.) valued at $6,630. Individual records have been established for each piece of zirconium showing type of material, purchase order, size and kind, weight and other pertinent information available.

COST ACCOUNTING

A Preliminary Financial Plan and a proposed allocation of the plan were received from HOO-AEC and Contract Accounting, respectively. The following is a summary comparison of the plan with the amounts budgeted for Research and Development.

(Amounts in Thousands)

	Financial Plan/Allocation	FY 1961 Budget
HLO R&D Programs		
2000 Program	$ 597	$ 597
4000 Program		
Plutonium Recycle	6 018	6 493
Reactor Fuels and Materials Development	1 750	1 898
Specific Fuel Cycle Analyses	-	190
Waste Disposal Development	300	300
Gas Cooled Power Reactor	700	1 082-1)
Neutron Flux Monitors	67	47-2)
Total 4000 Program	8 835	10 010
5000 Program	742	724
6000 Program		
Environmental Sciences	365	540
Biological Research	1 151	1 325
Radiological Physics and Dosimetry	717	994
Instrumentation	139	158
Total 6000 Program	2 372	3 017
Total HLO Programs	12 546	14 348
Sponsored R&D		
IPD	3 100	3 400
CPD	1 428	1 462
Total Sponsored R&D	4 528	4 862
Total On-Site R&D	$17 074	$19 210

(1 - Includes Long Term Irradiation and Creep Measurements.
(2 - Submitted as a supplemental budget item.

A letter was issued to the Section Managers explaining the Financial Plan and allocation of the plan in detail. Funds included in the allocation for other functions and services were essentially as budgeted. The HLO tentative operating control budget totals $25,403,000. This is $1,646,000 or 7% greater than FY 1960 actual expenditures; however, it is $1,853,000 or 7% less than the budget request.

Revised administrative routines were established for financial review and approval of source documents prior to release by the Biology Operation. These procedures provide for the Financial Representative - Biology to review and initial work orders, purchase orders, appropriation requests, requisitions for salaried employees, and change of payroll status forms.

Action as indicated occurred on the following projects during the month:

New Funds Authorized HLO

CAH-867	Fuel Element Rupture Test Facility	$600 000
AEC-167	Plutonium Recycle Test Reactor	150 000

Construction Completion and Cost Closing Statements Issued

CG-661 Additional Heat Generating Facility, 189-D Building

There were 30 new authorizations for $19,277 and 7 supplements for $39,250 issued to J. A. Jones Construction Company during the month. Work was physically completed on 36 authorizations and 50 authorizations amounting to $178,067 were still open at month end.

GENERAL

Travel, Living, and Entertainment Audit field work, started in July, is nearing completion. The activities audited appear to be high in quality and accuracy, and audit exceptions are expected to be negligible.

College graduates engaged in research and development activities were categorized according to instructions received from Employee Compensation Service in connection with the Los Alamos Annual Survey of Professional Scientific Salaries. The completed report was forwarded to L. L. Weiss, August 2, 1960. Comparison with last year's report indicated close similarity in most categories.

Recent Bureau of Labor Statistics figures indicating a further rise in the cost-of-living resulted in a 1.18% wage increase for Hanford Laboratories non-exempt employees. This increase on base rates, effective July 25, 1960, will be reflected in paychecks delivered to employees on August 5, 1960.

Payroll Statistics

Number of HLO Employees	Total	Exempt	Non-Exempt
Changes During Month			
Employees on Payroll at Beginning of Month	1 382	669	713
Additions and Transfers In	45	27	18
Removals and Transfers Out	(16)	(6)	(10)
Employees on Payroll at End of Month	1 411	690	721

Overtime Payments During Month	July	June
Exempt	$ 6 071	$ 4 893
Non-Exempt	14 165	22 424
Total	$20 236	$27 317

Gross Payroll Paid During Month	July	June
Exempt	$585 349	$545 550
Non-Exempt	343 161	437 310
Total	$928 510	$982 860

Participation in Employee Benefit Plans at Month End	July		June	
	Number	Percent	Number	Percent
Pension Plan	1 209	99.4	1 187	99.4
Insurance Plan				
Personal Coverage	1 363	99.8	1 339	99.8
Dependent Coverage	975		959	
U.S. Savings Bonds				
Stock Bonus Plan	79	39.7	79	40.3
Savings Plan	90	6.4	90	6.5
Savings and Security Plan	1 062	83.7	1 045	84.2
Personal Accident Insurance	761	56.6	-	-

Insurance Claims	July		June	
	Number	Amount	Number	Amount
Employee Benefits				
Life Insurance	0	$ 0	1	$10 758
Weekly Sickness and Accident	21	909	20	1 129
Comprehensive Medical	47	4 131	33	2 689
Dependent Benefits				
Comprehensive Medical	128	12 249	76	5 989
Total	196	$17 289	130	$20 565

Good Neighbor Fund	July	June
Number Participating	953	940
Percent Participating	67.5	68.0

DS Parsley

Acting Manager - Finance

DS Parsley:bk

8-10-60

INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

INVENTOR	TITLE OF INVENTION OR DISCOVERY
B. S. Kosut	Constant Temperature Irradiation Test Capsule - Nonoriented
B. S. Kosut	Constant Temperature Irradiation Test Capsule - Oriented
B. S. Kosut	Joint Design and Welding Technique for Hermetically Sealed Thermocouples
I. T. Myers and L. C. Davenport	A Liquid Nitrogen Level Controller
M. F. Scoggins	An Automatic Dust Cover Remover
J. Dunn	Magnetic Leak Proof Metering Pump
O. H. Koski	Recovery of Radiocesium from Cyanide Precipitates Through Reaction with Cuprous Salts
M. Lewis	A Nuclear Magnetic Deflection Method for Separating Isotopes
M. Lewis	A Possible Application of Nuclear Magnetic Deflection to the Gaseous Diffusion Isotope Separation Process (and Other Similar Isotope Separations Processes)
D. P. Granquist	Improved Design for Nuclear Reactors
L. G. Faust	A Dosimeter for Measuring Radiation Doses to the Human Hand
J. J. Tiffany	Borescope Tube Adaptor

END

DATE
FILMED
12/7/92