HW--66960-Del.

DE93 001336

HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
SEPTEMBER, 1960

[redacted]

Compiled by
Operations Managers

October 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.

Route To:	P. R. No.	Location	Route Date	Signature and Date
Hm				
Attn: J. E. Travis				

[redacted]

DISTRIBUTION

Copy Number	
1	W. E. Johnson
2	H. M. Parker
3	O. C. Schroeder
4	F. W. Albaugh
5	C. A. Bennett
6	J. L. Boyd
7	L. P. Bupp
8	F. E. Crever, GEAPD
9	W. E. Foust
10	P. F. Gast
11	A. R. Keene
12	H. A. Kornberg
13	R. S. Himmelright, Acting Manager
14	L. H. McEwen
15	W. Sale
16	H. P. Shaw - V. R. Cooper
17 - 20	Atomic Energy Commission, Hanford Operations Office Attn: J. E. Travis
21 - 23	G. F. Quinn, Director, Division of Production, Washington 25, D. C.
24	Savannah River Operations Office, Aiken, South Carolina
25	300 Files
26	Record Center

TABLE OF CONTENTS

STAFF

Manager, Hanford Laboratories	H. M. Parker
Manager, Biology	H. A. Kornberg
Manager, Chemical Research and Development	L. P. Bupp
Manager, Laboratory Auxiliaries	J. L. Boyd
Manager, Operations Research and Synthesis	C. A. Bennett
Manager, Physics and Instrument Research and Development	P. F. Gast
Manager, Programming	L. H. McEwen
Manager, Radiation Protection	A. R. Keene
Manager, Reactor and Fuels Research and Development	F. W. Albaugh
Manager, Professional Placement and Relations Practices	R. S. Himmelright
Manager, Financial	W. Sale

TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE September 30, 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	130	110	240	134	113	247	0	8	4	11
Reactor & Fuels Research & Development	198	178	376	198	199	397	2	3	2	24
Physics & Instrument Research & Development	73	39	112	80	40	120	2	3	9	4
Biology Operation	37	45	82	40	44	84	2	1	5	0
Operation Res. & Syn.	16	4	20	16	4	20	0	0	0	0
Radiation Protection	38	99	137	35	99	134	3	0	0	0
Laboratory Auxiliaries	54	197	251	54	198	252	1	1	1	2
Financial	16	15	31	15	15	30	1	0	0	0
Prof. Placmt. & R. P.	88	11	99	90	12	102	5	0	7	1
Programming	16	4	20	17	4	21	0	0	1	0
General	1	3	4	1	3	4	0	0	0	0
Total	667	705	1372	680	731	1411	16	16	29	42
Totals excluding internal transfers.	667	705	1372	680	731	1411	14	13	27	39

BUDGETS AND COSTS

September operating costs totaled $2,351,000; fiscal year-to-date costs are $6,094,000 or 23% of the $26,249,000 control budget.

Hanford Laboratories research and development costs for September compared with last month and control budget follow:

(Dollars in Thousands)

	Current Month	Last Month	FY To Date	Budget-a)	% Spent
HLO Programs					
02 Program	$ 68	$ 74	$ 209	$ 597	35%
04 Program	888	740	2 177	9 612-b)	23%
05 Program	78	60	192	811	24%
06 Program	201	209	599	2 372	25%
	1 235	1 083	3 177	13 392	24%
IPD Sponsored	300	257	785	3 100	25%
CPD Sponsored	158	151	432	1 658	26%
Total	$1 693	$1 491	$4 394	$18 150	24%

(a - Represents Revised Financial Plan transmitted from HOO-AEC in October.

(b - Includes $50,000 for Special Reactor Studies not specifically identified in the Financial Plan.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

The PRTR Phase III fixed price contract was terminated on September 12, with the contract completion, excluding acceptance test performance, at an estimated 98%. Termination of the contract prior to completion permitted the startup program for the PRTR to commence while the remaining construction is completed by CPFF contractor, J. A. Jones Construction Company. Work on the various mechanical systems stopped on September 20, due to a plant labor dispute involving pipefitters.

The construction contract for the PRTR Maintenance and Mockup Building was awarded to the George H. Grant Construction Company.

The Gas Loop (Project CAH-822) ex-reactor equipment and piping complex has been acceptance tested at the vendor's plant and is being prepared for shipment. The main gas blowers, which continue to cause difficulty at another vendor's plant, are not included.

Design tests on several PRTR auxiliary systems including the secondary coolant system water treatment, liquid effluent system, personnel air locks, communications and alarms, ion exchange removal tests, and portions of the compressed air and raw water systems have been performed by PRTR Operations personnel. No major deficiencies in equipment or design have been noted as a result of the tests to date.

Startup plans for the PRTR have been reviewed by the General Electric Reactor Safeguards Council. The Council recommended the addition of two visual alarms on containment vessel penetrations. It was concluded by the Council that the preliminary critical and power testing of the reactor should proceed as planned.

The report of the IPD team which audited the PRTR startup and operating plans has been received and was generally favorable. However, the report contains some thirty recommendations which are now under study. Changes in plans resulting from these recommendations are not expected to delay the startup schedule.

The guide bearing of the drive motor in the spare PRTR primary process pump failed after 1584 hours of operation. The resulting vibration caused an increase in seal leakage, but did not seariously damage the seal. The seal was re-installed and is functioning normally after 1952 hours of operation.

Permanent records of the inside diameter and surface appearance have been made of all 85 PRTR process tubes while in place in the reactor, as a reference for future process tube monitoring.

The first-stage creep deformation measured, ex-reactor, on short PRTR process tube sections was lower by roughly a factor of two than for flat strip specimens, presumably due to grain orientation and biaxial loading of the tubes.

A swaged 19-rod UO_2 prototype fuel element failed after 25 days of operation in the ETR at a flux 170% greater than the maximum contemplated in PRTR.

By hot swaging, rods were successfully fabricated to 91% of theoretical density (T. D.), employing UO_2 powder that yielded 80% T. D., by cold swaging and only 55% T. D., by vibrational compaction.

Preliminary results of failure tests conducted in ETR indicate that Zircaloy-4 is more resistant to hydriding than is Zircaloy-2 after UO_2 fuel element failure.

Studies show that, for modest burnups, the melting point of irradiated UO_2 may be as much as 135 C above the value for unirradiated material. A gradual decrease in melting point to 2800 C for highly irradiated material

was noted. This is still approximately 50 C higher than the irradiated value.

The Pu-Al spike element loading for the PRTR critical tests will be completed October 1. Fabrication of similar elements with higher quality cladding for PRTR power operation remains incomplete because of slow deliveries of Zr-4 jacket tubing meeting the ±0.002" ID tolerance specifications.

High exposure plutonium-(13 w/o and 29 w/o Pu-240) aluminum alloy billets have been cast, in preparation for extrusion of fuel cores. Radiation levels at working positions have been less than expected for this type of material.

The first in-reactor rupture of a Hanford fabricated plutonium element occurred when a UO_2-PuO_2 capsule ruptured in the MTR. The capsule had been inadvertently placed in a flux ten times that specified, which resulted in surface heat fluxes of four and one-half million Btu/hr-sq ft. The ruptured capsule is being returned for examination.

Radiometallurgical examination of a Zircaloy-clad Pu-Al cluster with a nine-mil diametral gap between core and cladding revealed that no changes had occurred during ETR irradiation. An in-reactor rupture test of a Zircaloy-clad Pu-Al cluster is being designed for the ETR loop.

PuO_2 formed by calcining plutonium oxalate at various temperatures and then sintering in hydrogen containing water vapor up to 2% at 1100 C showed sintered density to be inversely proportional to the amount of water vapor present but no suboxides could be found by x-ray diffraction.

A single tetragonal phase exists in the PuO_2-ZrO_2 system from about 40 w/o PuO_2 to 72 w/o PuO_2. At higher concentrations, the ZrO_2 is apparently in solid solution in cubic PuO_2. Below 40 w/o PuO_2 a two-phase monoclinic-tetragonal region exists to at least 0.5 w/o PuO_2.

All coextruded Al-clad Pu-Al fuel rods for the transplutonium and high exposure plutonium programs have been fabricated and delivered to SRP on schedule.

EGCR graphite prototype burning tests in air indicate a very slow uncontrolled temperature rise in an adiabatic system in the temperature range from 400 C to 650 C, compared with a rapid runaway reaction at or above 740 C.

It is believed that previous correlations of irradiation exposure and graphite irradiation damage have been in error because (1) in Ni foil activation experiments the burnout of Co-58 is more rapid than previously supposed and (2) the damaging range of neutron energies is wide - from ca. 0.03 to 3.0 Mev.

A decontamination reagent employing potassium permanganate plus sodium carbonate - bicarbonate may satisfactorily replace peroxide-bicarbonate for removing UO_2 and associated rupture debris from a reactor system following

a fuel rupture, thus obviating the handling and storage hazards associated with the use of hydrogen peroxide.

It has been clearly shown the mechanism of failure of an NPR specimen after 3200 MWD/T exposure was localized plastic deformation of the clad on the outside of the inner tube. Relief from this failure mechanism lies in thicker clad and the minimization of interface roughness.

Studies of heat treating procedures for NPR tubular fuel indicate that the best uranium structure is achieved by employing an oil quench after beta transformation and holding for 20 seconds in air. The cooling rate through the transition temperature is 3700 C/min.

Identical boiling burnout conditions were obtained from two horizontal test sections with completely different boiling lengths (2-1/2 and 5 feet). These results indicate the validity of using inexpensive short test sections to investigate heat transfer conditions for long horizontal fuel element assemblies such as are found in the Hanford reactors.

Fluid flow data provided the basis for the design of new flow restricting orifices for the fringe tubes in the present production reactors.

Hydraulic characteristics of a new type of inlet nozzle for C Reactor were determined in the laboratory. It was found that the new nozzle has an overall pressure drop of 35% less than the nozzle presently in use and, as a result, would allow an increase in flow through the process tube.

Laboratory data of maximum discharge rates (critical flow) for steam-water mixtures were compared with theoretical values. It was found that the actual flow rates were greater than theoretical flow rates by magnitudes as great as five. The data are of particular value in making calculations concerning reactor hazards following piping ruptures.

Previous radiation measurements at the front face of B Reactor have indicated that the principal neutron dose was coming from several dry tubes which were shielded with steel plugs. A prediction that a two-fold reduction in neutron dose rate could be obtained by replacing the steel plugs with concrete-filled plugs has been verified by IPD.

2. Chemical Research and Development

Experiments performed in a small scale water treatment plant modeled after the production water treatment facilities showed that the substitution of aluminum nitrate for alum reduces the arsenate in influent water by a factor of nine or more relative to that presently obtained by the alum flocculant treatment. One-half scale reactor tests were undertaken during the month to determine the extent of As-76 reduction in the effluent water by use of the modified water treatment process.

A flowsheet for the recovery and partial decontamination of Sr-90 from Purex waste was firmed up in the laboratory and demonstrated through plant tests. Recoveries of Sr-90 now average 85 percent; decontamination factors for Zr-Nb, RuRh; Ce and Y are about 15, 240, 20, and 60, respectively; and the flowsheet time cycle was reduced from 5-1/2 days to 3 days.

Ethylene Diamine Tetra acetic acid (EDTA) has been found to be an effective reagent for preventing the absorption of Ce-144 onto Decalso, the inorganic ion exchange material to be used for the absorption of Sr-90 prior to off-site shipment in shielded casks. The use of EDTA not only reduces the radiation hazard stemming from Ce-144 contamination but effects even distribution of Sr-90 throughout the ion exchange material thus minimizing "hot spots".

The solvent extraction isolation and final purification of Sr-90 from the Purex plant semi-refined product are being extensively studied. Feed stability tests, single batch contact studies, mini-mixer settler runs, and pulse column investigations continue to show promise that the di(2-ethyl hexyl) phosphoric acid liquid-liquid extraction system will suffice for use in the Hot Semiworks.

The pilot scale facility for investigating the removal of reactor effluent radioisotopes by means of an aluminum turnings absorption bed has accumulated 840 hours operating time. Currently 68, 87, 57, and about 25% of the As-76, Zn-65, P-32, and the Np-239 radioisotopes, respectively, are being removed from the effluent water by this treatment.

3. Physics and Instrument Research and Development

The enrichment required for the NPR fuel is in considerable doubt as a result of experiments conducted in the PCTR and in an exponential mockup. Two different approaches to the problem in the PCTR gave conflicting results with current work now being directed to resolving the differences. Enrichment higher than that originally planned may be required. Meanwhile, exponential experiments indicated that the increase in neutron leakage from the reactor arising from the steam relief passages in the graphite was in line with expectations. Also, an experiment to determine the effect of moderator temperature on the reactivity is being designed.

The nuclear safety of NPR fuel outside of the reactor was investigated experimentally and a somewhat unusual situation encountered in that the outer tubes of tube-in-tube elements were found to have a smaller critical mass and critical volume than entire elements when immersed in ordinary water. Further, when the tubes were in a close packed condition, the reactivity was near the maximum value as distinct from the usual situation with rods which are considerably less reactive close packed than in a more open array. The safe mass limit will depend on the enrichment finally chosen but will be the material contained in a few reactor tubes, allowing the usual safety factors.

Satisfactory operation of the NPR building radiation monitor will be obtained in most locations according to results of field testing. Alternate designs were recommended for other building areas where widely varying radiation levels are expected. Meanwhile, final design details are being determined for the Beta-Gamma Air Monitor and for the Gamma Spectrometer portion of the Fuel Failure Monitor.

Shakedown of the new Critical Mass Laboratory continues. Modifications are being made to further insure against the escape of plutonium from valves, connectors, vent lines, etc., to areas which should remain clean.

In the Plutonium Recycle Program, design for the last ditch safety system for the PRCF progressed when calculations indicated that satisfactory operating times would be obtained for thermostatic switches activated by fissile material. Other instrument work included improvement of the Unit Motion Camera and the process tube diameter measuring devices, and the assembly of equipment for PRTR critical tests.

Understanding of the physics of plutonium fueled reactors will be aided by PCTR measurements on plutonium fueled graphite lattices, by newly developed methods for calculating the effect of resonance neutron captures on the neutron energy spectrum, and by the acquisition of further data on the neutron scattering properties of water.

In the Nondestructive Testing Program, filter techniques for analyzing broad-band eddy current signals are being developed, supported by a research contract with Johns Hopkins University. Improvements were achieved in the infrared and inductive thermometry equipment being developed for evaluating fuel core-cladding interfaces by heat transfer methods.

The lifetime of in-reactor neutron flux monitors may be five times longer when using a suitable mixture of plutonium isotopes as compared to U-235, according to first quantitative estimates made in initiating work on the new Flux Monitor Program. The dependence of the behavior on neutron energy spectrum is now being explored.

Improved use of the Whole Body Monitor, resulting from the acquisition of some auxiliary equipment, has resulted in the detection of several new cases of Na^{24} deposition. Amounts detected were of the order of 1/1000 of the maximum permissible body burden for all cases.

Convenience of alpha monitoring may be considerably improved in the future by use of surface barrier diodes as detectors. A prototype of such a device, using solid state circuits, was completed and has operated satisfactorily. Orderly progress was also made on other radiological instrument development including continuing promising results with small thermoluminescent dosimeters.

4. Biology

About two times more I^{131} was measured in jack rabbit thyroids this month than in September 1959.

Concentrations of beta emitters in Columbia River organisms were five times higher than a year ago.

Columnaris infected fish were rarely found among those caught in the Hanford area. The only infected ones came from near the mouth of the Snake. Those observations do not indicate that the disease's severity is associated at all with Hanford.

Blood sampling schedules for hematology in the chronic Sr^{90} toxicity experiment in swine is being revised in the interests of increased efficiency. Their schedule of dietary supplement of vitamins is also being changed in hopes of avoiding illness among the animals.

Np^{237} IV injected into rats follows a retention and turnover pattern similar to plutonium. No measurable absorption of neptunium was noted when rats were fed "Paducah Dust." Among other rats allowed to inhale the dust, one died, due presumably, to chemical (non-radioactive) toxicity caused by constituents other than Np^{237}.

It appears that the use of EDTA in decontaminating wounds containing plutonium neither harms nor benefits, as based on variations observed in experiments with rats. Most of the plutonium (70%) administered remains at the wound-site. When intradermally injected into pigs, 90% remained at the site and could be removed with the scab one week after injection.

5. Programming

One hundred grams of plutonium containing about 16% Pu-240 have been received for use in Plutonium Recycle Program physics tests. This is the first receipt of such material. The schedule for procurement of much more of such compositions is developing satisfactorily particularly if ORNL separations facilities are available for use as expected early next year.

A method has been developed and applied which rapidly evaluates the allowable amounts of alternate jacketing materials which can be used under a variety of thermal reactor and economic situations. A typical result is that in the case of 19-rod UO_2 fuel assemblies equal minimized fuel costs are attainable with zirconium cladding at $50 per pound of uranium and stainless steel at $19.50. The method can also be used to compare jacketing of various thicknesses. Such comparisons support the use of stainless steel jacketing in the less than 10 mil range which is industrially available.

Technical Publications completed typing the final draft of the PRP Annual Report, Fiscal Year 1960, for publication. It has been proofed, approved, and sent to printing. HAPO distribution should take place about October 15. Off-site distribution will again be held up by patent clearance.

A report on the effects of increasing the plutonium content of PRTR fuels was completed. The plutonium content of PRTR loadings can be doubled by enriching depleted uranium (instead of natural uranium) with plutonium for the uniformly enriched loadings. Such a loading could be substituted for the now planned uniformly enriched natural uranium loading without significantly affecting the current goals of the PRP.

The Meleager code has been changed so as to allow a print-out of reactor fuel compositions at six month intervals. This change permits an easier economic analysis, as AEC use charges are set up on a six month interval.

The spectrum computation method of re-evaluating Westcott g and s factors described previously has been successfully compiled on the IBM-709 and is now ready for use.

The results of the Muleager computations of batch recycle cases for the Advanced Pressurized Water Reactor (APWR) have been edited and placed in tabular form on duplimats. A preliminary write-up of the physics portion of the program as well as a few typical graphs have been prepared.

A preliminary study has been completed which investigates the feasibility of extending exposure lifetime by more efficient irradiation of fuel elements. The plan consists of making two or three long sections of fuel element and placing the sections in a time-constant flux distribution. After a certain total exposure, the column would be removed and re-assembled -- putting new sections in for the highly burned parts and reversing (end-for-end) the lesser burned sections. Results indicated up to 18% higher total exposure in some cases.

A total of 326 visitors to HLO were accommodated during the month. Of these, 77 visitors were here on official business (including 4 French and 7 British visitors). Students, teachers, and school administrators comprised 108 visitors. Professional and technical society members on group tours comprised the remaining 141 visitors.

TECHNICAL AND OTHER SERVICES

Measurements on two tubes of irradiated nickel plated fuel elements taken before and after cleaning in order to estimate film losses afforded an opportunity to estimate the reproducibility of the C-basin profilometer under operating conditions.

Application of a multicompartment migration model to data from a rat experiment

involving a single administration of W^{185} was completed with the emergence of several facts which should be of significant interest in planning similar experiments in the future.

There were two new cases of plutonium deposition confirmed during the month, thus bringing the total on record to 264 of which 259 occurred at HAPO. There are 190 employees currently on the active rolls with plutonium deposition.

A proposal that certain project roads bc made available to the public was reviewed. The findings of a comprehensive study on specified routes through the project completed in June 1959 were applicable to this most recent proposal with certain exceptions. It was noted that one of the proposed routes is not desirable because of heavy traffic of project vehicles hauling radioactive liquids. The other route, 4S combined with the old army road, might be subject to some contamination spread but the probability for such a spread is no different from the previously proposed Cold Creek road.

The month of September had a higher frequency of incidents of several varieties which necessitated whole body counting. There were three incidents involving plutonium contaminated injuries in one month compared to the 12-24 that generally occur annually. There were three separate instances involving 200 East diversion boxes that caused skin contamination and positive nasal smears. In IPD there were two cases of reactor effluents, both water and gases, causing contamination requiring whole body counting.

There are 22 currently active projects having combined authorized funds in the amount of $20,551,000. The total estimated cost of these projects is $23,926,000. All but seven of these authorized are on or ahead of schedule and five are more than 3% behind schedule.

Microfilming of the File's holdings is scheduled to start October 3. Documents are now being prepared for microfilming and material of no further record value is being destroyed.

SUPPORTING FUNCTIONS

Travel for first quarter FY-1961 is approximately 10% higher compared with the same period last year. The increase is attributable to increased travel to professional society meetings.

Equipment activity initiated this fiscal year is well ahead of the comparable period last fiscal year. Appropriation Requests processed through the first quarter aggregated $643,500 or 23% of total allocation compared with $382,950 (17%) in first quarter FY-1960.

An additional $306,000 was authorized by HOO-AEC during September for the Gas Cooled Reactor Program, increasing the total amount to $1,006,000.

As of September 30, 1960, the staff of the Hanford Laboratories totaled 1372 employees, including 667 exempt and 705 weekly salaried. Of the total, 572 possessed technical degrees, including 345 B.S., 124 M.S., and 103 Ph.D.

The medical treatment frequency for September was 1.21 as compared with 1.48 for the preceding month. There were no disabling injuries or serious accidents during the month. There was one security violation, bringing the total for the year to date to 24, as compared with 33 for the corresponding period last year.

During September there were two visits by Ph.D. candidates seeking employment. Three offers were rejected, including an IPD offer to an inexperienced Ph.D. physicist and HLO offers to an experienced Ph.D. physiological chemist and an inexperienced Ph.D. metallurgist.

Plans are essentially complete for the participation of HAPO scientists and engineers in Ph.D. recruiting at 21 campuses this fall. HAPO will coordinate Company Ph.D. recruiting at six campuses.

Four Technical Graduates were added to the rolls, four accepted permanent assignment and three terminated, including one Engineering and Science Program member, and two returning to school. At month's end there were 75 Technical Graduates on the roll, including 5 members of the Engineering and Science Program. Overall Company requirements for engineers and scientists in engineering, manufacturing, and marketing appear at this time to be about the same as those for last year.

Copy and photography for the technical recruiting booklet, "General Electric at Hanford," is nearly complete. The booklet should be ready for layout in about two weeks.

A second seminar in Business Operations in Our Changing Environment was begun with 16 participants, including one from CPD and one from the AEC.

There were 16 weekly salaried vacancies filled during the month, including three internal transfers. At month's end, there were 24 weekly salaried vacancies in HLO.

L. P. Bupp

for Manager
Hanford Laboratories

HM Parker:LPB:mlk

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Hydriding of Scratched Autoclaved Zircaloy-2 in H_2-H_2O Mixtures. Last month data were reported on hydriding of vapor blasted Zircaloy-2 in H_2-H_2O mixtures. Since the NPR tubes will have an autoclaved surface, a series of scratched autoclaved samples were run in a similar experiment.

The samples were heated to 400 C in high vacuum and a current of H_2 gas at 10 mm pressure was passed over the samples. In each run the H_2 contained different H_2O partial pressures, ranging from 0.0001 mm to 0.1 mm. The two-hour data show definite inhibition of hydriding at P_{H_2O} = 0.001 mm or higher, but after 16 hours at P_{H_2O} = 0.001 mm, all five samples disintegrated from hydriding. Although this experiment is continuing, it is expected that the required level of water vapor for protection of a scratched autoclave surface may be slightly lower than the 0.1 mm value found for highly surface active vapor-blasted samples.

Hydriding of Zircaloy-2 in Simulated NPR Atmosphere. A number of Zircaloy-2 coupons were exposed at 300, 350, and 400 C in two different gas atmospheres prepared by passing wet helium over 800 C and 950 C graphite. This experiment is similar to one reported in February 1960, where, with the graphite at 1100 C and Zircaloy-2 at 400 C, the samples hydrided destructively in 53 days.

Samples pulled after 53 days of exposure to the two gas atmospheres show no hydrogen pickup due to the water-gas reaction. The small quantities of H_2 picked up are due to the corrosion reaction with water. Thus, reducing the graphite temperature from 1100 C to 950 C changed the gas from "hydriding" to "safe" under the laboratory test conditions.

However, this experiment does not indicate that 950 C graphite in NPR is safe, as analyses indicate that the gas composition did not come close to equilibrium with the graphite. The gas from the 950 C graphite bed is of a composition more nearly typical of equilibrium with 600 C graphite. These results suggest the reaction rate of water vapor with 800 to 950 C graphite is quite slow. An experiment to study the kinetics of the water-gas reaction is being planned.

Fuel Element Failure During Autoclave Testing. An investigation was conducted on a recent coextruded Zircaloy-2 clad uranium core fuel element failure during autoclave testing in the 314 Building. The investigation showed that a rapid corrosion of the uranium core in one of the elements,

due to a defective Zircaloy cladding, completely consumed all of the water releasing an equivalent volume of hydrogen, with the result that the remaining fuel elements were then completely hydrided, leaving the hot uranium virtually unprotected when water was later added to the autoclave.

Radiometallurgy Laboratory Studies

The first thermocouple slug which was in a tube with a suspected rupture has been examined, and no evidence of any rupture has been found. The thermocouple connections on the cap were sectioned, but no flaws were found (RM-570). The second thermocouple element is being examined, but the point of water entry has not yet been found (RM-571). Two Zr-2 clad tubular elements with brazed end caps that were suspected ruptures in KER Loop 2 have been examined. The bonding under the end caps is poor, showing holes in the braze layer, but no evidence of a rupture has been found (RM-704). Examination of a hot pressed I&E aluminum clad fuel element has been completed. A considerable number of voids were found in the uranium under the nickel diffusion barrier (RM-705). Cold uranium specimens fabriacted into special shapes are being processed to determine the feasibility of using these shapes in future irradiations as part of the swelling program (RM-265). Several replicas of irradiated uranium specimens have been prepared for electron microscope studies of the distribution of fission gas voids (RM-284).

The inner tube of a KER failure was found to have a badly fragmented uranium core as well as surface bumping and warp. The tube was broken at the point of rupture. However, the fuel-clad bond survived the distortion and fragmentation very well (RM-569). Comparison of the fuel from near the midpoint of a coextruded rod and near the end cap of a cluster element with hot headed end closures showed that surface cracking was not limited to the ends (RM-703). Room temperature tensile testing of thorium samples has been completed. Part of the samples were annealed prior to testing. Elevated temperature testing will be completed shortly (RM-501). Stainless steel metallography samples from the neutron damage to metals program are being prepared for annealing and microhardness testing (RM-506). One of five thorium-uranium tensile samples was impossible to test because of an apparent weld failure during irradiation. Most of the NaK was missing and the tensile sample was completely oxidized. Another sample had been partially melted during irradiation (RM-508).

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

Basic Metallurgy Studies

X-Ray Diffraction Studies. Orientation of extruded uranium rods and tubes with various fabrication and heat treatment histories are being determined by various methods. A 1/2" diameter uranium sphere has been used to study sources of error in pole figure determinations. It is possible to obtain reliable pole figures of extruded rods by using 1/2" diameter spheres. Work is now resuming on the feasibility of determining the orientations of extruded uranium tubes by the pole figure method. Small hemispheres

and segments have been machined from uranium rings, one inch thick, sliced from a portion of FPD extrusion #7. The growth indices for this tube have been determined and these predict axial growth.

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. It was previously reported that abnormal grain growth occurred upon vacuum annealing 50 percent cold worked zirconium at 800 C. Results based on several long time anneals at 800 C for times from one day up to eight days show that no abnormal grain growth occurs in the Zircaloy-2. From inspection of microstructure it is seen that a second phase had segregated into the grain boundaries and restricts growth.

X-ray diffraction is being used to study the effects of irradiation on non-fissionable materials. The behavior during annealing of irradiated (5×10^{19} fast flux) molybdenum is currently being investigated. The annealing differs from that of material at lower exposures (6×10^{16} to 2.3×10^{19} nvt). Recovery occurs in the following stages: Stage I_a (50 C to 200 C) characterized by no change in lattice parameter a, and by decreases in x-ray line breadth B. Stage I_b (200 to 300 C) - little change in a or B. Stage II (300 to 450 C) - change in a; no change in B. Stage III (450 to 900 C) - complete recovery of a, corresponding to highly annealed state, incomplete recovery of B with respect to highly annealed state. Stage IV (900 C and above) - upper temperature limit undetermined - no change in a but B decreases.

Stage III annealing of cold work in molybdenum rolled to 30% reduction at 500 C parallels that of the irradiated (5×10^{19} nvt) molybdenum, indicating a similar recovery process. Complete recovery of lattice expansion is attained at 900 C. A substage appears during Stage II annealing and may be related to a higher impurity content due to the rolling operation.

Fourier analysis of the broadened peaks for as-worked molybdenum yields essentially the same broadening coefficients for 10%, 20%, 30%, and 40% cold rolled material. The extent of cold work damage is apparently the same in each case. Preferred orientation becomes more pronounced as the amount of working increases. The work is being expanded to include samples rolled to 90% reduction.

Electron and Optical Microscopy. A prototype capsule containing flux and temperature monitors together with a capsule holder have been delivered to the Irradiation Testing Operation for use in the 4B Snout Facility at 105 KW. This facility will be used for a variety of film and foil irradiations of both short and long duration. Preparation of foils and microtensile specimens for irradiation are in progress.

Fissionable thin films of uranium dioxide have been observed to undergo extensive changes during irradiation in vacuum and in air. Carbon films,

200 A in thickness, positioned at a distance of approximately one mm from the fissionable films during irradiation have been examined at magnifications of 100,000X. At these magnifications electron transparent lines, less than 100 A in width are observed. Since these lines resemble fission fragment trajectories, observed in metallic and nonmetallic films adjacent to fissionable films, it appears that the observed lines are also damage regions associated with the passage of a fission fragment. The lengths of the observed tracks are as long as 6000 A, consequently it is improbable that all of the tracks are due to fission fragments which originate in the film one mm from the collector. Since uranium dioxide is known to sublime from thin films during irradiation, many of the observed tracks may be due to the uranium dioxide present on the collector. Additional experiments for differentiating fission fragment damage in structural and cladding materials are being planned.

A paper, "Radiation Damage to Thin Films of Uranium Dioxide," was presented at the 18th Annual Meeting of E.M.S.A. A circuit tour of N.W. ASM chapters has been completed. The topic for the technical meetings was "The Behavior of Some Materials on a Microscopic Scale." Five exhibit posters fo for the annual ASM Metallographic Exhibit have been prepared.

Metallic Fuel Development

Tubular Fuel Elements. Two NPR inner tube fuel elements have been prepared for testing in the GEH-4 facility of the MTR. This test was designed to test brazed closures with electron beam welds. The caps were brazed in place with a 12 Fe + 4 Be + 84 Zr-2 braze alloy. The joint was step cut and electron beam welded to form a smooth weld. The specific power of these elements was calculated at 105 kw/ft. The jacket temperature at a flow rate of 17 gpm will be 93 C, the uranium surface temperature will be 170 C, and the core temperature about 375 C. This test will be quite severe due to the high power generation and low fuel surface temperature.

An enriched KER tube-tube element failed in July after 3200 MWD/T exposure. The fuel surface temperature was 287 C, and the maximum core temperature was 410 C at the point of failure.

Radiometallurgy examination shows the failure was the result of localized plastic deformation of the clad on the outside of an inner tube. Examination of a transverse section of the failed tube showed that the striations which extended longitudinally from the failure were necked down areas in the clad. Similar failures and striations have been seen in co-extruded rods irradiated to high exposure both in water and in NaK capsules. Internal cracking had occurred in the uranium fuel. However, none of the cracks penetrated the clad except where a buildup of corrosion products had expanded the crack and propagated it into the clad subsequent to the clad failure.

Eighteen NPR inner-tube test elements are being made for KER testing. These elements will have unbonded, welded end caps and will be available for charging into a KER loop during October.

Thirty-seven feet of coextruded KER size single component fuel tube from two extrusions have been received from FPD. This material is 1.6 percent enriched with inside and outside clad thickness of 0.027 inch. Fuel elements are being fabricated for KER testing; the operating conditions of these elements will be prototypical of NPR tube-tube fuel elements. The fuel elements will be closed by Zr-Be eutectic brazing by FPD. Close inspection will be made during all phases of the closure processing followed by dual autoclave prooftesting (i.e., both water at 300 C and steam at 400 C). Mild steel (1020) supports fastened to the fuel tube with Zr-2 studs will also be tested on these elements. Finished elements will be ready for loop charging by November.

Exploratory work on the "extrusion closure" process has led to two procedures which appear to yield the desired results. The principal problem in effecting closures has been to provide a firm bond at the Zircaloy end cap/uranium interface. It appears that either a copper shim 0.003" thick or an iron-clad face of similar thickness on the Zr-2 cap will furnish a good bond under the conditions of the test. Efforts to attach the iron shim to the Zr-2 by vacuum-brazing left, in the assembly, a braze layer full of blow holes, so that a better means of effecting the iron cladding is being sought.

Thorough examination of 2 braze-closure fuel elements (PT 309B) discharged 8/8/60 after about 24 hours of exposure revealed no evidence of rupture nor leak in the jackets. However, longitudinal sections through two of the end caps showed the braze layers to contain many bubbles. Where the braze alloy had flowed up into the weld bead, severe erosion of the jacket wall had occurred and at one place, a bubble in the weld bead was open, through a pin-hole, to water entry from outside. However, this bubble appeared to be isolated from neighboring ones, and not responsible for the radioactive discharge that led to the shutdown.

Component Fabrication. Eight additional 18-inch lengths of KER outer tube of enriched (1.6 percent) uranium - 2 w/o Zr alloy were inspected and heat treated prior to braze closure for irradiation test elements. An additional extrusion (NMI #21074) was used for this stock. Two of the elements had surface defects that will reject the elements. The pieces were heat treated by salt bath heating in NUSAL ten minutes at 730 C, ten-second air delay and oil quenched. Warpage and dimensional changes were recorded. Double throw warp varied from 0.001 to 0.038 inch before treatment and varied from 0.009 to 0.040 inch after treatment with no consistent changes.

Sections of KER single tube (1.752 OD x 1.052 ID) with 0.027-inch Zr-2 inner and outer cladding were heat treated and the macrostructure examined. Heating and cooling curves were recorded and midwall quench rates determined. Sections are heated to the beta phase in two minutes and to 730 C in 3.4-4 minutes. This geometry is cooled from 730 C to the transformation in 36 seconds in air. Quench rate for 20 C water was 7700 C/min, for ten-second air delay and oil quench, 4650 C/min; and for 20-second air delay and oil quench, 3700 C/min. The best macrostructure was observed for the 3700 C/min quench rate. Microsections are being examined.

The rolls for the three-roll straightener have been dressed, and the unit is being re-assembled. The misalignment of the rolls is being removed at this time. The scraper-wiper combination which scored the rolls initially is being modified to dual felt wipers on each roll. Drawings are in the shop for fabrication of a fuel element holder, furnace run-out tube, and thermocouple supports. These accessories will reduce variables due to temperature overshoot, heat loss between furnace and straightener, and inconsistent thermocouple placement. Material obtained thus far consists of 22 pieces of KER outer tube and nine pieces of NPR outer tube. The KER outer stock will be used to study cladding effects. The NPR stock will be used for establishing straightening conditions.

Closure and Joining. Work in evaluating a projection welded brazed closure concept has to date produced a very promising and reproducible projection weld between the Zircaloy-2 clad and the Zircaloy-2 closure cap. This concept is initially being tried on coextruded Zircaloy-2 clad uranium rods due to the limited capacity of the available spot welding machine. The closure consists of projection welding a Zircaloy-2 cap directly onto a projected cladding ring produced by acid milling approximately 0.030 inch from the end of the rod. The pressure is maintained on the cap and the power continued for several cycles after the initial projection weld in an effort to resistance braze the cap to the uranium. A 0.005 to 0.010 inch layer of braze material is initially placed on the 0.030 inch space provided between the flat bottom of the cap and the uranium surface. The cap comes in contact with the braze material after settling from the initial projection weld. Approximately 35% of the uranium surface was bonded to the Zircaloy-2 cap in one attempt in which no braze material was added. An attempt to braze the cap to the uranium using a Zircaloy-2 - Be - Fe braze material was tried but could not be evaluated because of a malfunction of the welding machine during the brazing cycles.

The inner tubes for a KER tube-tube production test have been brazed and prepared for welding. The outer tube material pitted badly during acid milling the end cap grooves. It was thought that iron was rolled into the jacket during straightening. When this material was placed in the acid, a galvanic cell was created which resulted in severe pitting of the Zircaloy jacket. More fuel stock has been prepared for brazing. The core material is 1.6 percent U-235 and alloyed with two percent of zirconium. The brazing alloy is 12 Fe + 4 Be + 84 Zr-2. Brazing is performed in a vacuum at 950 C, held for 60 seconds, then vacuum cooled. The closures are surprisingly free of voids and extremely well bonded.

In the last monthly report several autoclave ruptures of brazed material were reported. Analysis of the braze material showed an abnormally high oxygen content, almost twice that normally found in the braze alloy. The other gaseous impurities were at the normal level.

Several new alloys have been ordered from Oregon Metallurgical Corporation. These alloys are:

Zr-2 + 8 Cr + 8 Ni
Zr-2 + 8 Cr + 8 Fe
Zr-2 + 6 Cr + 6 Fe + 6 Ni.

These alloys should melt around 900 C and contain no beryllium. Corrosion data on these alloys indicate that the corrosion rate is only slightly above that of Zircaloy-2.

Work is continuing on new brazing techniques. Present efforts are being directed toward reducing the braze line thickness by mechanical deformation. Preliminary results appear promising.

A circuit has been designed for automatic control of the brazing power cycle. This control device will insure a reproducible cycle for any brazing operation.

Allied Fuel Studies. The two thermocoupled fuel rods which were discharged from KER Loop 1 because of rupture indications have been examined by Radiometallurgy Operation. The examination of the first thermocoupled rod has been completed, and no evidence of failure was found. This rod was discharged in July 1960. The rod was cut transversely at the thermocouple end and the uranium examined. No evidence of water entry to the uranium was found. The Zircaloy-2-to-stainless steel braze joints were sectioned, and no evidence of deterioration could be found. It now appears that the rupture occurred in one of the two 36-inch long heater tubes which were charged to add heat to the loop. These tubes were examined in the KE view pit just after they were discharged. No evidence of failure was observed. They have not, however, been examined by Radiometallurgy Operation.

The second thermocoupled fuel rod, which was discharged from KER Loop 1 in August 1960, had failed. The cladding was split adjacent to both of the peripheral thermocouples and the uranium core was split longitudinally in the plane of the thermocouples. The examination has not yet been completed, but no evidence has been found which would indicate that the Zircaloy-2-to-stainless steel braze joints were the cause of the failure.

Self supports of iron or low-carbon steel attached to the Zircaloy-2 clad with Zircaloy-2 studs will meet the support requirements for NPR elements, according to tests made ex-reactor. Final proof of the design will require irradiation testing under loop conditions prototypical of NPR. Zircaloy-2 studs welded to the jacket are used as rivets to attach the steel support to the jacket. The Zircaloy-2 stud is projection welded to the jacket with a copper electrode counterbored so that about 0.060 inch of stud projects from the cladding surface after welding. The force required to shear these 1/8 inch studs off of the jacket is over 1000 pounds, a shear strength greater than 80,000 psi. Steel supports prepared for irradiation on NPR inner tubes withstood 200-pound loads at 0.012 inch deflection before their elastic range was exceeded. After the appropriately spaced studs are attached to the jacket, the fuel tube is pickled and autoclaved. Inspection following autoclave treatment is improved by the absence of supports at this stage. Also, the difficult rinsing of pickling solution from crevices under Zircaloy-2 supports is eliminated.

Tests showed the best way to upset the studs over the chamfered hole in the support tabs was with a tool heated to 550 C. A load of 1500 pounds on a flat faced upsetting tool is necessary. Loads up to 2000 pounds caused no damage to the Zircaloy-2 clad fuel element.

Development drawings of candidate support designs for the NPR elements were made. The primary purpose of these drawings was to serve as a reference for making inquiries on support costs and quantity production methods. The drawing numbers are SK-3-9602, SK-3-9600, and SK-3-9601 for the steel support, Zircaloy-2 stud and inner tube zirconium support, respectively.

To improve the flow and pressure drops attributed to the supports, it may be desirable to change the cross-sectional contours. Ingot iron supports with a cross-sectional radius of curvature reduced to 3/8 inch did not scratch the autoclaved Zircaloy-2 surface within a wear distance of 180 feet. Tests with a smaller radius of curvature are planned.

Localized necking of the Zircaloy cladding of irradiated fuel elements has caused fuel element failures. Since the localized necking occurs after small uniform elongation, the strains in the outer cladding of tubular fuel elements should be minimized for successful operation. Assuming the deformations due to the thermal expansion and swelling volume changes can be shifted from the outer to inner cladding of tubular elements, a mathematical model of a plastically deformed fuel material with strain hardening cladding has been developed. The appropriate mathematical relationships and method of analyses have been obtained. Programming for numerical evaluation is starting. When the program is completed, analyses using various yield strengths for the uranium, volume expansions, tube geometries, inner clad thicknesses, and exterior cladding strains can be run. The analyses will give appropriate outer cladding thicknesses, cladding strains and stresses, and the stress conditions within the fuel material.

Tests have been run on uranium under constant load while undergoing cyclic temperature changes. The microstress distributions in polycrystalline uranium due to the anisotropic thermal expansion of the uranium crystals have increased the deformations. A specimen loaded to 750 psi and cycled between 150 C and 450 C is presently being tested. After twelve cycles, the strain is $\sim$0.6 percent with $\sim$0.05 percent strain per cycle. This strain is less than the 0.08 percent strain per cycle previously observed with another sample tested under similar conditions.

Coextruded fuel rods of the dual enrichment concept are being fabricated. Several extrusions have been made using cast, triple beta-treated uranium components. It was not possible to completely clean up the castings by machining and slight surface defects appeared in the interfaces of the coextrusions. There was also some undesirable variation in the Zr-2 clad thickness. Additional coextrusions will be made using uranium components which have been extruded to size from cast billets.

2. REACTOR PROGRAM

Coolant Systems Development

Nickel-Coated Fuel Elements. Aluminum-jacketed fuel elements, coated with either 0.6 or 1.1 mils of nickel, continue to resist pitting attack or flaking of the nickel in ex-reactor mockup tube tests. Exposure times for these elements total 11½ weeks in 165 C process water or 12½ weeks in 120 C process water. Defects made in the coating before exposure have not been enlarged.

Rupture Testing. An unirradiated prototype of the ETR rupture-at-will tubular fuel element was successfully tested in an ex-reactor loop. The projection over the defect was sheared with the loop at 300 C, 1650 psi, and 60 gpm flow rate. After one-half hour the rupture had progressed to a 3/4 inch diameter raised mound about 0.17 inch high at the center. After another hour at 300 C, the ruptured area had increased to a 1-3/4 inch diameter raised and torn mound. The element lost 66 grams of uranium metal during this period. After 1/2 hour more the rupture increased to 2-1/4 inch outside diameter, with the inside surface of the tube bulged but the cladding not broken. Seventy more grams were lost during this half-hour test.

Decontamination Tests. A decontamination test was made in the Rupture Experiment Prototype using: (a) Turco 4502 and (b) Turco 88-48B. The Turco 88-48B is essentially sodium bisulfate, with a modification of the inhibitor system to decrease the attack on the carbon steel, stainless steel galvanic couple. The over-all loop decontamination factor was very poor, only about 1.2 with the coupon test section giving a 106 mr/hr final reading. The coupon decontamination factors averaged between four and six for carbon steel, stainless steel, Zircaloy-2, Inconel-X, and monel.

Effect of Permanganate Concentration on Pitting Attack of Stellite. A preliminary test with Stellite 6 and 12 in an alkaline permanganate solution indicates that decreasing the potassium permanganate concentration from 4 oz/gallon to 0.5 oz/gallon has no effect on the pitting corrosion as determined by weight loss. The samples are being sectioned for photomicrographs at present.

Reagents for Dissolution of UO_2. A demonstrated procedure for removing UO_2 and fission products entrapped in the UO_2 in carbon steel systems is a decontamination with a mixture of hydrogen peroxide, sodium carbonate and sodium bicarbonate. However, hydrogen peroxide is unstable, difficult to store, and potentially hazardous to handle. If some solid could be substituted for peroxide, the storage and handling problems would be simplified. Solutions containing different concentrations of $KMnO_4$, Na_2CO_3, and $NaHCO_3$ were examined to determine the solubility of UO_2 in these solutions. It was found in laboratory tests that a solution of 30 g/liter $KMnO_4$, 27 g/liter Na_2CO_3, and 21 g/liter $NaHCO_3$ dissolved about three to four times as much UO_2 as the standard peroxide solution.

Removal of Oxalate Film. The inhibited oxalic acid solutions, such as Turco 4518, are effective decontaminating reagents except that they seem to deposit a film on the carbon steel samples. Some testing has been conducted to develop a method of removing the oxalate film. Solutions tried were $K_2C_2O_4$, $KMnO_2$-H_2SO_4, and inhibited phosphoric acid (Turco 4512). The best solution appears to be a dilute (2%) solution of inhibited phosphoric acid at 60 C. It may be feasible in a mixed carbon-stainless steel system such as NPR to use the Turco 4518 which effectively cleans both steels (except for the loose film on the carbon steel), and then circulate a dilute Turco 4512 solution as the first rinse to remove the oxalate film.

NPR Process Tubes. The technique used by Chase Brass and Copper Company in radiographing welds in NPR process tubes has been greatly improved. A standard tube specimen containing voids of known size and location was fabricated at Hanford. Use of this specimen was instrumental in developing the vendor's panoramic method of radiographic exposure to its present state. The method now produces films equivalent to Hanford's for the purpose of evaluating the welds in NPR tubes. The panoramic method has the advantage of showing the entire weld on a single uniformly exposed strip of film. The conventional method in use at Hanford employs six separate films to cover the full length of the weld.

The first shakedown run was completed in a new 60-foot autoclave at White Bluffs installed for autoclaving NPR tubes on September 23. Five 18-inch long Zircaloy tube sections and a number of smaller samples were distributed along the length of the autoclave, both top and bottom. Weight gains were all in the 19 to 25 mg/dm^2 range for the 38-hour period at temperature. The maximum temperature variation recorded ranged from 365 to 420 C, and minor equipment changes may be desirable to reduce this range. However, the tube sections exhibited satisfactory black oxide films except for a white area about 1-1/2 inches long on the bottom of one sample. All of the small tube ring samples except one exhibited black films that would be considered acceptable on corrosion test coupons. The 12 corrosion coupons were uniformly black.

ETR Irradiations. A new experiment was installed and is operating in the ETR N-5 position which is designed to determine the effect of neutron intensity on radiation damage to graphite. Twelve samples of CSF and NPR reflector graphite in four groups at the same temperature, 725 C, but at different levels of flux will be irradiated to 10^{21} nvt ($E > 1$ Mev), midplane peak. Through intercomparison of damage, the effect of intensity can be determined.

Hanford Irradiations. NPR core graphite samples have been prepared for charging into a hot test hole facility early in October. A series of low exposure tests will be conducted to determine the extent of growth which may occur at low exposures shortly after startup. Higher exposures will be obtained from sample bars arriving in October. These bars were selected from regions which attained 3000 C in the graphitizing furnaces.

NPR Graphite Oxidation. It is anticipated that around 0.1 mm water vapor pressure may be necessary in the NPR reactor atmosphere in order to retard hydriding of the Zircaloy-2 tubing. In order to determine the effect of this much water on the NPR graphite, experiments have been started to test the compatibility of NPR graphite in the temperature range 625 to 825 C with a flowing stream of He which contains 0.1 mm H_2O vapor. The reaction will be followed by weight loss of the graphite sample on an automatic recording balance.

Graphite Burnout Monitoring. Graphite burnout monitoring samples were discharged from 1960-C on 9/8/60 after 178 operating days. Weight losses (average of four samples) are shown below:

Boat No.	% Weight Loss per 1000 Operating Days
1 (upstream)	5.4
2	11.0
3	16.0
4	5.1
5 (C_L of stack)	1.3
6	0.77
7	0.58
8	0.02
9 (downstream)	0.02

Previous samples in this channel which were discharged on 1/25/60 suffered as high as 35% weight loss per 1000 operating days. Thus, channel 1960-C continues to show burnout rates in excess of the allowable 2% per 1000 operating days.

There was no appearance of the Swiss cheese type pitting that was seen on the previous set of samples; nevertheless, autoradiographs will be taken to check for the presence of catalysts.

Graphite oxidation monitoring samples were charged into 2577-H on 9/14/60, and are planned for discharge in three to four months.

Effect of Fillers on the Irradiation Resistance of Neoprene. Work has been completed on the effect of various fillers on the radiation resistance of a typical neoprene, type GM. For a wide variety of fillers the change in tensile strength with irradiation dose followed the same general trend. For any particular case the magnitude of the change depended on the type and amount of filler.

The hardness of each of the compounds tested increased with increasing radiation dose, with all the values approaching the same hardness as a limit. All of the compounds lost elongation with increasing dose. The total doses ranged from 5×10^6 r to 5×10^8 r.

O-Ring Degradation. Nitrile and silicone O-rings have been used in a new type of rear face pigtail installation. Inspection has revealed

that the nitrile materials have failed within six weeks after installation. The O-rings rub on a brass surface that has been roughened by corrosion in high velocity effluent water, and the nitrile O-rings appeared to be failing due to cutting or abrasion. However, the silicone O-rings which should be mechanically weaker have apparently been unaffected. In order to determine the cause of failures, mechanical abrasion tests of the O-ring materials have been started. The possibility of chemical attack on the O-ring will be investigated by comparing an oxidation-resistant nitrile rubber with normal nitrile O-rings in mockup tests being conducted by IPD.

Neutron Flux Measurements and Irradiation Dose. During the last year graphite irradiations performed at Hanford and off-site have been compared on the basis of fast neutron flux as computed by activation of nickel foils. Substantial progress has been made during this period in delineating the fast neutron spectra in the various test reactors and Hanford production reactors, and in firming up the range of neutron energies believed most significant in causing irradiation changes in graphite. As the dosimetry for the neutrons of graphite-damaging energies has been refined, several factors have been identified which help improve the correlation of damaging dose among test reactors and the Hanford reactors. Two of the most significant refinements are discussed below.

Cobalt-58, the measured reaction product in nickel foils has a previously-unsuspected large thermal neutron burnout cross-section. Consequently, fast neutron fluxes calculated from nickel foil activation after long exposures in test reactor core positions have been low by about a factor of four. Very recent detailed theoretical investigation of the damage in graphite by neutrons suggests that the neutrons responsible for damage to the graphite are predominantly those with energies between about 0.03 and 3 Mev. This is a lower range of energies than previously considered important. This change acts in a direction such that estimates of test reactor exposure based on neutron energies greater than 1 Mev provide too large a damaging dose by as much as about a factor of two.

These two refinements in graphite-damaging dosimetry partially compensate each other, with the over-all result that fast-neutron damaging doses calculated for long exposures in test reactor core positions have been low by only about a factor of two.

NPR Core Graphite - Coefficient of Thermal Expansion. The coefficient of thermal expansion for NPR core graphite has been measured between 25 and 425 C. The values are not directly comparable with measurements on NPR reflector or old reactor graphite because the samples were selected to provide "as stacked" values for the NPR (i.e., regions of the bar which will support the graphite stack were selected). Average values are:

Perpendicular to extrusion axis	$3.42 \times 10^{-6}/^{\circ}C$
Parallel to extrusion axis	$0.94 \times 10^{-6}/^{\circ}C$.

Thermal Hydraulic Studies

Experiments to Investigate the Influence of Boiling Length on Boiling Burnout. An important question concerning boiling heat transfer is how great an effect does the boiling length have on the burnout conditions. The length of a heated surface over which boiling occurs affects the boiling burnout conditions by influencing the flow patterns of the steam-water mixture. This is true especially for horizontal flow channels where the steam and water tend to stratify. This question is important since most experimental data regarding boiling burnout are obtained on test sections of lengths different from the fuel elements under consideration.

The most ideal manner to study the effects of boiling length is to use test sections of the same size but different lengths and to hold the same values of flow, pressure, heat flux and enthalpy at the point of burnout. This requires a large capacity for controlling the preheat in a precise manner in order to establish the proper inlet enthalpy. This was done in the 189-D heat transfer laboratory by using the silicon rectifiers as a controllable heat source for preheating and the motor-generators to generate heat in the test sections.

Twenty-four boiling burnout points were obtained using a 2-1/2 foot long heated test section consisting of a 0.435 inch ID pipe in a horizontal position with flow through the hole. With the outlet pressure held at 100 psia, burnout was obtained for flow rates between 500,000 and 2,000,000 lb/hr-sq ft and outlet steam qualities between 26 and 52% by weight. The heat flux at boiling burnout for these runs ranged between 500,000 and 2,000,000 B/hr-sq ft. For most cases the coolant at the inlet was a well mixed steam-water mixture.

Boiling burnout data were also obtained under similar outlet conditions with a test section of the same size but five feet in length. The coolant at the inlet to this test section was always liquid at some temperature below the boiling point. Although the boiling lengths were different for the two test sections, the boiling burnout data were nearly identical for the same flows and outlet qualities. This indicates that at least for the conditions studied, 2-1/2 feet is sufficient to establish the flow pattern and that longer lengths would not affect boiling burnout conditions. The results are very important for future experimental programs in that they indicate the validity of using inexpensive short test sections to investigate heat transfer conditions for long horizontal fuel element assemblies such as are found in the Hanford reactors.

Flow Orifices for Hanford Production Reactors. The solid fuel elements still used in the fringe zones of the present production reactors will soon be replaced with I&E (internally and externally cooled) fuel elements as the production of solid fuel elements is discontinued. Since the I&E fuel elements have a lesser flow resistance, this means that the fringe tubes must be re-orificed to maintain proper reactor flattening. With the pressure drops that now exist across the Hanford reactors, the use of I&E fuel pieces in the fringe tubes requires a very high pressure drop in the

[redacted]

flow restricting orifices of these tubes. However, there is a limit as to how much pressure drop can be taken across an orifice without attaining a condition of self-limiting or choking flow which is referred to as critical flow.

Operation in a condition of critical flow could result in the failure to attain a Panellit trip on the rupture of an inlet connector or the loss of a nozzle cap. In addition, critical flow could result in damage to the inlet connector by cavitation and vibration. Therefore, operation of the reactors is avoided under critical flow conditions in the flow orifices as determined in the laboratory.

Critical flow constants were obtained or re-checked in the hydraulics laboratory for a number of inlet orifice assemblies to determine their suitability for use with I&E fuel pieces in fringe tubes. Using these data and orifice calibration curves already determined, new orifice assemblies were designed to meet the needs of the fringe tubes. The designs were preliminary and were presented to the reactor personnel to allow them to choose the particular orifice assembly which would best suit their needs. After this selection is made, vendor prototypes of the chosen assembly will be tested in the laboratory to determine the final calibration and critical flow characteristics.

Hydraulics Studies. The use of self-supported I&E fuel elements in the ribless Zircaloy-2 process tubes in C Reactor will require inlet nozzle modification. A new inlet nozzle assembly has been proposed by Equipment Development personnel of IPD which includes some mechanical improvements in addition to the necessary modification. Prototypes of an early model of this assembly have been made, and one assembly has been tested in the Hydraulics Laboratory to determine the venturi calibration characteristics (for use in reactor production test IP-351-AP) and also to determine the over-all pressure loss (front header to tube inlet) for the assembly. The data are presented in HW-66773.

The over-all pressure loss for the new assembly was compared to that for the assemblies presently used on the reactors. It was found that the loss in the new assembly is only about 35 percent of that for the present C assembly, 50 percent of that for the BDF type assembly, and about equal to that of the present K Reactor assembly. This means that significant flow increases could be realized by using this new inlet nozzle assembly.

Critical Flow Studies. In performing calculations for a reactor hazards evaluation, it usually becomes necessary to know the flow rate of steam-water mixtures. A knowledge of such flow rates is necessary, for example, when predicting the events following a rupture of the primary coolant system. If the pressure difference is large, then critical flow occurs and the flow rate is independent of the pressure drop above a certain critical value.

Critical flow rates can be calculated from theoretical considerations, but it has been found that such values are often many times less than actual flow rates as determined experimentally. In preparation to

obtaining experimental critical flow rates at pressures between 1000 and 2000 psi, an apparatus was built and data were obtained for steam-water mixtures from pipes of 1/2 and one inch ID at pressures between 15 and 100 psia. Reduction of the data gathered during July and August was undertaken and the results were correlated.

The critical mass velocities, G, were correlated in the usual fashion by plotting the ratio of the observed mass velocity to the mass velocity calculated from the homogeneous flow model versus percent steam. This correlation was compared with data obtained at the University of Minnesota (Isbin, Moy, and DaCruz - AIChE Journal, 3, 361-365 (1957)) which, at the present time is being used extensively to predict critical mass velocity in reactor and other geometries, and recent data obtained at the University of Washington. The present data exhibit little pressure dependence over quality ranges of 100% to 20% and below 2%, and this checks well with the general trend of the University of Washington data. Between 2% and 20% a strong dependency exists between G observed/G calculated and the critical pressure. For example, a decrease of the critical pressure from 100 to 50 psia in this quality region will increase the G ratio by as much as 50%.

In the quality range between 10% to 15% an increase in quality will cause an increase of the G ratio. This was unexpected. Although the University of Washington data are incomplete in this quality range, similar behavior is exhibited. The University of Minnesota correlation indicates no pressure dependence whatsoever. This correlation also indicates that a maximum value of the G ratio of approximately 2.7 occurs at zero quality. In the present investigation, 15 data points were obtained at qualities less than one percent, all of which had G ratios greater than 2.7. The maximum value attained for this ratio was 5.4 at 0.4% quality.

The values indicated for G observed/G calculated by the University of Washington data agree well with the present investigations in the quality ranges from 0-2% and 20-75% (maximum deviation of 4%). However, at about 50% quality the present results deviate from the University of Minnesota correlation by 80% to 100%.

Possibility of critical flow was also examined for flow through 4- and 6-inch valves in the nearly closed position. These valves are used in controlling the front headers flows on the present reactors and the critical flow characteristics would make a difference in valving procedures during a contemplated method of charging fuel elements. The results of flow tests indicated that from 110 gpm to 240 gpm at upstream pressures of 50 psig to 100 psig and downstream pressures from 0.5 psig to 10 psig there would be no critical flow in either valve.

Shielding Studies

Attenuation Measurements. It was previously recommended that the steel plugs in the air (dry) tubes of B Reactor be replaced with concrete-filled bayonets for improved neutron shielding. During the last shutdown the three central air tubes were shielded with bayonets filled with

iron-serpentine concrete with a density of about 265 lb/ft^3. Subsequent measurements at the front face have confirmed the predicted two-fold reduction in neutron dose rate. A further reduction is expected when the remaining three air tubes (fringe tubes) are similarly shielded. It is currently planned that this technique will also be applied to the air channels at C Reactor. There is a strong incentive for reducing front face dose rates at the production reactors because of the considerable amount of time spent by operating personnel with supplemental controls during reactor operation.

Shielding Instruments. Calibration of the Perlow neutron spectrometer for use in shielding studies has continued at the 300 Area Ion Accelerator Laboratory. Difficulties in reproducing data when changing methane gas pressures in the chamber have been resolved by improvements in gas filling technique. Reproducibilities of ± 1% are now being achieved. The third Perlow chamber has been received from ANL, and final assembly is in progress. All three chambers will be calibrated at the same time when the positive ion accelerator next becomes available. This calibration is expected to cover a neutron energy range from 50 Kev to about 1.2 Mev.

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. After the rupture of a Zr-2 clad Pu-Al rod in the autoclave, it was decided to refabricate the last 15 clusters of the criticality load from the new Zr-4 tubing rather than risk further contamination incidents. Two hundred sixteen fuel rods have been processed through autoclaving requiring only wire wrapping and final assembly. The remaining 84 rods will be completed by October 1.

Fabrication of Pu-Al elements for the PRTR power loading continued to be bottlenecked by delayed and out-of-specification deliveries of fuel jacketing. Of the 400 35-mil wall Zircaloy-4 tubes received to date, only 60 have fallen in the close tolerance (0.002") category. The supplier is confident that the dimension problem has now been solved, however.

Other steps in the fabrication of the power loading proceeded routinely. One hundred and eight Al-Pu billets were cast and 398 extruded Pu-Al cores were drawn to a range of final diameters. This range was set by the cladding dimensions and the specified tube-to-core clearance. The greatest measured difference between the maximum and minimum diameters of all cores drawn through a particular size die was 0.0001 inch. Three rejects were attributed to the drawing operation.

An external foot switch and a speed control device were added to the equipment which is used for pointing the lead end of the fuel cores. A hydraulically operated rod cutter was installed to replace a hand-operated cutter for cropping the drawn rods to length. It was determined that a sustained production rate of 36 cores per eight-hour day for two-man operation was a realistic figure for scheduling the use of the hooded draw bench and for purposes of cost analysis.

For the first time Zr-2 end brackets exhibited white corrosion product after autoclaving. An entire autoclave load of six sets was rejected. The first 33 sets previously autoclaved had been 100% acceptable. An attempt is being made to recover the reject brackets by grit blasting, vacuum annealing, etching, and re-autoclaving.

Autoclave No. 2 was successfully decontaminated in two working days using a mixture of alkaline complexing agents and a submersible ultrasonic transducer. The estimated contaminated level after rupture was 7.5×10^{10} d/m assuming that 0.05 gm of plutonium was corroded. After decontamination to an average nonmeasurable level of 500 to 1000 d/m, a trial run was made for 48 hours with a dummy fuel load at 400 C and

1300 psi. The rods exhibited no sign of surface contamination, and the Zircaloy oxide coating was black and uniform. Two more runs have been made in autoclave #2 with full loads of Mark H type PRTR fuel rods with 100% acceptable results.

Fabrication Development. Two Al-Pu extrusion billets were cast from high exposure plutonium for irradiation capsule experiments. Two separate batches of high exposure plutonium oxide were used for starting material, one batch contained 13 w/o Pu-240, and the other batch contained 29 w/o Pu-240. The Pu oxide was reduced by Al in presence of cryolite directly to the required alloy composition which was 3.12 w/o total Pu for the 13% 240 plutonium and 3.91 w/o total Pu for the 29% 240 plutonium. Analyses of the 3.12 w/o alloy indicated that the Pu recovery in the alloy was 96%, four percent was lost to flux and skull. Analyses of the 3.91 w/o alloy were not received. Radiation readings through the lead-glass shielding on the hood front was 2 mr/hr., which is similar to readings obtained using lower exposure Pu; however, the total quantity of high exposure plutonium in the hood was only 180 grams.

The swage was used part of the month for sizing tubing, but some work was done on oxide swaging. Four rods were respectively reduced in area 27.4, 29.0, 41.6, and 42.5 percent. Density samples were taken from the middle and end of each rod. It was found that the middle of the rods reached a high density, 89.6% theoretical, after the 27.4% reduction. The ends, on the other hand, did not achieve a comparable density, 89.4%, until the 41.6% reduction had been effected. If the ends could be brought to high density as fast as the center section, a considerable amount of swaging time could be saved with reduced wear and tear on the tubing. Experiments with inert end plugs (MgO) have already been started to explore this possibility. Also, new vibrating techniques have been developed which allow tube loading to a density of 8.1 gm/cc. Further studies are being run to determine the effects of the higher starting density. It has already been determined that higher density results in a greater elongation and more wall thinning for a given reduction in area.

With the present end cap design there is a tendency for the wall to thin just over the end of the cap. It seems likely that this thinning (down to 22 mils in some rods) can be successfully overcome by changing the cap design and counterbore technique.

Oxygen-uranium ratios were rerun on three batches of fused oxide, Norton, original Spencer "Hi-Fired", and a new shipment of Spencer-fused. The analyses were run both by oxidation and coulometer.

Type	O/U Ratio (Oxidation)	O/U Ratio (Coulometer)
Norton	2.026	2.019
Spencer "O"	2.015	2.006
Spencer "N"	2.004	2.002

Recently published data from Bettis confirms our analysis previously reported of a U_4O_9 phase in the Norton material and to a lesser extent in the old (type "O") Spencer material. The comparative abundance of this second phase in the Norton microstructure compared to the Spencer type "O", which has a comparable oxygen content, can possibly be explained by the manufacturing techniques used. While Norton is known to slow cool their oxides after fusion, using a batch process, Spencer is known to have a continuous process. It can be surmised that the latter process should include a quenching step to be practical. If this conjecture is right, the Bettis phase diagram indicates that the excess oxygen would not appear as U_4O_9, but would be absorbed as a UO_2 defect structure. From theory one would predict that a structure such as that found in the Norton material would not behave well under irradiation. Before any appreciable amount of oxide showing this structure is loaded into reactor grade assemblies, its characteristics will be more thoroughly investigated.

Aluminum clad, Al-Pu bearing billets are being fabricated for the co-extrusion of eight-foot long rods of 9/16" diameter. The cores are being configured to predict the flow of metal through a streamlined die with a 60-degree entrance angle. Work is also under way to evaluate Zr-clad extrusions containing Zr powder plus PuO_2. Initial extrusions will contain UO_2 instead of PuO_2 for handling purposes.

Fuel Evaluation. Twelve UO_2-PuO_2 capsules were recharged into the MTR for additional irradiation. The capsules had acquired an exposure of 1300-1800 MWD/T. The goal exposure now is set at 5000 MWD/T. One of the specimens ruptured. It had operated for about one week in the L-5 position. The Zircaloy-clad capsule had a hole (1/2" wide by 3/4" long) near one end and visual inspection disclosed that some of the core material was missing. The capsule contained three sintered and ground UO_2 - 5.67 a/o PuO_2 pellets. Density of the pellets was 91 percent of the theoretical value. Investigation showed that the thermal neutron flux in this position was 2.2×10^{14} nv. Under the requested flux, 2×10^{13} nv, the fuel sample would have generated 19 kw/ft and had a heat flux of 440,000 Btu/hr- sq ft. The ruptured capsule is currently being transferred to HAPO for radiometallurgical examination.

Radiometallurgical examination of irradiated Pu-Al clusters is continuing in support of PRTR. Measurements taken on the cores of the irradiated three-rod Zircaloy-clad cluster which had as much as nine mils gap between the core and cladding indicated that no changes had occurred due to irradiation. Also, there was no appreciable difference in pre- and post-irradiation density determinations made on the core material. These results would indicate that even though excessive gaps existed, the core did not attain the temperature necessary to promote swelling.

A Pu-Al Zircaloy-clad seven-rod rupture experiment is being proposed and designed for the ETR 3x3 loop. It is planned to operate the element under maximum PRTR conditions and intentionally rupture the cladding at full power. The point of rupture will be located in a flux of 1×10^{14}, and the associated heat flux at this position will be about 300,000 Btu/hr-ft^2.

Experiments designed to investigate the reactivity and irradiation characteristics of the self-shielded and Phoenix fuel concepts are progressing. The mechanical design of the Phoenix reactivity change experiment is completed, and fabrication of the parts is under way. Some of the alloys to be used are being cast. Physics and heat transfer calculations are still being made of the various proposed Phoenix fuel concepts.

UO_2 Fuel Development

PRTR Fuel Elements. The swaged 19-rod UO_2 cluster fuel element being irradiated in the ETR developed a cladding leak after approximately 25 days of irradiation at a heat flux approximately 170% of the maximum anticipated in PRTR. The test was continued for 12 hours after the initial fission gas release, four hours of this time at full power. The discharged bundle will be returned to Hanford for examination. This test will provide valuable hydriding data as well as fission gas release data which is directly applicable to PRTR operation.

Capsule containers which will be attached to PRTR fuel elements have been fabricated. These holders will contain Pu-Be and Ra-Be source capsules for PRTR physics tests. They can be remotely assembled and disassembled.

Fabrication Development. Attempts to weld 75-mil round wire on 3.068-inch OD tube by the continuous seam welding process were unsuccessful. Evaluations of the welds included micrograph, macrograph, autoclave (PRTR), and shear strength tests. Satisfactory strength for the joint was attained; however, the micrographs show a narrow crevice of approximately four-fifths of the contact area with the remaining one-fifth as weld nugget. The weld width varies from 0.003 to 0.009 inch in the seven samples tested. Because all joints had a high crevice-to-weld ratio, it was concluded that even at low contact pressure and low current the rate of wire deformation always exceeds the rate of nugget growth.

Distortion is one of the major problems in attaching spiral wrapped wire (75-mil) to 0.563 inch OD tubes by the Thermatool high frequency welding technique. Tests for weld quality have involved 15-mil wall tube, and the distortion problem has been of secondary interest. Distortion was expected to be eliminated by increasing the wall thickness to 30-mil. Recent 30-mil wall tests demonstrate that, even with sub-minimal weld current and moderate hold-down pressure, distortion is encountered. These tests involved stainless steel which has a coefficient of thermal expansion three times that of Zircaloy-2. It may be possible to reduce the distortion by using Zircaloy and striving for an optimum heat balance between wire and tube, or by preheating the tube and post-heating the tube and wire to relieve residual stress.

Further studies were made to determine the effects of particle size composition on the density of vibrationally compacted UO_2. A series of three-size mixtures of fused UO_2 were compacted in eight-foot long, 0.575 inch ID Zircaloy tubes on the 5000-pound-force vibration system. The particle size ranges selected for the coarse, medium, and fine

fractions were, respectively, -6 +12 mesh, -35 +65 mesh, and -200 mesh. Screen analysis of these fractions after blending, however, showed that some particle size reduction had occurred; 23% of the coarse fraction, for example, had particle sizes less than 12 mesh.

Mixtures were prepared with compositions ranging from 55 to 75% coarse, 2.5 to 25% medium, and 15 to 35% fine. Eighteen 3-kilogram mixtures were compacted at frequencies that were varied continuously between 75 and 4000 cps, and at accelerations to 100 g at the shaker table. The highest density under these conditions (90.5% T.D. bulk UO_2 density) was obtained with the mixture consisting of 62.5 w/o coarse, 17.5 w/o medium, and 20 w/o fine. The average particle densities of the three separate fractions and of the composite mixture were 10.68 grams per cc (97.3% T.D.), corresponding to a compaction efficiency* of 93% for the rod having the highest density. The lowest density was 87.5, and most of the mixtures were compacted to greater than 88.5% T.D., indicating that variations in particle size composition have a relatively small effect on compacted density up to a fairly high density and become more important at the highest densities. For example, a mixture consisting of 50 w/o (-6 +10), 12.5 w/o (-10 +20) mesh, which was screened from the coarse fraction and mixed with the as-blended medium (17.5 w/o), and fine (20 w/o) fractions, had a compaction efficiency of 93.7%.

Results, however, do not conclusively define the optimum ratios of the several size fractions, because of variations in the rate of filling the tubes, and in the vibration conditions. These variations are reflected in gamma absorptometer traces, which show minor irregularities in the distribution of UO_2 in the rods having lower densities. These irregularities can be prevented by a proper match of feed rate and vibration conditions, or corrected by additional compaction time.

Remaining components for the vibration system have been received recently, and the final checkout is being completed. Compaction of various mixtures will be repeated, using identical conditions, and gamma absorptometer traces will be compared with plots of acceleration versus frequency for each rod, and with visual and photographic observations.

A program was conducted in cooperation with Atomics International for vibrational compaction of uranium carbide in 0.010 inch thick stainless steel cladding. Eleven kilograms of fused UC (-4 mesh) supplied by A.I. was crushed, screened, and blended under an argon atmosphere. Particle size composition selected for compaction was as follows:

50 w/o	-6 +10
12.5 w/o	-10 +20
17.5 w/o	-35 +65
20 w/o	-200

*Ratio of density of compacted fuel to particle density of the powder employed times 100.

Preliminary examination of the material indicated an average particle density of 94.4% T.D.

A plastic glove box was fabricated to permit loading and compaction of the material in an argon atmosphere. Five, 9/16" OD, 0.010 wall, stainless steel clad rods were fabricated. Four were two feet long, and the fifth was eight feet long. Bulk fuel densities are listed below.

DENSITY OF VIBRATIONALLY COMPACTED UC

Rod No.	Length(ft)	Bulk Density		Compaction Efficiency, %
		g/cc	% T.D.*	
1	2	11.65	85.5	90.6
2	2	11.58	85.0	90.1
3	2	11.67	85.6	90.7
4	2	11.63	85.3	90.4
5	8	11.69	85.8	90.9

*Based on 100% T.D. being 13.63 g/cc.

Welded end closures were effected without serious difficulty, using specially designed end caps.

Welding of end caps to five and ten-mil stainless steel tubing by the Magnetic-Force Welder has been tried with some success on the ten-mil material, according to metallographic results. The standard end cap for this welding procedure and several variations of a new design were investigated. The new cap was tapered to permit a press fit. The weld occurred between the side of the tube and the cap. This type of cap apparently eliminates the uneven heat distribution between the thin tube and the cap.

One problem encountered in these attempts was splitting of the collets holding the tube. No welding occurred where these splits were located adjacent to the tube. With the 10-mil tubing, the unwelded areas were eliminated by simply rotating the tube slightly and rewelding.

Difficulties were encountered in making MFW closures of lead-containing PRTR design test fuel elements. Subsequent studies reveal that the OD of the cladding varied and the tubing wall thickness was not within tolerances required by the machine. For each set of machine settings, there appears to be a critical range of acceptable tubing dimensions.

Hot swaging continued to show promise for compacting to high densities UO_2 having poor packing characteristics. Fifteen Zircaloy-4 clad fuel rods containing -100 mesh fused UO_2 were successfully swaged at 850 C. The fuel rods were resistance heated just prior to and during the swaging. The swaged UO_2 densities were 90-91% T.D. For comparison, this particular powder vibrationally compacts to only ~55% T.D., and cold swages to ~80% T.D.

Two hot-swaging problems were solved: (1) Fuel rods for hot swaging were normally plugged with short lengths of asbestos rope to contain the powder during swaging. During heating water in the asbestos was driven off at 600 C and vaporized. High internal gas pressures resulted and often caused or contributed to rupture of the hot, soft cladding near the end plugs. The use of Fiberfrax or similar water-free insulating material to plug the ends of the fuel rods has solved this problem. (2) The graphite brushes used in the resistance heating unit usually become red hot during heating of the fuel rods. Damage to the fuel rods sometimes resulted. These brushes were replaced with copper-bonded tungsten carbide brushes which have higher thermal and electrical conductivities. These new brushes remain relatively cool during operation. No fuel rod damage attributable to these brushes has been detected.

Corrosion Studies

The Effect of H_2 Pressure on Hydriding of Zircaloy-2. It is known that the rate of absorption of dry hydrogen gas into a bare, unprotected Zircaloy surface is approximately parabolic with pressure. In order to investigate the effect of H_2 pressure on the rate of hydriding in the presence of H_2O vapor, vapor-blasted vacuum-annealed Zircaloy-2 coupons were exposed at 400 C to 0.1 mm H_2O pressure with 10, 5, 1, and 0.1 mm H_2 added. It was found that at 1, 0.1, and 5 mm H_2 pressure, the H_2 pickup reached a constant value after about 24 hours. After 24 hours when the ZrO_2 film is formed, hydriding is relatively pressure-independent. The extent of initial hydriding increased with increasing H_2 pressure due to hydriding during the unprotected early portion of the reaction. Furthermore, the extent of initial hydriding was greater in experiments with a larger area of Zircaloy surface present in the system, presumably due to local depletion of the H_2O vapor concentration at the surface. This points to the dynamic nature of the inhibition reaction; it is only water supplied to the metal surface which is effective in slowing the rate of hydriding.

Effect of Oxygen on Corrosion Hydrogen Pickup (pH 10). To determine the effect of oxygen, if any, on the corrosion product hydrogen pickup of Zircaloy-2 and Zircaloy-4, several samples of each alloy were exposed to 300 C, pH 10 water in two different autoclave systems. Hydrogen gas was removed from both systems, but one was maintained at a standard Hanford inlet oxygen concentration in the water of three to four ppm, while the other system was maintained at less than 0.1 ppm oxygen. Except for four samples which had relatively short exposure times, the percent of corrosion product hydrogen picked up was low for both series of tests, ranging 7% or less in three to four ppm oxygen, and 10% or less in 0.1 ppm oxygen. From these tests it is concluded that the low hydrogen pickup of Zircaloy samples in refreshed Hanford autoclaves is due primarily to low hydrogen overpressure rather than to residual oxygen in the system.

Chromium Plating of Zirconium. Dicumene chromium plating compound (obtained from Union Carbide Chemical Corporation) was vaporized into a purified stream of argon which passed through a two-foot x 1/2-inch diameter Zircaloy tube heated to about 320 C. The inside surface of the tube was coated with chromium which varied from two microns (0.08 mil)

thick near the inlet to 0.6 micron thick near the outlet. The thickness of the coating was determined by stripping small segments of the chromium-coated tube anodically in a sodium hydroxide solution. Hydrogen analysis of other segments of the tube (including the chromium coating) showed no hydrogen pickup by the tube during the plating operation. The resistance of the Hanford-applied coating to hydrogen permeation has not yet been determined. Experiments now in progress will attempt to produce a coating of uniform thickness on the inside of a Zircaloy tube for evaluation as cladding for ceramic fuel.

Zircaloy Fretting Corrosion Tests. The Zircaloy-2 fretting samples under test at 316 C and a pH of 10.0 (using LiOH) were removed for examination after 1690 hours of exposure. Both samples were suspended vertically inside Zr-2 tubes with an initial clearance of 20 mils. Normal loop vibration was supplemented on one specimen with an imposed vibration of three cps. The penetrations observed on the Zr-2 members exposed to the supplemental vibration ranged from five to ten mils. The control members had penetrations of about two mils. However, the components in the control test were not contacting each other when removed; therefore, this penetration of approximately two mils may be low. The samples were recharged for continued testing.

Structural Materials Development

PRTR Process Tube Monitoring. All 85 process tubes in the PRTR reactor were examined internally with the Mark I monitor. Two mutually perpendicular inside diameters were measured, and the tubes were inspected visually with a television camera and a movie film recording of each tube was made. The total time required to inspect all tubes including equipment set-up was about 170 hours. The ID varied along the length of the tube by about 0.010 inch. Although the TV camera system used for this examination did not perform well, it was observed that many tubes showed water marks and rust on their inner surfaces. One tube had a rather rough ID surface. On many tubes the nozzle is mounted eccentrically with the tube. In at least some, if not most, of these instances, the gasket was pulled out by the inspection probe. The problems encountered with the monitoring equipment during the first inspection are being remedied before the next inspection, tentatively scheduled for mid-October.

PRTR Process Tube Creep Rates. Annealed 20-inch long samples of PRTR Zr-2 process tubes were tested at each of three temperatures and two pressures for a 48-hour period. The results to date are as follows:

Temp.	Permanent Deformation After Removing Load	
	1100 psi	2200 psi
450 F	None	0.004" (0.11%)
550 F	"	0.004" (0.11%)
650 F	"	0.006" (0.17%)

The BMI tensile creep tests of annealed Zr-2 strip at 550 F and 650 F and at a tensile stress equivalent to 1100 psi internal tube pressure would exhibit about 0.1% deformation in about 48 hours and about 0.25% deformation at a tensile stress equivalent to 2200 psi internal pressure. Thus, the first-stage creep deformation for the PRTR process tubes is lower than for flat strip specimens, presumably due to the grain orientation and biaxial loading of the tubes.

Steel Cladding Materials. Non-destructive testing of 3/4" OD x 0.010" wall x 12" long sample tubes, TIG welded by Airline Welding and Engineering from Fe - 7.6 Al - 5 Cr alloy strip, proved that these tubes are free of defects and acceptable according to specifications.

Sample tubes of the same dimensions but with 0.020" wall thickness, TIG welded by the above company from AISI 406 SS strip, were butt welded into 48" lengths. Although the welds of these tubes were not perfect and rather brittle, one tube was reduced in the as-welded condition in four successive cold swaging operations, without intermediate annealing, from 3/4" to 13/32" OD. This indicates that it should be possible to fabricate fuel capsules from the 406 SS, as intended, by charging 3/4" OD welded tubes with UO_2 and swaging them to finished dimensions. Welded tubing 0.563" OD x 0.010" x 12" of these alloys is on order for experimental capsule fabrication by vibratory compacting of UO_2.

Ultrasonic spot welding of cold rolled 0.010" thick Fe - 7.6 Al - 5 Cr alloy strip produced metallurgically sound joints with no signs of grain growth. Determination of the physical properties of such welds is required.

Allegheny Ludlum Steel Corporation representatives plan to submit and discuss a proposal regarding the hot extrusion and finish drawing of seamless tubes from conventional and modified AISI 406 stainless steel and Ferral type experimental alloys on October 6, 1960.

Radiometallurgy Laboratory Studies

A 7-rod Al-Pu cluster has been photographed, examined, disassembled, and the individual rods measured for length and diameter (RM-656). No serious hydriding was found in the cladding of a purposely defected Zr-4 clad UO_2 element (RM-611). Examination of a PuO_2 capsule showed little recrystallization of the ceramic compacts indicating a lower temperature during irradiation than predicted (RM-654). The Lamprey rare gas collection equipment has been calibrated, installed, and operated successfully. Except for the difficulty in obtaining a vacuum tight seal against the side of an irradiated fuel element, no major problems remain, and there is no obstacle to carrying out a number of fission gas runs with this equipment in the near future.

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

Thermal Hydraulic Studies

Problems of a Small Leak Downstream of the Flow Monitor in a PRTR Process Tube. If a small leak should occur in a reactor process tube, the result would be an increase in flow through the inlet piping including the flow meter but a decrease in flow past the fuel elements. The concern, if such a leak should occur, is whether the increase in flow through the flow monitor is sufficient to cause a high flow trip and a reactor shutdown if the flow past the fuel elements were reduced to a point where boiling burnout would occur.

A calculation of such an event is of interest in the hazards evaluation for any reactor. Therefore, a general analytical procedure was developed to treat this problem. The method will determine the terminal conditions reached following a small leak from a reactor process tube and also describe the maximum and minimum flows during the time before steady state conditions are reached.

This procedure was applied to the PRTR and the results were described in HW-64340 Rev 1.

PRTR Project Management and Design

Phase III PRTR Contract. The Phase III portion (reactor complex and power piping) of the PRTR construction was terminated on September 12, with the contract completion, excluding acceptance test performance, at

an estimated 98% according to AEC determination. Termination of the contract permitted the startup program for the PRTR to commence while the remaining construction is completed by CPFF contractor, J. A. Jones Construction Company. The welding and sniffer testing of the temporary construction opening in the containment vessel was completed prior to termination of the Phase III contract. Listings of all Phase III contract items which were left uncompleted by the contractor have been prepared.

The J. A. Jones work (Phase III-A) on the various mechanical systems stopped on September 20, because of a labor disturbance involving the pipefitters. The primary pumps were readied for installation prior to this date. Preparations are in progress for cleaning and flushing the primary moderator and refelctor systems as soon as work resumes.

During hydrostatic testing of the 26" and 12" steam line upstream of pressure reducing valve, the expansion portion of the line failed. The contractor had procured the bellows sections and tie-rods from Cook Electric Manufacturing Company and field assembled the joint. The contractor procured an additional unit and hydrostatically tested before installation at 675 psig. The entire effluent system up to the PRV will be retested at 675 psi.

The river pump 70-day run-in test was continued with no apparent difficulties.

During Design Test 54, process tube inspection, 15 tube-nozzle gaskets were pulled out of place by the inspection device. Gaskets have been deformed sufficiently by normal tightening so that they are slightly smaller in bore than the process tube. Although no difficulty has been encountered in charging and discharging fuel elements in the laboratory, new gaskets with a larger bore have been procured and will be used to replace present gaskets as necessary.

Installation of the rotating shield has disclosed minor interferences as the result of the paint coating. Operation of the shield during the process tube inspection design test was satisfactory after the paint was worn off the high spots.

The dry gas system blower was shipped from the vendor's plant with minor leaks not repaired. The leaks will be repaired after installation. Design for the new location of the high pressure helium compressors has been completed. Design of additional helium compressor instrumentation to detect diaphragm failure is started.

Installation of the permanent section of the thermal barrier in the lower access room disclosed a very poor fit between the barrier and the wall. The Phase III contract specifications had called for the barrier structure to be constructed to the "as built" dimensions of the wall. The structure has been successfully altered to provide a good fit between the movable and permanent portions of the barrier.

Loadout Cask. The PRTR fuel element shipping cask has been returned from the National Lead Company to Industrial Products Engineers for final finishing. A study of the radiography results disclosed a shielding weakness at the plug end of the cask. The weakness was determined to be due to the design of the plug rather than to a casting void. The plug will be modified or replaced, as determined by the results of further shielding calculation.

Fuel Element Examination Facility. The W. F. and John Barnes Company continued to encounter difficulties which delay the assembly and testing of the primary manipulator. Excessive wear was noted on the chuck drive gears after a short time in service. The cause of the wearing has not been determined.

Minor modifications are being made in the viewer components that go into the control console to clear interferences found on the installed console sections.

Maintenance and Mockup Building. The contract for the M & M Building was awarded to George H. Grant Construction Company on September 19, 1960, in the amount of $633,700. The contract includes the PRP Critical Facility Structure, the PRP Rupture Loop Structure, and the PRTR Stack Filter Structure. The contract period is about eight months in duration. The contractor has performed layout work and excavation is scheduled to start at month's end.

Instrumentation and Control. The vendor of the rupture monitor electronics system is experiencing difficulty with background pickup from the switching circuits, and this problem is delaying final testing and delivery. He is currently revising the circuitry in an effort to eliminate the pickup problem. Representatives of PRTR Operations and of Nucleonic Instrumentation Operation are to visit the vendor to evaluate the status of the system.

The assembly of the mechanical portion of the rupture monitor system was progressing well until the current J. A. Jones labor disturbance involving pipefitters. Currently, nearly all work is stopped. The rotameters were received, and a partial shipment of the needle valves was due on September 26. The solenoid valves were to be shipped prior to September 30. Preliminary work on the wiring of the unit was to begin the week of September 26 but not much progress can be made until the pipefitters complete the assembly step which is currently about half done. Completion of the system appears to hinge on the labor disturbance rather than the material delivery problem which had been limiting.

Work is currently under way on the installation of the reactor radiation monitoring system. Both preamplifiers for the startup channels had been furnished by the manufacturer with the wrong gain and had to be returned for modification. Return shipment was to be made by the end of September. The log count rate meter for the permanent startup channel had several cut wires which resulted in the instrument chassis

being at about 220 volts above ground potential. It is believed that it had been done by the manufacturer when it was returned after the first checkout for correction of a power supply malfunction. The damage will be repaired locally, and the manufacturer will be furnished a complete case history with pictures.

Light Water Injection System. The design of the automatic operation of the emergency light water injection system and the second piping system were analyzed to insure proper operation in cases of two simultaneous failures. Necessary revisions are: (1) additional equipment for the second (low) pressure H20 injection system, (2) an emergency blowdown valve for the primary system for use in event of medium size leaks (50-150 gpm), (3) isolation valve between the emergency water line and boiler feed piping for cases of failure in the boiler feed piping, and (4) an increase in emergency water pressure. Valves are being ordered; the best means of increasing emergency water pressure is being investigated.

PRP Critical Facility (Project CAH-842). Design of the in-cell components was continued. Drawings of the reactor tank assembly, the moderator tank, and the poison injection system are being circulated for approval.

Development of the flux fuses or sensing devices which are to trigger the poison injection system is under way. Both bi-metallic switches and meltable fuses are being investigated.

It has been decided to use the regular PRTR shim rod motor in the control rods. The adjustable weir will use the same motor with a different gear reducer head. A larger motor will be required for the safety rods. Negotiations have not been completed; however, it is planned that orders be placed with Western Gear for these motors within the next two weeks.

Bids were received from United Aircraft and Bendix for the synchro units required for the control rods, safety rods, and adjustable weir. The total Bendix bid was for $47,085 and United's bid for $14,405. Both of these bids are high, and further negotiations are being started in an effort to reduce the cost of this position indicating equipment. The use of a slide-wire potentiometer is being investigated for use on the safety rods; however, accuracy requirements preclude the use of a potentiometer for the control rods.

Fuel Element Rupture Test Facility (Project CAH-867). Bids received for major FERTF equipment during the month are summarized as follows:

Item	Project Proposal Estimate	Low Bid
Immersion Heaters RLH-1	$ 34,000	$22,750 (Montgomery Bros.)
Circulating Pumps RLP-1a,1b	70,000	89,704 (Aldrich)
Regenerator (RLHX-1)	100,000	61,700 (Struthers-Wells)
Zircaloy Pressure Tube	10,000	5,229 (Tube Reducing - does not include material)

It may be necessary to rebid the heater package because the apparent low bidder excluded the specified high temperature connection wire in his bid. The actual price of the pumps may be somewhat greater than that indicated because the low bidder did not include structural pump bases as required by the specifications. Only one bid was received for the Zr-2 process tube assemblies. As a result, the AEC will negotiate with Tube Reducing on the final cost.

Specifications and purchase requisitions for the loop storage tank, deoxygenator, chemical feed system, cleanup system deionizers, makeup system deionizers, and heat exchanger RLHX-2 are being routed for approval.

Drawings of the test section outlet nozzle were completed and issued for comment. Tentative design for the tube inlet assembly was completed, and drawings are being prepared. Comment drawings of inlet and outlet access spare piping have been issued.

Negotiation for design of the water plant and holdup tank by an outside architect-engineer is in process.

Over-all completion of the GE portion of the detail design is 32%.

Design and Component Testing

PRTR Fueling Vehicle. Fabrication of the replacement fuel element shroud assembly is complete. A thermocouple installation for measuring fuel element surface temperatures while positioned in the fueling vehicle has been designed. Work instructions have been issued for installing the fuel element surface thermocouple, gamma monitoring alarm system, skirt overtravel safety cables, emergency hydraulic bridge brake, air cooling filter shielding, and replacement air cooling coil.

PR-10 - Primary Loop Mockup. The malfunction of the high pressure seal in the spare PRTR primary process pump was found to have been caused by failure of the guide bearing in the 350 h.p. drive motor. Excessive vibration caused some heat checking of the rotating face although no serious damage was observed. The pump was re-assembled after bearing replacement using the slightly damaged seal components without relapping. The high pressure seal is operating normally after an additional 378 hours this month, for a total of 1952 hours.

The pump was started with full suction pressure of 1025 psi, and, as on a previous occasion, the leak rate from the high pressure seal assumed a higher rate of 1.1 gallons per hour. The pump was operated for 140 hours without any noticeable change in rate. The pump was shut down and restarted at 600 psi suction pressure and resumed a normal leak rate of 0.1 gallon per hour. The thrust reversal resulting during a high pressure start apparently causes the higher leak rate.

The prototype pump with the self-adjusting seal assembly has operated for a total of 2724 hours without incident. The leak rate is 0.7 gph at conditions of steady, high temperature loop operation. An order has been

placed for one of the four optional self-adjusting seal assemblies for future testing in the spare PRTR pump. The option for the other three assemblies has been extended for an additional six months.

The Aldrich injection pump has now operated 1488 hours with the R/M Vee-Flex rings. The packing glands, which have been adjusted twice during the month, now have leak rates of 220, 1800, and 200 ml/hr.

Process Tube No. 586-6063, which contains a prototype 19-rod cluster element, has been operated for 375 hours and 17 thermal cycles during the past month for a total of about 4125 hours at simulated reactor conditions.

Process Tube Seal Experience. Leakage results from the Single Tube Prototype and the Flexure Test Loop seals have remained essentially unchanged during the past month. The Flexure Loop operation was shut down September 16, and the test pieces removed for gasket inspection. It has been found in the reactor that gasket extrusion and inner spiral ring buckling causes gasket projection and interference in the process tube bore. Test operation of the Flexure Loop will be resumed when new gaskets with an enlarged ID are received.

PR-40 - Shim Control Mockup. The shim control drive with Western Gear Motors was operated for a total of 1115 cycles during the month, which is equivalent to about 112 hours of continuous operation. Some tendency for the drive to jam during the last one hundred cycles was observed. This jamming, when it occurred, could be released by reversing the direction of travel momentarily, and then the drive would continue to function. This drive was disassembled to determine methods of installing a small brake on each motor to prevent possible drifting.

A brake on the lower end of the lead screw immediately above the lower bearing block was tried. This brake consisted of a spring loaded hard rubber brake shoe in contact with the aluminum lead screw. This brake worked satisfactorily; however, methods of equalizing the radial thrust and controlling the torque applied by the brake are being investigated.

Irradiation of the Western Gear motor was stopped after it was exposed to 10^8 R gamma. It was returned to the 314 Building and has been set up for testing. Testing of the motor is not yet complete.

Four drives have been received from APED, San Jose. This leaves only one drive yet to be delivered.

PR-70 - Helium Compressor Test. A Hanford rebuilt oil pump using a hardened steel liner and piston without rings was operated for 150 hours and was found acceptable for reactor use. Leakage rate throughout the test remained constant at about 35 ml per minute. Three pumps have now been run in and approved for high pressure stage compressor operation. A fourth pump is now being prepared for testing. This pump, if satisfactory, will provide two complete sets of pumps for reactor operation.

PRTR Special Reactor Tools. Remote locations, radiation hazards, and the necessity of performing certain maintenance operations through the rotating shield requires the use of special tools. Some of these special tools have been turned over to reactor operations personnel while others are still in the design and testing stage. The following special tools have been delivered to the PRTR Operations group:

1. PRTR Shim Rod Electrical Disconnect Wrench and Discharge Tool, SK-3-9407 and H-3-13389. These tools are used to remove and replace the amphenol connector on top of the shim rod and to provide a hook for the C-D machine to remove a used shim rod assembly.

2. PRTR Shim Rod Flange Wrench, H-3-13350. This wrench is used to remove and replace the three socket head screws holding the shim rod assembly to the top shield.

3. PRTR Jumper Nut Wrench, SK-3-9408. PRTR Nozzle Nut Wrench, SK-3-9417. These wrenches are used in removing or installing a jumper.

4. PRTR Miscellaneous Wrenches, SK-3-9424.

   (a) Nozzle Nut Torque Wrench
   (b) Jumper Nut Torque Wrench
   (c) Jumper Spreader
   (d) Nozzle Cap and Set Screw Wrench.

   Wrenches (a) and (b) are used in conjunction with the Jumper Nut Wrench and Nozzle Nut Wrench for first loosening and last tightening of the nozzle and jumper nuts. Wrench (c) is used to spread two jumpers apart to give sufficient clearance for the Jumper Nut Wrench. Wrench (d) has two interchangeable heads; number one for removing and replacing the nozzle cap, and number two for removing and replacing the Allen Lead screws holding the inlet bellows in place.

5. PRTR Seal Cap Wrench, H-3-13390. This is a wrench used to loosen and tighten the three socket head set screws in the nozzle cap.

6. PRTR Splash Guard and Installing Tool, H-3-13692. The splash guard is a funnel which is screwed into the top of the nozzle, after the cap is removed, and allows faster removal of the fuel element without loss of the heavy water.

7. PRTR Process Tube Nozzle Gasket Replacement Tools, H-3-13387. These tools are used to lift the process tube nozzle assembly above the rotating shield. The assembly is then clamped in place, the nozzle removed, and the gasket replaced.

8. PRTR Fuel Element Basket Stand, H-3-13388. This is a device which holds the loadout cask basket in a vertical position to receive the irradiated fuel elements.

9. PRTR Core Saw, H-3-13366. PRTR Cut-off Saw, H-3-13365. If it is necessary to discharge a process tube fuel element assembly, the core saw is used to cut off the nozzle elbow and hold-down bolts to free the process tube from the reactor. In the case where the process tube cannot be completely raised into the charging machine, the cut-off saw is used to cut off that portion of the process tube which extends below the charging machine.

Special tools which are in the design, fabrication, or testing stage are:

1. Load-Out Cask Gate Wrench. The cask used to transport irradiated fuel elements to the separations plant must be opened and closed under water because of radiation hazards. The load-out cask gate wrench will perform this function. Fabrication of this tool is 95% complete.

2. PRTR Load-Out Facility Hanger Replacement Tool. When the irradiated fuel elements are placed in the cask basket (which is then placed into the cask), the long fuel element hanger is removed and a small lifting bail attached to the top of the fuel element. The Hanger Replacement Tool is used to accomplish this in two steps: (1) the tool is used to pull the pin or pins holding the long hanger to the fuel element; (2) the tool is then used to pick up a lifting bail and pin and attach them to the fuel element. Design of this tool is complete, and fabrication has been started.

3. Process Tube-Nozzle Alignment Mandrel. It has been determined recently that very accurate alignment is required between the process tube and nozzle. To accomplish this, an expanding mandrel is being designed which, when inserted into the assembly, will maintain the alignment of the process tube and nozzle while the flange bolts are drawn up. Design of this tool is 50% complete.

PRTR Unit Motion Study. The necessity of maintaining alignment between the primary shields and calandria requires that periodic position checks of these components be made.

The camera which has been modified for photographing the unit motion indicators has been tested. A few minor modifications to the camera will be required before it is released to reactor operations.

Installation of the reference targets for the optical measuring system has been started.

Design Analysis

PRTR Safeguards Review. The PRTR was reviewed again by the General Electric Reactor Safeguards Council at their sixteenth meeting on September 8. Presentations were made to the Council on three subjects:

1. Supplement 1 to the Final Safeguards Analysis, HW-61236, SUP 1.
2. Plans for the startup program.
3. A preliminary description of the gas-cooled loop.

The Council recommended that visual alarms be added to indicate the closure status of the single freight door and the sluice gate in the fuel handling passage. Although some concern was expressed about the problem of satisfactorily completing safety checking and construction inspection after the premature termination of the construction contract, it was concluded that present plans seem to be adequate.

The Council further concluded that there seems to be no reason why the preliminary critical testing and design power testing of the PRTR should not proceed as planned. It was requested that the PRTR Sub-council be informed about progress of this testing at the point of first critical operation, the point of first operation at 1 MW, at first attainment of full power, and at any other point if significant deviation from predicted operating conditions should be observed.

PRTR Safeguards Analyses. Analog computer studies of various PRTR nuclear excursions were conducted to supplement previous studies.

A study was made of fuel temperature during a startup accident under the following conditions:

1. The reactor was loaded for full moderator level operation with shim rods in.

2. All shim rods had been withdrawn, reducing the critical moderator level to 3.75 ft.

3. The moderator was then raised at the maximum possible rate with the rate of moderator level increase being controlled by the gas balance system pilot valve.

The results of this study indicated maximum fuel temperatures of about 320 F. Studies of the consequences of various step and ramp reactivity inputs were conducted for completing the "Uniform Reporting Form for Accident Analysis" proposed by the General Electric Reactor Safeguards Council. These studies indicated that a step reactivity change of about 13 mk or a ramp change of about 19 mk per second would be required to melt Pu-Al cores. A step of about 19 mk or a ramp of about 25 mk per second would be required for melting of UO_2 cores or melting of fuel element jackets.

For the PRTR the maximum ramp input, obtained by simultaneously withdrawing shim rods and raising moderator level, is less than one mk per second. No means of inserting a step reactivity increase is known.

PRTR Startup Preparations. The report of the IPD team which audited the PRTR Startup and Operating Plans has been received. This report (HW-66559) contains some 30 recommendations and about 20 additional suggestions which are currently being studied. These recommendations and suggestions are not such as to significantly affect the schedule for the startup program.

Detailed procedures for the first fourteen critical tests have been completed and reviewed in conjunction with the Critical Test Sub-council. A scram transient test is to be appended to Critical Test 10 to comply with recommendations made by the IPD audit team. The objective of this added test is to measure the transient neutron flux following a scram while the moderator level is rising (from sub-critical level) at the maximum rate.

Planning and review of Power Tests is continuing in conjunction with the Power Test Sub-council. The Xenon Poison and Shielding Adequacy Test descriptions have been rewritten in greater detail.

PRTR Physics Analyses. A study of power generation and neutron flux in both the gas and rupture loops has been completed. Maximum values of 1.1×10^{14}, 7.4×10^{13}, and 4×10^{13} n/cm^2-sec were calculated for the unperturbed thermal, epithermal, and fast fluxes, respectively. The peak power density for a Mark I fuel element at both loop positions was calculated to be 180 kw/ft. Details of this investigation are given in HW-66604.

Several additional two dimensional, three-group calculations of the PRTR core have been performed. Cases considered were for fresh (unexposed) fuel and for burnout times of 30 and 60 days. In each case the loading was 51 UO_2 elements and 3/4 Pu-Al spike elements, with moderator at full height. A report summarizing all of the two dimensional calculations made to date is being written.

A solution has been obtained to the problem of predicting changes in effective multiplication due to variation of reactor parameters. This is an extension of earlier work which now includes a three-energy group, multi-region model of reactor systems. The perturbation method used indicates the sensitivity of influence on multiplication of each parameter in any region through the integral of products of group-flux and group-adjoint flux distributions (and their gradients) in that region. The three-group, one dimensional diffusion theory reactor code (for the IBM-709) FLUX-WEIGHT is now being modified to include this calculational option.

A calculational review was made of the shielding placed outside the containment vessel to reduce radiation through the large steam line penetrations. It was concluded that the shielding was adequate as planned. Calculated dose rates outside the vessel were found to be less than 20 mr/hr through the hole and less than one mr/hr through the bulk shielding.

Plutonium Fuel Physics Studies. A calculational study of mixed oxide fuel elements (PuO_2-UO_2) has been completed for varying mixture percentages and densities. Cladding materials considered have included Zr, Cd, Ta-Zr, and Hf-Zr. Varying Pu-240 content for fixed PuO_2 content has also been studied. Most of the mixtures studied show strong self-shielding effects. These calculations are being used by Plutonium Metallurgy Operation in the design of rabbit capsules for irradiation in the MTR, as part of the program for development of promising plutonium-bearing fuel concepts.

PRTR Operations Planning

Preparation of PRTR Operating Standards continued. Fifty-five of the 91 standards pertaining to the reactor have been issued. Review and approval of the PRTR Operating Procedures by the PRTR Startup Council continued. Sixty-four of the 92 procedures have been approved.

An extensive electrical system study program, which began in June, was completed. The object of this program was to train one nonexempt engineering assistant on each shift to troubleshoot electrical circuit problems. The D_2O Inventory Procedure for PRTR heavy water systems was completed during the month. The two PRTR engineering assistants, who had worked in the Radiometallurgy Building to gain experience in inspecting and handling irradiated elements, returned to PRTR this month.

Training continued with emphasis on Operating Procedures and the Electrical Manual. Considerable on-the-job training is being accomplished during Design Testing.

Spare diaphragms and check valves for the Hofer helium gas compressors have been received. Other spare components are not yet available. Autoclave Engineering, the U.S. importer, indicates that parts delivery from Germany is unreliable. Autoclave plans to manufacture spare parts in this country to relieve the parts shortage.

Card indexes, which catalog all equipment changes and system acceptances, are being adjusted to reflect Phase III-A work. The various systems are being cataloged to provide flexible records of system acceptance with exceptions.

The starting battery for the diesel pump was found to be damaged through failure to add sufficient water to the cells while this equipment was in the custody of the Phase III contractor.

Installation of the temporary shop is in progress by Minor Construction forces. Currently, the lack of shop facilities limits the effectiveness of the Plant Forces group.

Design Tests. Performance of design tests started September 12, 1960. During Design Test #12, Secondary Coolant System - Miscellaneous, the process water pumps were found to be misaligned. In addition, the pumps vibrated excessively. It was necessary to completely overhaul all three of the pumps before they could be operated satisfactorily. Much difficulty

was experienced with the automatic cycler and valves on the water softeners before these units could be tested successfully.

The primary system ion exchanger was replaced remotely under Design Test No. 37, Ion Exchange System, with little difficulty. A number of welds were found in the piping from each of the four ion exchangers to the extension piping in the containment vessel which prevented the passage of the internal pipe cutter. These extensions will be replaced by Minor Construction prior to operation of the coolant systems.

Design Test No. 43, Moderator Storage Tank Volume Determination - H_2O, was satisfactorily completed. Surveying for the locations of remote targets for the unit motion readings under Design Test No. 35, Unit Motion, was started.

Five Design Tests were essentially completed during the month:

Design Test No. 10 - Raw Water System
Design Test No. 17 - Compressed Air System
Design Test No. 22 - Effluent System
Design Test No. 32 - Air Locks
Design Test No. 33 - Communications and Alarm System.

Approximately five percent of the design test work has been completed to date. HW-61900-A RD, PRTR Design Tests, Test Performance Issue, was issued during September.

Power Tests. A schedule for the preparation of the detailed test description for the individual Power Tests and for the preparation of the detailed procedure for each test was prepared by the Power Test Sub-Council. By month's end four test descriptions had been presented to the Startup Council. Five more will be presented early next month. Adherence to the present schedule will result in the Power Test descriptions being completed by December 31, 1960.

Critical Tests. Preparations for Critical Test performance continue. Agreement was reached with Security for storage of fuel in the containment vessel during the testing program. Test procedures for the first group (14 tests) were completed and are currently being reproduced. Instrumentation for the test is being installed in special cabinets and instrument cables are being fabricated. Data books and data sheets are complete. Material procurement and fabrication are on schedule.

Design and Construction Liaison. The Test Engineer visited the Struthers-Wells plant to inspect the Gas Loop ex-reactor components to determine if adequate access room for maintenance work would be available if the package were installed against the wall of B Cell, as presently planned. Inspection indicated that maintenance access to the components located near the back of the packages would be difficult. Layouts are being made to determine if it is feasible, both economically and time-wise, to relocate the equipment package to allow access from both sides. If it is possible to improve access, the costs and personnel exposure required for maintenance will be materially reduced.

2. PLUTONIUM CERAMIC RESEARCH

Experiments during the past month have been directed toward determining the effect of calcination temperature and water content of hydrogen on the structural stability of plutonium dioxide. Oxide powders were obtained by calcining plutonium oxalate in air at 150 C increments over the range 150-1050 C. Pellets of these various powders were heated at 1100 C in hydrogen containing from 0.45% to greater than two percent of water vapor. The initial data showed densities to be inversely proportional to the amount of water vapor in the gas. X-ray diffraction showed no suboxides present in any of the samples, and lattice parameters of the PuO_2 phase were very near 5396 A, which indicates no oxygen loss during heating. The samples were then heated to 750 C in oxygen. Extrapolation of weight gain data showed that a very slight reduction had occurred to all samples during the hydrogen sinter. The oxygen/plutonium ratios averaged about 1.99 with a low of 1.972. With this slight reduction, there was no apparent correlation between O/Pu ratio and calcination temperature or water content of the gas. Experiments at higher temperatures and in vacuum are presently being carried out.

Stoichiometric PuC was prepared by reacting alpha-Pu metal with carbon at 1150 C in vacuum. The lattice parameter was 4.970 A, which corresponds to the carbon-rich end of the PuC phase field. A very small quantity of PuO_2 was present and is probably the remains of an oxide coating on the metal particles. No Pu_2C_3 was noted. The material, upon removal from the furnace, was extremely pyrophoric, and data are presently being obtained on the "deterioration" of plutonium carbide in air. A sample of Pu metal plus carbon plus 50% UC was heated at 1150 C in effort to get data on solubility in this system. The temperature was apparently too low since both a UC and PuC phase resulted. Homogenization at 1600 C for four hours gave what appeared to be a single phase. Resolution of this phase was difficult since due to the pyrophoricity the sample was not polished. The lattice parameter of this phase was 4.971 A, which is about 0.005 A greater than that calculated for the PuC - 50 w/o UC solid solution.

A new top plate for the thermal conductivity apparatus has been designed. This plate, which is water-cooled, is presently being built. It is anticipated that this new part will eliminate many of the vacuum problems with which the program has been plagued.

Discussions have been carried out with PMO and BMI personnel pertaining to the possibility of thermal conductivity measurements on irradiated ceramics containing plutonium. BMI would build a device which would be operated within a dry box inside of a hot cell. Samples about 1/2" dia. x 5/8" long have been proposed and would be acceptable. The possibility exists of using UO_2-PuO_2 specimens which are presently available after MTR irradiation to about 2000 MWD/T. A major difficulty, however, will be in extracting a specimen suitable for conductivity measurement, since flat, parallel ends and a smooth surface are required.

In the investigation of the PuO_2-ZrO_2 system, x-ray diffraction patterns have been received for 18 sintered specimens ranging in composition from 0.5 w/o PuO_2 to 95 w/o PuO_2. Photomicrographs indicate a two-phase region at 0.5 w/o PuO_2. The intensity of the (111) monoclinic reflection was measured as a function of PuO_2 concentration and used to quantitatively analyze the two-phase (monoclinic-tetragonal) region for the monoclinic constituent. This (111) line disappeared at approximately 40 w/o PuO_2. The single-phase tetragonal region extends to 72 w/o PuO_2. In all higher concentrations of PuO_2, the solid solution is cubic, indicating that the ZrO_2 is in solution.

3. URANIUM DIOXIDE FUELS RESEARCH

Fuel Evaluation

A very small amount of hydride was observed in Zircaloy-4 cladding (low Ni content) during post-irradiation examination of the fourth deliberately defected and irradiation swaged UO_2 fuel rod. The hydride (< 100 ppm maximum H_2) was localized near the 0.006 inch defect hole. The hydride concentration was much lower than that observed in the previous defected fuel element irradiations using Zircaloy-2, even though the irradiation conditions were more severe than those of any of the previous defected element tests. The preliminary results from this series of tests indicate that Zircaloy-4 is more resistant than Zircaloy-2 to hydriding during irradiation of a defected UO_2 element.

A 7-rod, swaged UO_2 cluster purposely defected with four 0.006 inch holes is being irradiated in the ETR at a maximum surface heat flux of approximately 475,000 BTU/hr-ft^2. The swaged UO_2 fuel element contains PRTR rods clad in both Zircaloy-2 and Zircaloy-4 (low Ni content). Maximum amounts of fission products release occurred during the first part of the irradiation, primarily after the first power cycle. The coolant temperature during the irradiation has been approximately 125 F. The coolant temperature will be increased to >500 F before termination of the test.

Swaged UO_2 capsules have attained estimated exposures up to 19,000 MWD/T in ETR-MTR.

Basic Studies

The outer, finned aluminum cladding for "Prometheus I" (ultra-high core temperature fuel element test) has been received. The tantalum inner tubing is on order.

Single crystals of UO_2 have been sectioned into 0.050 to 0.060 inch thick slices for irradiation in the ETR. Pre-irradiation electron microscopy studies of this material are being completed.

Establishment of the high temperature electron microscopy laboratory proceeded satisfactorily. The laboratory space has been completed according to original plans. Accessory equipment has been received (including vacuum evaporator and quartz liquid-reagent still), and is being installed

and adapted for specific applications. The JEM microscope was received and preliminary installation completed, including provision for three-phase power, running multiple-cable wiring between the microscope and its remotely located power supply, and connection of water cooling lines. Assembly and testing of the microscope is scheduled coincident with the arrival of the vendor's physicist-engineer, about October 1.

Measurement of thermal conductivity has continued on the non-irradiated UO_2 sample prepared by sintering material compacted on the 300-ton press. The measurements (at BMI) have been made to 1300 C; the values obtained continue to fall between the curves established in earlier work on isostatically pressed and extruded samples.

No further measurements have been made on irradiated UO_2 at BMI, following recent refurbishing of their hot cell. Irradiated specimens removed from the Hanford reactor in June, having a burnup of about 0.05%, are ready for shipment. Additional samples removed from the reactor earlier (at about 0.02% burnup) and broken during removal from the capsule will also be shipped to BMI; measurements on these pieces probably will be made using special adaptors in the existing apparatus at BMI. Attempts are currently under way in Radiometallurgy to grind the broken end of several pieces to a suitably flat condition.

The melting points of uranium dioxide samples irradiated to various exposures have been determined. A plot of melting temperature versus burnup shows a maximum melting point at about 0.06 a/o burnup of the uranium. The maximum occurred at approximately 135 C above the melting point of unirradiated UO_2. A gradual decrease in melting temperature to 2800 C, for material having 1.74 a/o burnup, was observed. The change in volatility with irradiation follows the same trend as the melting point but decreases initially. Crystal growth by vapor deposition occurs with irradiated UO_2 as it does with unirradiated material, but higher temperatures are required.

A new hooded enclosure was designed for the furnace to reduce possible personal hazards arising from work with UO_2 irradiated to very high burnups. A furnace which permits measurement of specimen temperatures, while observing the specimen from the side of the tungsten filament, has been designed and built. This furnace will facilitate taking motion pictures of specimens from the side, against a dark background, while taking temperature measurements simultaneously.

Electron micrographs of UO_2 compacted to high density by high energy impact, using a Dynapak machine, reveal the presence of micropores caused by the residual gas trapped in the UO_2 powder. Although the capsules containing the UO_2 are sealed in vacuum after heating them to 600 C, it is possible that the excess oxygen contained in non-stoichiometric UO_2 is liberated at the temperature of compaction (1100-1200 C). Future experiments will determine if this is the case.

4. BASIC SWELLING STUDIES

The irradiation of general swelling capsule No. 4 containing four natural uranium spheres has continued at a control temperature of 550 C. Components in this capsule still retain their original integrity. Capsule No. 5 containing two natural and one three percent enriched sphere operated at a control temperature of 525 C under continued irradiation during the month. Numerous problems concerning external equipment have arisen in connection with this latter capsule. The loss of one thermocouple occurred when the power to the heater was interrupted due to a circuit checkout at another part of the reactor. This thermocouple loss was believed due to the thermal shock to the capsule during the accidental power outage and the subsequent sudden re-application of full heater power when the blown fuse was replaced. A spurious AC signal is also occasionally being picked up by the thermocouples on this capsule causing errors in the temperature indicating equipment. The behavior of the capsule has revealed that placing specimens with more than one enrichment in a single capsule results in very large longitudinal temperature gradients. In this instance temperatures differ by 150 C between specimens. Capsules assembled in the future will, therefore, contain specimens of but a single enrichment.

The assembly of a general swelling capsule containing three split, hollow cylinders of natural uranium is in the final stages. Two of the cylinders are as-machined from the extruded rod and contain fine but oriented grains while the third was oil quenched from 730 C after machining and has a large grain size. Further assembly and testing of the metallographic swelling capsules, which are also part of the over-all swelling program, have been postponed to allow for delivery of some redesigned components.

Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. Such information is needed for understanding how gas atoms migrate, coalesce, and grow into large pores. The following table lists pertinent swelling data for uranium as a function of post-irradiation annealing. The uranium specimens had been irradiated under restrained conditions at a core temperature of approximately 550 C and a periphery temperature of 350 C to a burnup of 0.29 a/o prior to the annealing. Inspection of the table reveals good agreement between the experimentally determined $\Delta\rho/\rho$ ratios (immersion medium was tetrabromoethane) and the pore void fraction values determined statistically from electron micrographs. Since the pore void density values increase and then decrease with increasing annealing temperature, it is obvious that at the lower annealing temperatures, gas agglomeration into observable pores occurs. At the higher annealing temperatures, pore elimination occurs by one of two processes: (1) resolution of gas atoms from small pores and precipitation on larger, growing pores; (2) growth of large pores which consume nearly stationary smaller pores. Which of these two processes is applicable should be determinable from comparison of the pore size frequency curves which have been prepared for the specimens studied.

The densities of two unrestrained specimens irradiated in a NaK environment to nominal burnups of 0.03 a/o and 0.07 a/o are 18.894 and 19.049, respectively. The precision and accuracy of the individual measurements made have been analyzed and were found to be good. The apparent increase in density from the initial value of 19.01 g/cc cannot be explained at present. The sample has been ground down to half the original size for additional metallography and density determinations.

SWELLING IN URANIUM DUE TO POST-IRRADIATION ANNEALING*

Specimen History	ρ	$\Delta\rho/\rho$	Pore Void Fraction	Pore Void Density/μ^3	Ave. Vol./pore μ^3
Pre-irradiation	18.92	--	--	--	--
Post-irradiation	18.62	0.016	0.028	3.05	0.009
600 C Anneal	17.68	0.066	0.068	7.72	0.009
650 C Anneal	17.20	0.091	0.096	6.16	0.016
700 C Anneal	17.18	0.092	0.098	2.96	0.033

*Specimens were held at annealing temperatures for one hour; heating and cooling rates were 50 C/hour, and these were reduced to 10 C/hour within a 40° range of the transformation temperature during the 700 C anneal.

In-reactor swelling experiments of Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposures are being conducted employing NaK filled, temperature monitored capsules. Five swelling capsules GEH-14-98, 14-99, 14-101, 14-104, and 14-105, are presently being irradiated in the MTR with goal exposures in the range 0.25-0.31 a/o B.U. Exposures and average center uranium temperatures for the fuel rods in these capsules through MTR cycle 143 are, respectively, 0.25, 0.09, 0.29, 0.25, and 0.36 a/o B.U., and 500, 290, 450, 600, 335 C. A sixth capsule of similar design, GEH-14-102, was charged in the ETR at the beginning of cycle 30. Center uranium temperature is 425 C. Two swelling capsules GEH-14-97 (0.42 a/o B.U., and 650 C) and 14-103 (0.21 a/o B.U., and 300 C) are now awaiting examination at the Radiometallurgy Operation. Density decreases up to 3.1% were measured on three Zircaloy-2 clad fuel rods irradiated in NaK swelling capsules. These were irradiated to a burnup of 0.25 a/o at center temperatures ranging from 480 to 525 C. Three other fuel rods irradiated under identical conditions but which suffered cladding failures at some time during the irradiation have density decreases in the range 3.7 to 7.3 percent. The difference in density changes between the failed and unfailed fuel rods may demonstrate the effect of external restraints on uranium swelling. The minimum nominal cladding thickness in the unfailed fuel rods was 0.020".

5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

The creep measurements of a Zircaloy-2 specimen in-reactor are continuing in the single prototype capsule. No new creep rates have been obtained since the last rates were reported due to transient operation of the reactor and capsule malfunction. Loss of helium to the capsule occurred during the month due to an external piping leak. Loss of helium removed the stress from the sample. During the time the helium leak was being repaired, the capsule was checked for helium leaks and none were found. That test revealed the numerous radiation-resistant ceramic seals in the capsule are still helium tight and that no leak has developed in the bellows.

The capsule is now back in operation and will continue for at least another month before it will be removed and replaced by a new capsule. The creep rate at 33,000 psi and 500 F stress should be established during this month in the prototype capsule.

The new, second-generation capsule will be charged early in October to begin the next series of in-reactor creep tests. Final checks made on the mechanical extensometer in the second-generation capsule have been completed. The mechanical system performed quite well, reproducing within three micro-inches over the operating temperature range of the capsule. Duplicate components used in the mechanical extensometer have been life tested. The limiting component is the 20,000 to one gear box. The first few gear boxes lasted only about 50 hours. Reduction of the operating speed increased the life expectancy to 100 hours. This 100-hour life will be adequate to accurately check the electrical transducers every few days for a period of a year. The life of the gear box limits its use to that of a secondary standard in this set of capsules.

Extensometry (the measurement of specimen elongation) is still the major problem in the capsule design and construction. Extensometry also accounts for the largest single portion of cost in the capsules, as well as the difficulty of capsule assembly. Simplier methods of extensometry are being considered. One method is a linear variable transformer which is now being bench tested. The linear variable transformer is of radiation-resistant construction and has demonstrated 20 micro-inch sensitivity at room temperature. Elevated temperature tests are now in progress. Another method of extensometry, which has been proposed, is a cavity resonator whose frequency of resonance is changed by increasing the length of the cavity. The length change of the cavity would be coupled to the elongation of the specimen, and the change in frequency of resonance would then be compared to a standard cavity also in the capsule. It is predicted that the method would be capable of 10 micro-inches sensitivity. Apparent advantages of a resonant cavity system are: combined sensitivity and range, all metal construction, and light weight for reduced gamma heating. A system combining a sensitive transducer with a precision screw for range extension is being mocked-up in the laboratory for evaluation at the present time.

6. GAS GRAPHITE STUDIES

EGCR Burning Hazard Evaluation. Data from initial experiments on the EGCR graphite oxidation prototype demonstrated several combustion characteristics of the reactor. The data must be normalized to actual reactor conditions to be applied; however, the following trends should still be valid.

(1) Runaway (or uncontrolled temperature rises) can occur with graphite temperatures as low as 400 C and inlet air at room temperature. However, the temperature rise rate is slow, up to about 650 C (equal to or less than 1 C/min). Thus, a considerable safety factor is provided.

(2) When a severe runaway has been established at a graphite temperature at or above 740 C, the graphite temperature rises exponentially. Increasing the air flow up to 11-fold served only to make the runaway more severe rather than arrest its course.

Graphite Air Oxidation. Experiments to date indicate gamma irradiation significantly increases graphite oxidation by oxygen at temperatures up to 650 C. An increase of oxidation rate by a factor of 16 is noted at 650 C. However, since the activation energy of the gamma enhanced reaction appears to be 10 to 15 kcal/mole lower than the thermal rate, the relative importance of the irradiation-induced oxidation becomes less as temperature increases.

Oxidation of SiC-Coated Graphite. The first group of SiC-coated graphite rods from the Carborundum Company that had been in reactor and received approximately 3000 MWD/AT exposure was tested for oxidation resistance. The samples were exposed at 1000 C with an air flow of one cfh. Five samples were tested - one failed after less than 75 hours and the other four ran 244 hours with no signs of failure. Failure was indicated by excessive weight loss of the graphite.

Thermal Cycling of SiC-Coated Graphites. As part of the coatings evaluation program, five graphite spheres coated with siliconized SiC by the Minnesota Mining and Manufacturing Company were thermal cycled in air from 200 C to 1200 C at six cycles/hr. After 58 hours, one sphere had developed circular cracks and showed a weight loss. All others showed no cracks and a slight weight gain of two to three milligrams.

Microwave Activation of Nitrogen Gas. Studies of the weight loss rate of graphite in flowing nitrogen (700 pressure) activated by a microwave discharge are continuing. The specific weight loss rate appears to decrease with an increasing number of hours in the glow. Total times in glow from approximately 1.5 to 24 hours have been used giving weight loss rates in the range of 2×10^{-4} to 8×10^{-5} gm/gm-hr.

Surface Oxide Formation. Studies are continuing on graphite surface oxide formation in flowing CO_2 and CO systems. Preliminary results using CO as the gas show a weight gain of 4.15 mg in 87.5 minutes at 800 C. The rate of approach to equilibrium is of the same order of magnitude as in the CO_2 system.

GETR Irradiation of EGCR Graphite. The H-3 capsule in the GETR is scheduled for removal after four cycles of irradiation on October 3. Samples in the capsule will be measured and then prepared for re-insertion into the GETR. Part of the samples will be replaced with actual EGCR graphite, which is now available.

Gas Loop Project Management and Design (Project CAH-822). The gas loop completion date has been extended to June 30, 1961, by AEC Directive No. AEC-145-Mod. 4, dated September 13, 1960.

Final testing of the Phase "A" assembly (gas loop proper) was performed by the vendor, Struthers-Wells, during the early part of September. The pneumatic and leak tests were successfully completed except for one Fisher-Governor and two General Kinetics valves and bellows, which showed leaks. These were removed from the loop and returned to the suppliers for repair. After repair the items will be shipped directly to HAPO for reinstallation. Shipment of the Phase "A" subassemblies is expected to start about mid-October and extend over a two to three-week period. The flow tests required for the loop were deleted because the primary blowers were not available from Bristol-Siddeley. No further progress with the primary blowers for the gas loop has been reported by Bristol-Siddeley. Details of the primary blowers were forwarded to the General Engineering Laboratory to determine what assistance GEL could provide on the blower problems.

Installation of the 2400-volt metal-clad feeder switchgear which will feed backup emergency power from the 384 Building emergency turbine-generator to the Gas Loop and Fuel Element Rupture Test Facility in PRTR has been completed.

Gas Loop Component Testing. The prototype process tube was installed in the 314 Building loop mockup and the main loop piping completed. Recirculation of helium in the gas loop shroud was unsuccessful due to excessive pressure drop in the two main loop heat exchangers. Pressure drop in the heat exchanger directly downstream from the compressor is approximately 10 psig at 274 lb/hr helium flow (total compressor capacity). Total pressure drop of the entire system cannot exceed 10 psig, and it will be necessary to replace the heat exchangers or add heat exchange units in parallel with the existing exchangers prior to system operation. The Roots-Connerville blower has operated satisfactorily thus far.

Cycling of the Solar Aircraft gimbal joint continued during the month. The furnace was shut down September 21, when a small leak was detected. Location of this leak has not yet been determined. A pin joint furnished by Arrowhead Products will be tested next.

Equipment for monitoring in-reactor movement of the PRTR high pressure tube relative to the shroud tube is being irradiated in a production reactor. One of the Fenwal line detectors failed after reaching an accumulated neutron dose of 10^{17} nvt. The other instrument is still operating with an accumulated exposure of over 10^{20} nvt.

Irradiation Effects on Nickel-Base Alloys for Gas-Cooled Loop Facility. Nickel-base alloys will be used as in-reactor structural materials for the gas-cooled loop in PRTR. An important factor in the performance of candidate materials such as Inconel, Inconel 702, Hastelloy X and Hastelloy R-235 is the effect of irradiation on mechanical properties. Thin washer samples of a number of alloys were exposed for 30 days to a reactor environment similar to anticipated service environments. Surface reactions or excessive deterioration of any washer sample would preclude further tensile property evaluations of that alloy. Post-irradiation visual inspection of the washer samples revealed no excessive surface reactions, and average percent weight gain ranged from 0.88% for AISI 406 stainless steel to 0.026% for 304L stainless steel. The four nickel-base alloys of interest gained 0.036% to 0.042%. The three-month exposure tensile specimen capsule containing the nickel-base alloys has been discharged and is being opened in Radiometallurgy.

7. GRAPHITE HIGH TEMPERATURE IRRADIATION DAMAGE STUDIES

Microscopy. A workable electron microscopy method for studying selected areas on graphite specimens before and after irradiation has been developed. The specimens are prepared by hand or Syntron lapping techniques followed by a cathodic etch. Areas of interest are then referenced with a marking pin mounted on an optical microscope. Graphite fragments produced during scribing are removed with repeated application and stripping by Formvar replicating films. A series of light micrographs are then taken of both the graphite and negative carbon replica at magnifications of 50 to 750 X. These serve as guides in locating and mounting carbon replicas of the selected areas on grids for electron microscopy. A two-stage petrographic microscope is used for aligning the replica with a grid opening. The high resolution of the electron microscope results in a considerably different impression of the structural details of graphite than given by light microscopy; however, an area of interest referenced by light micrographs has been identified with the electron microscope and photographed at magnifications up to 40,000 X. The sample will be replicated by several different methods for comparison, and then will be irradiated to an exposure of 500 to 1000 MWD/AT at 30 C for the initial post-irradiation studies.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Damage Annealing Studies

Radiation damage recovery is being studied for a number of metals, namely copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. One anneal has been made to date in evaluation of the new isothermal annealing fixture. A zirconium specimen was annealed for five minutes at 550 C under a helium pressure of approximately four psi. Heatup time was 39 seconds, and cooling time was 33 seconds. Integrated time at temperature was 5.66 minutes, in contrast with best results on the order of 9.0 minutes in the old fixture. Further tests will be made in dynamic vacuum and in helium at 25 psi.

Post-annealing x-ray studies have been completed on isochronally-annealed titanium specimens, annealing having been terminated at 575 C. The specimen with an exposure of 1.1×10^{19} nvt showed an expansion along the A axis and a contraction along the C axis (relative to the unirradiated specimen), and decreases in microhardness and electrical resistance to values considerably lower than the control values. The specimen exposed to 1.5×10^{20} nvt showed complete recovery of lattice parameters but retained a slight amount of line broadening. The probable cause of the apparently anomalous behavior of the irradiated specimens is the difference in interstitial impurity contents. The control specimen and the high exposure specimen contained nearly four times as much N_2 and O_2 as the low exposure specimen.

A second microhardness recovery stage was observed in copper at 425 C for both exposure levels (0.09 and 1.5×10^{20} nvt). Irradiated molybdenum specimens exhibited a major microhardness recovery stage at approximately 815 C. This recovery does not appear to be an overaging effect.

E. CUSTOMER WORK

Radiometallurgy Service

The examination of a ruptured I&E element has been completed. The failure was caused by a side hot spot that penetrated the C-64 aluminum alloy can wall.

A second element, which was classed as a side-other rupture, has been examined. The failure occurred under the male end cap. Swelling collapsed the inner tube and broke the outer cladding at the base of the core. The point of water entry was found to be a pin hole in the male weld (RM-409).

An aluminum stud welder has been ordered by FPD for installation in one of the 327 Building hot cells to permit evaluation of the effects of irradiation on the bond strength of aluminum clad fuel elements. Aluminum studs will be welded to the cladding on irradiated fuel elements and then pulled in tension to test the bond area between the cladding and the uranium core below the stud. Modification of the stud welder for remote operation and in-cell installation will be necessary.

Metallography Laboratories

A cracked section of stainless steel tubing removed from KER Loop 4 was examined during the month. The failure occurred at a weld in a tee-section where the possibility of high thermal stresses as well as mechanical stresses appeared to exist. The failure was attributed to thermal fatigue although sections from other parts of the tee and the loop will be examined to determine whether stress corrosion cracking contributed as a cause.

All samples for the AlSi annealing study which were to be annealed for periods greater than one day have been heat-treated. The balance of the samples will be annealed for periods as short as fifteen minutes up to one day. The shorter annealing tests will be conducted using molten lead as the heat transfer medium in order to minimize the effect of time required to heat the samples to the annealing temperature. Tests recently completed show that lead has no adverse effects on the samples resulting from prolonged contact at high temperatures. This confirms information obtained from the phase diagrams which show that lead and aluminum are mutually insoluble.

Natural flake graphite single crystals were thinned or cleaved by means of a "scotch tape" technique and examined by means of transmission electron microscopy. Moire' patterns and dislocation movements were observed. Diffraction patterns of one micron areas were obtained.

Samples Processed During the Month:

Total samples	409
Carbon replicas	37
	446

Photographs

Micrographs	390
Macrographs	114
Electron Micrographs	100
	604

Special Fabrications

A total of 1440 coextruded fuel rods have been shipped to the Savannah River Laboratory as scheduled. The final 96 rods needed to complete this work were shipped during the first week in September. Evaluation experiments have continued during the month. An x-ray absorptometer was set up to measure variation in plutonium content along the length of a rod. Preliminary results show that the plutonium variation is about what would be expected from the variation in cladding thickness. Metallographic specimens taken from transverse sections of a rod showed significant grain size variations. The larger grains being on the central portion of the rod. No marked degree of segregation was observed.

Design and fabrication of several experimental coextrusion billets are progressing. Aluminum cladding components for the I&E element have been

fabricated. Several aluminum 7.4 w/o plutonium cores have been cast and machining of the configuration is now being completed.

Fabrication of eight 4-rod clusters containing UO_2-PuO_2 pellets for Westinghouse-Bettis reactivity studies is nearing completion. About 200 pellets containing up to one w/o PuO_2 were sintered at 1500 C to densities near 90 percent of theoretical. These pieces were centerless ground to 0.3565 ± 0.0005" diameter and end ground via a rotating chuck and diamond wheel to give smooth parallel faces. Seven pellets of a given composition were loaded into four rods by the cowbag technique. End caps were then welded into place. Special care was taken not to contaminate the welding chamber, as each plastic filter plug was monitored and was found to count from 20,000 to 40,000 d/m. The closures were made using 35 amperes, and 15 volts, in helium atmosphere. The speed of rotation was eight rpm. The end caps were then turned to give a small nipple and four rods were inserted into the end bracket to give a cluster. Spot welding by the tungsten inert gas process was used to tie the cluster together.

NPR Charging Machine

Fabrication of the prototype charging machine has been delayed pending IPD decisions on the following matters:

1. Prototyping a reduced or full size machine.
2. Driving the fuel monotube across the "C" elevator rather than installing tube extensions during loading.
3. Providing overpressure relief on the nozzle adapter rather than incorporating a fail safe header valve.

Long term procurement items have been held up pending clarification of the above items.

Limited activity has been continued in completing the positioning cylinder which is now being set up for testing. Detailed drawings of the shortened charge machine frame and carriage are 40 percent complete.

Final arrangement drawings of the nozzle adapter were completed and estimates of fabrication costs were obtained.

F. W. Albaugh

Manager, Reactor and Fuels Research
and Development

FW Albaugh:kb

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

SEPTEMBER 1960

FISSIONABLE MATERIALS - 2000 PROGRAM

FUELS

Nuclear Safety in FPD

At the request of the Engineering Operation, the nuclear safety of changes proposed in the Core Recovery Operation and the shipment of C-6 sludge for 0.96% enriched uranium were reviewed. In the Core Recovery Operation (NS 3.06), where the aluminum jackets are chemically stripped off of reject cores, it was proposed that the number of uranium cores processed per batch be increased from 672 up to 1088. This change was approved on the basis that the height of uranium being processed is of a safe slab height and that the new batch size is 73% of the minimum critical mass.

In the offsite shipment of 0.96% U-235 scrap metal and C-6 sludge, the present specification limits a railway shipment to twelve barrels containing 200 lb. each of either of these materials. Since the C-6 sludge is safe in unlimited quantity, the specification (NS 3.10) was rewritten to this effect. A minor change was also made in the specification for metal scrap. This change permits the shipment of any number of barrels of scrap, provided the total weight of scrap uranium in the shipment does not exceed 2400 lb. These changes will provide more flexibility in the shipment of these materials back to the vendor.

REACTOR

Effect of Absorber on Neutron Energy Spectrum

In the investigation of the effect of an absorbing cylinder on the thermal neutron flux spectrum in the surrounding nonabsorbing moderator, the improved solution for the case of 1/v absorption has been programmed for the IBM 709 and several test cases have run satisfactorily. This improved solution for 1/v absorption was obtained as an intermediate step in a solution for resonance absorption, which is more important but much more difficult to obtain. The improved solution is based on a more accurate analytical approximation to the blackness of the absorber than was used in the original solution to the 1/v absorption problem. In both the original and improved solutions, the calculation proceeds in two steps: a) the evaluation of expansion coefficients in the series solution, and b) with these expansion coefficients, the determination of certain descriptive integral quantities, such as total flux and effective neutron temperature. In comparing results of the original and improved solutions for the same test case, it was found that the integral quantities agreed within a percent or less, although sizable differences in the expansion coefficients were obtained. This good agreement in the integral quantities is considered a verification of the soundness of the assumptions in the original solution.

Digital Computer Codes for Reactor Analysis

Debugging of HFN, the Hanford version of the multigroup neutron diffusion theory code FN, is continuing. HFN is needed to provide, in FORTRAN language, a multigroup diffusion theory code allowing transfer probabilities from any group to all other groups. The major debugging effort at present is to reproduce with HFN the results of two sample problems run with FN. An exact duplication of results is not expected in view of our information that the results of the sample problems were not obtained with the same version of FN as that on which HFN is based. In analyzing one of these problems, a two group, three region reactor model, HFN yields fluxes and reactivities within 0.1 percent of the FN results. This is considered satisfactory agreement at present. In the second problem, an infinite medium thermal spectrum calculation, HFN yields the same general trend in the flux as a function of energy as does FN, but the magnitudes of the calculated flux variations agree very poorly.

An additional check on this spectral calculation was devised after noting that in an infinite, homogeneous system, the multigroup diffusion equations reduce to a set of simultaneous, linear, algebraic equations. In view of this fact, the spectrum calculation was run on an existing program designed to solve simultaneous algebraic equations. Although the HFN fluxes are generally closer to the simultaneous equation results than are the FN fluxes, none of the calculations agrees very well with either of the others.

It is believed that the differences between HFN and FN may be due to different round-off errors in the two codes. A large portion of the spectrum calculation difficulties in HFN mentioned last month was in fact traced to round-off error. For example, it was discovered that in one subtraction, roughly six significant digits in the flux value were being lost. Since that discovery, the equations in HFN were reformulated in an attempt to reduce round-off error. The HFN results now under discussion were obtained with the new equations. It is believed that a similar reformulation must have been made in the version of FN used to obtain the sample result. Since these reformulations may not be identical, remaining differences in round-off error between the two programs could account for the difference in results. The resolution of the differences between the simultaneous equation and HFN results is still being sought.

Modifications which provide for a shortened form of the output have been made to the local version of Crisscross, the General Atomic's cross section averaging program. The input formats were changed in order to circumvent an annoying peculiarity of FORTRAN which caused the previous formats to skip cards under some conditions.

Bugs discovered during the month in the nuclear data tape code have been eliminated.

Some preliminary work on the assignment of storage for the Hanford version of C-5, an ANP slowing down spectrum code, has been done. This work has been slowed somewhat because of the need to improve the data on the existing nuclear data tape.

Several runs to generate three group cross sections using both NUDATA and C-3 led to the discovery of errors in each code. Both codes have been corrected and recompiled and are being checked out. A two group, multiregion test case was run on both the AIM-5 and F-3 diffusion theory codes; evaluation of the results

[redacted]

has not been completed. A study of the SOS programming methods has begun in preparation for effective use of the RBU code when it becomes available. Knowledge of these programming methods should also prove valuable beyond their usefulness for RBU utilization.

Computational Programming Services

VTOCL, the monitor version of BKL, the production code for exponential pile data reduction, is being extensively revised to meet the extended needs of its users. Data error detection techniques for this code are also being refined, in order to reduce the effort spent by Reactor Lattice Physics personnel, the principal users, in locating such errors. COFIT, the cosine-fitting companion of BKL, is awaiting its turn for conversion, reformulation, and refinement of error detection.

Exponential Pile Measurements of Large Diameter Fuel Elements

A rather large effort has been expended during recent months on measurements of extrapolation length as a function of source position, exponential pile size, cell position, and number of data points included in the horizontal cosine fit. These studies were undertaken because the variations in measured extrapolation lengths were a source of considerable uncertainty in measured bucklings. Some conclusions can now be reached based on data taken in an 8 foot pile with tube-in-tube fuel elements at a lattice spacing of 8 3/8 inches.

The variation of extrapolation length, λ, as a function of the number of points in the cosine fit and source position was studied. For the clustered source, λ increased from 2 to 4 inches as the number of points in the fit was decreased. For split sources with the same type of traverse, λ averaged 0.9 inches. This shows the typically high λ of the clustered source and indicates some systematic error in data analysis caused by, perhaps, the lack of the fast source term in the harmonic correction. The fast source correction is more important for the clustered sources.

Thermal and epithermal λ's were studied with split sources. The epithermal λ's were consistently higher than the thermal λ's. Epithermal λ varied from 1.6 to 4 inches as points were dropped and thermal λ's remained relatively constant at a value which averaged 1.1 inches. This confirms previous suspicions that λ is energy dependent. The variation in epithermal λ as points were dropped also indicates a position dependence. The source position effect on λ was studied in the standard pile in order to eliminate complications due to multiplication and cell fine structure. The same effect of larger λ for clustered sources appears.

Measurements have been taken in a 10 x 8 foot pile with the tube-in-tube fuel at a lattice spacing of 14 9/16 inches. The amount of graphite at the edge has been varied to determine the error resulting from not reproducing the exact half-lattice at the edge of the pile since all buckling measurements before about 1958 had varying amounts of graphite. The λ's measured are unrealistically high, but the bucklings which are calculated with the measured λ's agree with each other and with small pile measurements. The reason for this agreement is not understood.

Exponential Measurements for N Reactor

Construction of the NPR mockup exponential assembly is complete. Preliminary measurements on the dry lattice yield a buckling of $27 \times 10^{-6} cm^{-2}$. An estimated extrapo-

lation length was used.

The final value for the diffusion length L in the NPR mockup with fuel and control rod channels empty is 83.0 cm. The diffusion length L_o without voids is calculated to be 52.8 cm (standard pile-corrected to a density of 1.7 gm/cm^3). The ratio $L/L_o = 1.57$ compares favorably with a Behren's streaming correction of 1.61. The L_o quoted in the monthly report for August 1960 is in error.

Plans for measuring the effect of reduced water density by filling the water channels with polyethylene balls have been dropped in favor of using the PCTR for the study. The water density will be reduced by adding aluminum or magnesium, with a measured correction for the effect of the absorption rate in the added metal.

PCTR Measurements for N Reactor

Measurements of Lattice Parameters

Measurements have been completed in the PCTR with the water-cooled NPR fuel element in the condensed graphite lattice of 7.56 inch spacing. The lattice parameters investigated were k_∞, p, f, and ϵ. Also, cadmium ratio measurements with gold and copper foils were made in the fuel and several positions in the graphite moderator to yield information about the neutron spectrum through the lattice.

The reactivity coefficient of copper poison was determined at two positions in the lattice, and a value of k_∞ was calculated for each set of data. Both values of k_∞ given in the table below are preliminary since more elaborate interpretation of the flux data is to be made, and nominal values of the volumes of the cell components were used, rather than the directly measured quantities. Also the value with copper close to the fuel assembly needs further correction for flux perturbations that occur with this arrangement.

	Poison near Fuel gm/cm	Poison at Boundary gm/cm
"1/v" poison required for $k_\infty = 1$	8.720	7.953
$(\bar{\phi}_{1/v})$copper/$(\bar{\phi}_{1/v})$fuel	1.83	2.07
k_∞	1.068	1.070

A preliminary value of 0.886 for the thermal utilization, f, agrees well with the value 0.885 calculated from the IDIOT code. The flux traverse calculated from the P_3 method, using a neutron temperature of 429°C, reproduced fairly well the experimental traverse throughout the lattice.

Measurements for the mockup lattice have begun. The spectrum has been matched for the wet case with a slightly higher cadmium ratio than in the condensed lattice due to the difference in the location of the copper in the cell.

Flux Traverses in a Heated NPR Lattice

Experiments in the PCTR or the TTR thermal column are planned at high temperature conditions. Because a recirculating pressurized system is complex and expensive,

a simpler static system has been proposed. Sealed process tubes containing fuel elements and water would be inserted in the previously heated graphite mockup. Foils would be irradiated when the water temperature reached the selected value. A layer of lampblack around the process tube would prevent too fast a rate of water temperature rise.

Experiments designed to determine the feasibility of this approach were completed during the month.

An investigation of the air flow through a 1/16 inch wide annulus around an NPR process tube showed that 20 to 40 CFM could be forced through this annulus with a pressure drop of 3 psi or less. The cooling capacity of this amount of air is sufficient to control the temperature of the process tube assembly with a rise in cooling air temperature of approximately 50°C, if the tube block is insulated from the heated graphite by 1/8 inch of lampblack. The heat transfer from a flat surface to air at the above required flow velocity lies well within the requirements.

A graphite temperature of 700°C and process tube assembly temperature of 300°C were assumed for the above investigation.

Instrumentation and Systems

Instrumentation determinations are nearly complete for specifying the design of the slow-scan gamma energy spectrometer portion of the NPR Fuel Failure Monitor. It will be similar to that originally proposed for the developmental HLO dual scanning monitor. Most of the design problems arising from the decision to combine the slow-scan system with the IPD developed Geiger tube system have been resolved by a cooperative effort with IPD-Instrument Development and CEMUO-Instrumentation Design.

Joint HLO-IPD field testing was concluded on the prototype Dual-Probe NPR Scintillation Building Area Monitor. Performance will be satisfactory if the instrument is properly applied to the possible various NPR building locations. With typical, normal, continuous phototube anode currents less than about five microamperes, errors (drift) of less than two or three percent per month of operation were noted. In addition, total exposures of 10^6 roentgens did not affect the instrument accuracy or calibration. With the dual-probe unit available, judicious range selection by high voltage adjustments should permit correct and adequate operation in most NPR building locations. The only requirement for extreme reliability and lack of drift error is the stated one of holding the normal, continuous, phototube anode current to less than about five microamperes. This is one-fourth full scale on the associated meters. Apparently, several NPR building locations, such as the Inner Rod room, charge-discharge areas, and the ball tunnel have widely varying radiation levels depending upon reactor power level. In these areas, it would be advisable to use the newly designed logarithmic, servo-controlled, scintillation area monitor which automatically reduces the phototube high voltage as the radiation dose-rate increases. This system holds the phototube anode current to about two microamperes under all dose-rate conditions, thus producing the desired reliability and extremely low drift error. This unit is presently being tested and complete circuit diagrams should be available in October. If the servoed log unit is not desired or proves to be inadequate, the previously tested dual-probe unit can easily be used by employing a high voltage cut-off relay in the low-level (sensitive) probe unit to deenergize it at normal up-reactor levels. Such a

system would provide complete coverage without having continuous normal phototube anode currents exceeding five microamperes.

All development work, except minor detector housing modifications, is complete on the prototype NPR Beta-Gamma Scintillation Air Monitor. Instrument drawings have been started by Instrumentation Design, CECUO. Sealing (air) troubles on the originally designed detector head forced a new, modified design.

Operating data on the 100-D reactor, in the form of chart records and tabulated data, have been collected for analysis for the reactor automatic control systems study. It is planned to plot several of the variables on a common time scale to facilitate correlation of the information. Arrangements also have been made to obtain in-core flux measurements from a group of in-core gamma and neutron flux monitors to be installed soon in 100-KW reactor by IPD Equipment Development Operation. The value of this information would be increased if a simultaneous recording of rod position and instantaneous flux level could be obtained. The possibility of attaching some suitable type of transducer to the rod position indicators will be investigated.

A meeting was held with interested people to determine whether digital computer codes capable of providing accurate solutions of the one-group reactor kinetics equations were available. It was decided that further attempts to obtain accurate solutions by analog computer techniques should be made before attempting to use a digital program. It was expected that use of the digital computer would be very expensive for this type of exploratory problem. The analog problem board is being rescaled in an attempt to improve its accuracy, and new runs will be scheduled in the near future.

Until recently it had been possible to show a strong probability that the reactor kinetic equations with sinuosidally varying reactivity always have unstable solutions. Towards the end of the month a rigorous proof, satisfactory to an exacting mathematician, that this is so has been found. A paper on this has been written and is ready for typing. This refutes some statements published by Argonne.

The study has been extended to show that a large reactor, which may be represented by several smaller ones coupled together, may, in some cases, be less stable than any of the smaller ones. This seems to refute statements made by APED at San Jose (it is possible the statements may have been misunderstood).

A further extension has been made to the study of the effects of temperature feedback. This is just starting. The results will be of immediate usefulness to reactor control system analyses.

Analog simulation of the NPR confiner pressure excursion problem was completed, and the results given the customer. A memorandum presenting this problem and its solution was prepared and issued.

Analysis of the NPR system has been started. An electronic model of the reactor primary loop has been designed and built, but has not been checked out as yet due to lack of computer availability. Parts of the NPR system have been and are being analyzed by the General Electric General Engineering Laboratory and by Goodyear Aircraft. The local study will differ mainly through a capability for analyzing scram and other fast transients by use of the new magnetic tape transport lag simulators in the Analog Computer Facility.

An analog analysis of the NPR Pressurizer has been started. This is a detailed study of the Pressurizer alone, without it being tied into the primary loop.

The reactor speed of control problem was programmed on the EASE computer for the old reactors and C reactor.

A study was made of the feasibility of using a tunable microwave cavity as a displacement transducer for in-reactor metallurgy creep measurements. The study showed that a cavity with a length and diameter of two centimeters operating at 30 KMC/sec should have a minimum resolution of better than 10 micro-inches. The added complexity of such a device may be more than offset by the insensitivity to radiation and high temperature.

During the month a meeting of the G-E Control Systems Steering Group was held at HAPO. Several papers were presented on control problems of various reactors, the separation problem, and fuel preparation, and the group were taken on a tour of the PRTR and Plutonium Fuel Pilot Plant. A number of HAPO people attended the meeting. To take advantage of the presence of experts in the control field, five who had Q-clearance were taken out to KE Reactor to discuss the problems peculiar to the control of the large, graphite-moderated reactor.

SEPARATIONS

Plutonium Critical Mass Facility

Personnel of Critical Mass Physics are proceeding to check out the operability of the equipment in the facility.

The vendor of the in-hood reactor components for the initial critical mass experiments has indicated shipment of these components would be made during the week of October 10.

A meeting was held on September 22 with representatives from CPD, CE&UO, and HLO to discuss certain modifications which are expected to result in an improved facility. As a result of the meeting, several modifications are to be made prior to startup, as part of the startup costs; these changes would be especially difficult to make if plutonium were in the system. This work is not expected to delay the initial criticality experiments.

Modifications which are planned or being considered are as follows:

Mixing Hood

In order to permit maintenance of the suction and discharge valves in the mixing hood, an access port will be provided in the floor of the compartment directly over these valves.

Storage Tank Vents

The storage tanks in the reactor room are now vented through a single CWS filter to the room air; this is believed to be inadequate for contamination control. The tank vents will be connected to a manifold and piped to the reactor hoods. The vent manifold will be provided with a single in-line filter.

Process Tubing Lines

All process lines are constructed of 304-L SS tubing with fittings. Although the fittings are the best available, they do not guarantee a no-leak system. The possibility of back welding these fittings was discussed. If it is feasible to back weld them, this will be done; CEMO will investigate this item further.

Valves

There are a number of tubing valves which are located exterior to the reactor hoods. A criterion in the design of the system was that all process lines should drain back through the manifolds to storage tanks with the entire system as flexible as possible to permit future changes in the flow diagram. The cost of reloacting the valves in hoods for improved contamination control appears to be excessive. Further considerations will be given to this item by HLO.

It was pointed out that even all welded joints do not insure a leakproof system, but the integrity of a welded system should be superior to one with fittings.

The hazards report ("Summary Report of Hazards of the Hanford Plutonium Critical Mass Laboratory", HW-66266) was completed and copies were transmitted to the Commission for review. Approval was requested of the Commission to begin operations when the checkout of the equipment indicates that such operations are feasible.

The Council for Review of Operations toured the Critical Mass Facility on September 27. The purposes of the Council are to conduct an audit of the laboratory operations with respect to safety and to make recommendations governing operating procedures and methods.

NPR Transfer Cask - Critical Mass Safety Evaluation

Final shipment was received of the one percent enriched uranium for experiments to evaluate nuclear safety of the NPR transfer cask. The shipment was completed with delivery of the outer tubes for the tube-in-tube type fuel elements of the NPR.

A series of experiments were made for determining the buckling and critical mass of these fuel elements in light water. These experiments were conducted in the exponential pile facility located in Room 15-A of the 326 Building. The buckling was measured with four lattice spacings with the complete tube-in-tube assembly. The buckling was also determined for these lattices with the outer tube only.

Measurements were also made in three of the lattices for evaluating the extrapolation lengths to be used for the water reflected assemblies. This was done by measuring the relaxation length of the neutrons in the exponential piles for each of several different pile loadings; since the material buckling is independent of pile size, it is possible to evaluate the extrapolation length from the above procedure.

A hexagonal pattern was used for the lattices which were fully water reflected. The fuel elements were encased in 20 mil thick aluminum tubes for insertion in the lattice assemblies.

The preliminary results of the exponential experiments are summarized in the following table. The critical mass values which are given were calculated from the measured bucklings with the values of λ shown in the table; values of λ marked with an asterisk were estimated from data given in BNL-C-7592.

The preliminary results indicate the outer tube by itself to have a slightly higher maximum buckling than the complete tube-in-tube assembly. The outer tube also has the smallest minimum critical mass (about four tons of U for an H_2O/U volume ratio of about 2.6). Further, for the case of the outer tubes only, the buckling still has an appreciable value when the fuel elements are in contact as bound together in a bundle (about 500 μ B less than optimum). The critical mass is considerably higher, however, because of both the smaller buckling and H_2O/U ratio for this case ($\sim$ 7.7 tons U).

The minimum mass for the complete tube-in-tube assembly is about 5.3 tons of U for an H_2O/U volume ratio of 1.8; the maximum buckling is about 2400 μ B. These values were obtained by normalizing theoretic values to the experimental data points--to obtain more complete curves for estimating the maximum and minimum values.

The buckling of the tube-in-tube assembly is negative for the case of the fuel tubes bound together in a bundle.

BUCKLING AND ESTIMATED CRITICAL MASS FOR NPR TUBE-IN-TUBE TYPE FUEL ELEMENTS IN LIGHT WATER

	H_2O/U Volume Ratio	Extrapolation Length (λ)	Buckling ($10^{-6}cm^{-2}$)	Estimated Minimum Critical Mass (Spherical Geometry)
Complete Fuel Assembly	0.68	8.61 cm.*	-550	Criticality not possible
	1.35	7.80 cm.	2049	8.02 tons U
	1.93	7.66 cm.	2255	5.60 tons U
	2.56	6.85 cm.*	1447	10.10 tons U
Outer Tube Only	1.60	8.51 cm.	1931	7.71 tons U
	2.64	7.34 cm.	2433	4.06 tons U
	3.51	7.70 cm.	1411	8.09 tons U
	4.47	6.52 cm.*	151	

Since the proposed transfer cask will have a maximum loading of 7400 lb. U, which is 70 percent of the estimated minimum critical mass, the cask is safe on a mass basis. The recommended nuclear safety specifications for the cask are as follows:

a) The enrichment of the fuel before irradiation should not exceed 0.95% U-235.

b) The size of the fuel tubes should be within 2% of the dimensions given in HW-66601.(1)

c) The cask should be limited to loadings of either tube-in-tube elements or outer tubes. (Inner tubes alone are excluded until the nuclear safety calculations are completed.)

d) The quantity of uranium in a cask at one time must not exceed 7500 lb. (equivalent to 24 tube-in-tube element bundles).

e) The internal dimensions of the cask should be within 5% of the dimensions given in SK-1-26886 (i.e., 24 in. by 42 in. by 88 in.).

f) Steel sheets should be used to separate quadrants in the cask; however, a neutron poison in the steel is not required.

These regulations are somewhat flexible, but would require further study before changes could be made. For example, the purpose now intended for the steel sheets separating quadrants is to limit the number of bundles that could be placed in the cask; these sheets could be omitted if another safe and inflexible loading arrangement were specified.

Further calculations are to be made to determine the nuclear safety of transporting the inner tubes alone, and to determine the maximum enrichment level of unirradiated fuel elements for which the cask is safe.

Criticality Hazards Specifications

Nuclear Safety in HLO

Nuclear Safety Specifications covering the Plutonium Recycle Test Reactor Operation were reviewed and approved. The titles of these specifications will be as follows:

K-1 Rules for the Storage and Transportation of Al-2.2 w/o Pu Alloy Fuel Elements

K-2 Rules for the Storage and Transportation of Natural or Depleted UO_2 Fuel Elements

K-3 Rules for the Accrual of Plutonium in PRTR Process Equipment

[illegible]

1) J. W. Nickolaus, Billet Design for NPR Fuel Elements, HW-66601.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

Further work was done on the development of a Monte Carlo Code for homogeneous infinite systems (HISMC). This code will be used to study the neutron spectrum, fission distribution (energy at which fissions occur), absorption distribution, mean life of neutrons, and migration areas of homogeneous infinite systems. Most of the computation loops in the code have now been debugged. The NU DATA subroutine developed by J. E. Schlosser was shown to be reliable for computing 100 group cross sections from the HISMC data tape. The Maxwellian distribution selection technique was rewritten so that a selection takes place with the generation of two random numbers. The Von Neumann method previously used required the generation of two or more random numbers before a selection took place. The new selection technique is presently being debugged.

The 18-group cross sections for use with the 9-Zoom multigroup diffusion code have now been revised and a new library tape generated. Problems to test the new cross sections are being run. An immediate result, though tentative, shows that the limiting concentration of Pu in Pu-H_2O mixtures which can be made critical is 7.3 gm/l. While this value agrees with some independent calculations, it does not seem to agree with the recent PCTR measurements. This point will be explored further.

Some trial runs on the three-group cross sections generated by the C-3 code indicate the need for some revision of the cross sections used in that code. The extent of the needed revision is being determined by trial problems with changes in the three-group parameters.

Criticality Studies in Support of Processing Power Reactor Fuels

Preliminary results of the measurement of k_∞ in the PCTR for a three percent enriched uranyl nitrate mixture with a nominal H/U atomic ratio of 9 have indicated the necessity for making a measurement with an H/U atomic ratio of 13. Work was begun on the preparation of a uranyl nitrate mixture with this H/U ratio. The purposes of these measurements are to determine the effect of nitrate on the value of k_∞ and to evaluate the limiting concentration of the solution for which k_∞ becomes unity.

Neutron Leakage Studies

A formal report dealing with estimating the neutron leakage from bare subcritical plutonium solutions is being worked on. The primary analysis in this report has considered only Pu-239 solutions. As a supplementary effort, an estimation of the effects of a small percentage of Pu-240 content was considered desirable. The effort was confined to estimating the change in neutron leakage from the 14 cm., 15 cm., and 16 cm. radii bare spheres used in the work on Pu-239 solutions due to including 5 percent Pu-240 in the plutonium. The results indicated that the neutron leakage changes from a slight increase at concentrations far below the original critical concentration to a decrease at concentrations near the original concentration. For the 14 cm. and 16 cm. spheres the decrease in leakage was about 45 percent at 95 percent of the previous critical concentration, while the decrease in the leakage from the 15 cm. sphere at the same percentage of critical concentration was about twice as great. This difference in behavior is attributed to the fact that, near the volume of the 15 cm. sphere,

a small change in the critical volume, caused by the presence of Pu-240, produces a much larger change in the H/Pu ratio at critical than does a similar change near the volumes of the 14 cm. and 16 cm. spheres. An estimate was also made of the effect on the results of uncertainties in the values of critical volume as a function of Pu-239 concentration. It indicated that one percent uncertainty in the critical volume at a given H/Pu ratio produced not more than a 10 percent uncertainty in the neutron leakage from a 14 cm. radius bare sphere.

Mass Spectrometry

The source vacuum interlock of the mass spectrometer for this program was again installed on the spectrometer after the parts had been lapped together in the hope of eliminating the intermittent binding previously encountered. The source pressure obtained after this modification does not appear to be significantly different from that previously obtained. No further binding has been encountered to date. Studies are being made to attempt to determine the cause of electrical breakdowns frequently observed in the source of this spectrometer. Observations to date indicate a correlation of electrical breakdown and the emission of elemental rhenium ions from the filament.

NEUTRON CROSS SECTION PROGRAM

Crystal Spectrometer Operation

A new gas ionization beam monitor chamber for the KE spectrometer which uses a thin boron deposited foil was tested and calibrated. The collimating apertures which were used to improve the pulse resolution had too low a geometry factor for the available boron foil thickness and were removed.

A laboratory grown aluminum single crystal was mounted for use on the DR spectrometer. The counting rates per resolution interval obtained with the /240/ diffracting planes were about 25 percent of that obtained with the beryllium crystal previously in use. The counting rates are large enough for the transmission measurements which are being undertaken to determine the burnout of cadmium in some pile irradiated control rod material.

Slow Neutron Scattering

The series of measurements of the energy distribution of 0.247 ev neutrons scattered from room temperature water was completed with additional measurements at 3, 10, and 30 degree scattering angles. The analysis of these measurements has not been completed.

A new series of measurements has been started on the scattering of 0.0995 ev neutrons from water. The energy resolution which is used is about 0.007 ev. Energy analyses near the elastic peak have been made for scattering angles of 3, 10, 20, and 30 degrees.

Measurements were made which verified that the windows of the water sample holder were deflecting to the extent that the effective sample thickness was about twice that which was desired. The holder has been modified to correct this defect.

Fast Neutron Cross Sections

The assembly of the slit boxes for the Van de Graaff has been completed, and the precision alignment system installed in the accelerator building. Several design changes were found necessary. The system was evacuated to better than 10^{-7} mm Hg before installation.

Mechanical alignment of the beam tubing is nearly complete. The portions finished so far are mechanically consistent within 1/4 mm. Most of the electrical hookup is in place, and the system will be tested as soon as the installation of the second remote positioner is finished.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE

Low Exposure Plutonium Lattices

The planned irradiations in the 10-1/2-inch graphite lattice with 1.8 w/o Pu-Al, 19-rod clusters, were completed. The foil data is being processed on APDAC-1. They are needed to complete the k_∞ measurements on this lattice.

Preparations are being made for a similar set of irradiations in the 8-3/8-inch graphite lattice, to begin during the second week of October.

PRTR Startup Experiments

Final drafts of the Detailed Procedures for Critical Tests 1, 2, and 12 have been prepared. In order for the procedures to correspond to the test sequence which is currently planned, Critical Test 2 has been divided into three parts 2A, 2B, and 2C. Tests 2A, 2B, and 2C are approach to critical experiments with the moderator at full level, 3/4 of full level, and 1/2 of full level, respectively.

Critical Facility of the PRP

The tentative plans for the MTR-RMF experiment are to use four Pu-Al samples with different concentrations of Pu-240. Each sample will be irradiated for 4 or 5 MTR cycles and reactivity measurements in the RMF between irradiations will be made. The reactivity of the irradiated sample will be compared to the reactivity of the "empty" RMF and to that of an identical unirradiated sample. In addition, it may be possible to separate the poison and fission effects by calibrating the RMF with two samples which differ only in the amount of poison material, e.g., boron.

The measurements will be made by personnel of Phillips Petroleum under the guidance of the Hanford representative at Idaho Falls.

Single Rod Experiments

A preliminary study has been made of the feasibility of PCTR measurements of k_∞ and f on a single fuel rod cell surrounded by a buffer zone of fuel rod cells of a different type. The advantage to be gained is that measurements could be

made on a single cell even if enough material were not available for a full nine cell array. The problem is that it becomes more difficult to obtain the proper flux environment for the test sample. It appears that such experiments could be done with accuracy comparable to present PCTR measurements of k_∞ and f, but at the cost of an increase in reactor time required to do the experiment. It also appears that a series of such measurements could be made quite rapidly if one is able to afford a considerable loss in accuracy. This might be useful in performing a rapid survey of the effects of relatively small changes in single fuel elements.

Analysis of Finite Heterogeneous Lattices

A rough draft for a writeup on heterogeneous reactor calculational methods in finite lattices using matrix inversion techniques was started during the month and the first part was completed. Some difficulties were encountered in the matrix inversion routine being investigated. These difficulties appear when other zeroes appear in either a row or column containing a zero on the main diagonal. A restriction has been imposed which rearranges the matrix to prevent this occurrence.

Neutron Spectrum Studies

a. Detector Foils of Lutetium

Data have been obtained for various thicknesses of lutetium from which the cadmium ratios of the lutetium isotopes can be determined. These experiments were conducted in order to discover if a discrepancy between the measured and calculated values for the resonance integral of Lu-175 is due to self-shielding effects. The results of the measurements are not yet available.

Epithermal-subcadmium resonance integrals for Lu-175 and Lu-176 have been calculated. These calculations assume a slowing-down spectrum which has been measured by Johannson et al. The calculations were made with the program ACE. For the calculation a ninth-order polynomial was used to describe the slowing-down distribution of neutrons.

The data which were obtained in lead and natural uranium assemblies have been analyzed. These data were obtained under the same experimental conditions as the data which had been obtained earlier with plutonium and uranium foils. Thus, a comparison of the two techniques is possible in a spectrum where the Maxwellian distribution is distorted. In the assemblies the distortions were large enough so that the different weighting properties of the two detectors (Lu or Pu-U) result in different values for the spectral index.

b. Neutron Rethermalization

1. Graphite Experiments

The rethermalization cross sections of graphite are being determined from traverses of the thermal activity of copper which have been taken across a temperature discontinuity in graphite. These cross sections are obtained from an analysis which uses a two-thermal, one-fast group diffusion model. During the past month the data at room temperature have

been fit using the diffusion coefficients calculated previously and either of two schemes for obtaining a good fit.

In both methods the thermal diffusion parameters are those calculated from fundamental cross section data, except for the absorption cross section in the fuel region. The latter is found by iteration. In the first method the fast diffusion parameters are calculated from fundamental cross section data. In the second method the fast diffusion parameters are adjusted so that the calculated fast flux fits a traverse of the epicadmium activity of gold. Here it is assumed that the gold traverse is a satisfactory measure of the distribution of the source of thermal neutrons. After the fast flux is fitted the absorption cross section in the fuel is adjusted to yield the fit of the thermal flux to the copper traverse.

Both methods yield calculated curves of the thermal flux which agree with the experimental traverse within counting statistics. However, the first method yields a calculated curve of the fast flux which rises approximately 25% faster than the observed traverse of the epicadmium activity of gold. The second method requires an absorption cross section in the fuel which is lower by approximately 30%.

The significance of the latter two conditions is difficult to evaluate at this stage of the analysis.

Several IBM runs have been made on the experiments which had temperature discontinuities.

2. Water Experiments

The preparation of traverse data for analysis with FIT-1 is nearly complete. The analysis must await the completion of the analysis of the graphite experiments, since the graphite cross sections are to be used as known input parameters.

A summary entitled "Neutron Rethermalization Cross Section Measurements in Water" has been accepted by the American Nuclear Society for presentation at the Winter Meeting in San Francisco on December 11-14, 1960.

Reevaluation of Effects Caused by Poisoning a PCTR Core

A study has been made of the interpretation of PCTR measurements of k_∞ for the case in which the addition of poison perturbs the neutron flux distribution in any or all of the various components of the test cell. The study was made in order to examine the method of analysis of experiments involving a large K_{ex} and consequently a large mass of copper poison.

An analytical expression relating K_{ex} to flux perturbations in the various cell components was derived. Numerical application of this expression to the results of the EGCR, 2.6 w/o enrichment experiment for example indicate that flux perturbations contribute 0.001 to k_∞ and this is due entirely to the change in the moderator flux.

The expression was also employed to indicate quantitatively the effect of placing poison at a position other than at the cell boundary. The effect on k_∞ of a possible change in η was neglected. A test case was used for which P_3 calculated flux traverses were available. This was a 2-1/2" solid fuel rod in a 10-1/2" lattice. Approximately 17 gm of stainless steel per cm of length was placed around the process tube. In both the wet and dry cases, the contribution to k_∞ due to flux perturbations in other than the moderator was approximately 0.001 ± 0.0005.

It is concluded that there is little reason for selecting one region over another for location of the poison based strictly on flux perturbations. However, in order to avoid changes in η, the poison should be located such that a moderating material separates it from the fuel.

Instrumentation and Systems Studies

Calculations were completed concerning a possible "last ditch" safety circuit system for the Plutonium Recycle Critical Facility. The most promising unit appears to be a thermostatic switch plus fissile material. Alternate methods include meltable fuses and bi-metallic strips employing fissile material. For the thermostatic device, a time-to-operate of 0.1 to 0.2 seconds can be obtained for a flux change from 10^8 n $cm^{-2}sec^{-1}$ to 10^{10}n $cm^{-2}sec^{-1}$ by calculation.

Calculations were completed concerning UO_2(in Zircaloy tubing) packing density measurements by gamma ray absorptometry using various radionuclides and associated scintillation detectors. An instrument design proposal was submitted to the Ceramic Fuels Operation.

A mockup of the cell traverse mechanism for the PRTR Critical Tests was constructed. This mechanism will be placed inside the calandria through one of the access holes. After being placed, a short section of tubing containing activation foils may be raised to a horizontal position and located to bisect a cell. The mechanism will preserve all gas seals. The mockup can be used as is, but will be rebuilt with 2S aluminum when it arrives. The electronic equipment necessary for the extra counting channels has been obtained and the checkout and interconnection of these units has begun.

Tests of the PRTR Unit Motion Camera indicated excessive internal reflection which reduced the contrast of the image. The condition will be corrected by inserting blackened brass tubes as liners. The tubes will be threaded to trap the light that strikes them. One such liner has been made and tested. By comparison with the liner, a black paint looks bright and produces glare. Fabrication of other liners is in progress.

The Mark I inside diameter measuring probe was used for continuous traversing measurements on all PRTR process tubes. The Mark I probe configuration and guide assembly are being modified preparatory to a second set of measurements to be made after test pressurizing of the process tubes. About half of the Mark II (radiation resistant) probe assembly and associated equipment has been received from the manufacturer.

A Magnaflux FW-400 eddy current testing instrument has been received and will be utilized in making the PRTR gas gap measurements. Some of the original instrument circuitry is being modified and additional logic and readout circuits are being developed in order to adapt the FW-400 to the dual coil probe being fabricated for this unique eddy current application. The switching circuitry, for alternately interrogating each dual coil probe, has been designed, fabricated and satisfactorily tested. Fabrication of the probe assembly is 90 percent complete and should be ready for mockup testing by early October. The calibrating test jig has been fabricated and satisfactorily tested. Present sensitivity, accuracy, linearity of operation, and drift using the modified FW-400 in conjunction with a mockup dual probe assembly are as follows:

Maximum Resolution - 0.0005 inch - minimum displacement (shroud tube with respect to process tube) consistently detected. (Gain setting at maximum.)

Sensitivity - 0.140 volts/0.001 inch movement of shroud tube. (D.C. output of FW-400 available for direct coupling to Visicorder.) Gain setting at normal.

Accuracy - ± 0.003 inch. (Reproducibility of output over a total shroud tube travel of ± 0.250 inch from normal center spacing.)

Linearity - ± 0.014 inch. (Maximum output deviation from a straight line over the ± 0.250 inch total travel of shroud tube.) Non-linearity errors will be calibrated out of actual in-reactor output.

Drift - Less than ± 0.002 inch per hour. (Gain setting normal, measured at several shroud tube positions.)

Note that the above data were obtained under ideal laboratory conditions, and only the parameter under consideration was varied. In-reactor conditions will later be simulated to obtain more realistic data.

The analog PRTR Safeguards Analysis was completed with satisfactory results.

Evaluation of the PRTR Controller period control has not been completed. It has been determined that logarithmic simulation of the PRTR kinetics with portable analog equipment is not feasible because of insufficient stability in the electronic multipliers. No alternate method has been decided upon as yet.

A tape reel mechanism is being added to the magnetic tape recorder which is to be used for PRTR prompt neutron lifetime measurements by reactor noise analysis. Noise analysis techniques require the averaging of data over long periods of time for accurate results. The tape handling mechanism will facilitate accurate analysis of reactor "noise", using a relatively short-term sample of the noise signal, by allowing repeated playback of the sample into the analysis equipment in a minimum time.

NONDESTRUCTIVE TESTING RESEARCH

A two-section, direct-coupled orthonormal filter based upon the Laguerre orthogonalized exponentials was built for use in the first application of orthogonalized exponentials to the analysis of the broadband eddy current test signals. First tests will be made using basic filter time constants equal to 25 microseconds. Additional filter sections will be added as needed to give additional component readouts. The filter is now being brought into operation with the rest of the broadband eddy current test equipment, including a time domain amplitude sampling circuit which will be used to pick off the values of the orthonormal components of the signal being analyzed. An attempt will be made to eliminate need for the time reversal operation on the signal by using a test probe current driving function made up of growing exponential components.

A six-section a-c coupled orthonormal filter was designed and is being built. This filter, being a-c coupled, will be more stable than the direct coupled type. The nature of the circuit, however, does result in a different weighting factor which causes the successive orthogonal components to decay more rapidly than in the case of the direct coupled filter which has a weighting factor of unity. The effect of this change in weighting factor is not known, but it is believed that the advantage gained in stability and the simplicity of the circuits will offset differences due to the weighting factor.

Modification of a lathe for rotating test pieces and scanning them with an induction heating coil and infrared radiometer during heat transfer tests is nearly complete. Two induction heaters are being considered for this application. One is a Radio Frequency Corporation 10 KW unit being loaned to HAPO for evaluation. The main advantage of this unit is that it is designed to efficiently provide high power density in a narrow region from a single turn work coil. The other heater is a Lepel 7-1/2 KW unit, and is available at HAPO for part-time use. The latter unit is not capable of inducing more than one-half KW in an aluminum sample from a single turn work coil. However, 0.7 KW was induced in the sample using a close-wound, flattened, two-turn coil of 3/16-inch copper tubing through a 9:1 impedance matching output transformer. It may be possible to further increase power densities available with this machine by further development of flattened, multiple-turn, close-wound coils.

Since it is necessary to move the work coil with respect to the induction heater during scanning, flexible leads must be used. Originally it was thought that motion of such flexible leads would change the loading on the output of the heater. However, tests have shown that no appreciable change due to motion of the flexible leads occurs when they are used to connect the Lepel 7-1/2 KW heater to the primary of the output transformer. The coil and transformer must then be translated as a single unit.

Modifications of the infrared radiometer to utilize a single 13-inch elliptical mirror are being made. The chopper assembly will be placed at the source rather than at the detector because of geometrical limitations. The advantage of using a single mirror is that it eliminates a secondary mirror used in the previous system to extend the focal point of the system behind the primary. Such a secondary causes prohibitive magnification of aberrations when used with large aperture optical systems.

A general purpose infrared radiometer is needed in the development of special purpose radiometers and for general laboratory measurements of surface temperatures. This radiometer must be sensitive to small, rapid temperature changes to be of maximum usefulness in a broad range of problems such as thermal bond testing of fuel element self-support welds, and monitoring of temperatures during spot welding or impact extrusion. Arrangements are being made to obtain a commercial general purpose radiometer utilizing a refrigerated detector. This instrument will be sensitive enough to detect changes of approximately 0.3°C, with a time constant of 2×10^{-4} second, in 50°C surfaces having an emissivity of 0.5. The sensitivity will, of course, increase with increasing system time constant (to be adjustable), and temperature and emissivity of the surface being observed.

Several versions of a simplified inductive thermometer have now been tested. A transistor model exhibits the least circuit noise, the noise being equivalent to less than 1°C temperature change of aluminum. Probe vibration induced noise has been reduced to about this same value by use of the oscillator-amplifier type of circuit in which better control of the effect of probe-to-metal spacing variation can be obtained. With this arrangement, variations in output signal under scanning conditions are observed which are attributed to point-to-point changes in electrical characteristics of the aluminum cans being used as test specimens. These variations are of the order of one prcent electrical conductivity, representing an equivalent temperature signal of about 2.5°C in aluminum.

Two inductive thermometer circuits of the latest design are being built in the shop for use with two separate probes for evaluation for differential surface temperature measurements in heat transfer test applications.

NEUTRON FLUX MONITORS

Investigations and calculations continued concerning plutonium alloy in-core neutron flux monitors. Initial calculations, for 25°C temperatures, using known cross-sections for the various plutonium isotopes, indicated a detector lifetime exceeding 90 days with negligible change in response at a thermal flux level of 5×10^{13} n $cm^{-2}sec^{-1}$. Later calculations, at a temperature of 600°C, with the known cross-section changes included, indicate appreciable changes are possible at this elevated temperature. Calculations now show a predictable lifetime is possible though not at as constant a level output as originally indicated by room temperature using only various plutonium isotopes in the alloy. Investigations are now progressing on a past history independent flux monitor perhaps using a combination alloy of plutonium, uranium, and thorium isotopes. This type of approach may require maintaining a flux-versus-time plot to give an advantage of extensive lifetime.

Plans are being made to obtain some equipment for investigating a possible microwave technique for neutron flux monitoring.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Editing of the mass and exposure data compilations from the 1959 field experiments in atmospheric dispersion and transport continued. Variances of crosswind

dosage patterns at distances of 200, 800, 1600, 3200, 12,800 and 25,600 meters from the source were computed and the variations with distance studied graphically. In addition, the variation of maximum dosage on a given arc with distance was examined. At the month's end, possible causes of anomalous behavior of these distributions were under investigation.

A review of our cooperative program with the Air Force Geophysical Laboratories was held September 12-16, 1960. The status of the Green Glow reports were reviewed and changes indicated where necessary. Information was received that an additional $27,000 (previously reported as $25,000) will be transmitted to the AEC for use by the Atmospheric Physics Operation for continued development of a two-color technique for atmospheric diffusion studies, a problem of mutual interest. The principal initial use of the technique is for the simultaneous release of a tracer at two levels on the Meteorology Tower to study the effect of height of release on the ground level dosage patterns.

In the current series of field experiments aimed at studying dispersion and transport, four additional tests were obtained yielding data of horizontal and vertical distributions to a distance of 3200 meters from the source.

The precipitation scavenging investigations are presently concerned with the efficiency of raindrops to collect and retain zinc sulfide tracer particles. Plans are now underway to conduct a diffusion experiment in natural rain and collecting samples for analysis.

DOSIMETRY

A magnetic tape spectrum stripper was installed on the pulse height analyzer at the whole body counter. This device permits recording spectra on magnetic tape and also permits insertion of known spectra back into the analyzer. Some minor difficulties are still being encountered in the subtraction mode of the stripper.

Previously, half of the pulse height analyzer was used for storage of the background spectrum. Now the background spectrum can be stored on magnetic tape through use of the spectrum stripper. The entire analyzer is thus available for use in counting. This has permitted inclusion of higher energy gamma rays emitted by human subjects. The first result has been the discovery of four new cases of Na^{24} deposition. Two to 11 mμc of Na^{24} were observed. Two of the subjects were counted the day after their initial count in the hope that observation of the decay of the radioisotope would confirm that it was Na^{24}. Both subjects, however, had more of the isotope on the second day than on the first.

Special margin-punched cards were designed and fabricated for keeping data obtained from the whole body counter. The punches in the margin of the card permit sorting of the cards by serial number, date, results of the examination or characteristics of subject. The cards are now being used as the primary record at the counter. They have to be supplemented by a separate card file by name of the subject on which are listed the serial numbers of the counts that have been made on them. The data obtained in routine counting in 1959 and the first half of 1960 have been transferred to the punched cards. The cards permit rapid sorting for averaging, preparation of histograms and searching for correlations.

A new NaI scintillation counter, the same size as our present one, was received. It is being mounted in a position beneath the bed used for scanning type counting. The input to the pulse height analyzer is being modified so that either counter may be used separately or both counters may be used together.

In an experiment run overnight a 10 mc Co^{60} source placed 18 feet outside the iron room increased the background of the whole body counter by a few percent. This was higher than anticipated but not high enough to be of any concern. This test was performed as a matter of our own interest and to help the University of Washington plan their whole body counter.

The rate of elimination of Cs^{137} has been studied for two subjects. The elimination has been exponential with half-lives of 63 and 95 days.

The positive ion Van de Graaff performed satisfactorily during the month. The alignment of the accelerator was checked after it had been opened for maintenance to the ion source. No change in alignment was observed. The accelerator is in the midst of a scheduled shutdown for installation of a new positioning device and a new analyzing chamber.

A study was completed of the response of the precision long counters to radioactive neutron sources. The study confirmed the reproducibility of the counters. One of the precision long counters was compared with the long counter that has been used as a standard for Hanford neutron dosimetry. The precision counter appears to have a better energy sensitivity than the old standard counter. A neutron source and calibrated BF_3 tubes were transferred to the National Bureau of Standards to get them started on their portion of the precision long counter program.

The current output of the helium ion source being developed for the Van de Graaff was considerably improved by substitution of a better oscillator circuit.

A set of small tissue equivalent ion chambers was completed for use in neutron depth dose studies.

The efficiency for neutrons of a silicon p-n diode manufactured at Hanford was measured. Recoil protons were detected from a sheet of tissue equivalent plastic placed in front of the diode. The efficiency was 5 counts/mrem.

A second radium source used in instrument calibration at Hanford was measured in the gamma ray calorimeter. The result indicated a source strength 1.4% less than the value now accepted.

New high voltage resistors were received for the beam sweep device for the electron Van de Graaff. A guard foil to reduce radiation losses was installed in the electron beam calorimeter. It reduced variations in the calorimeter calibration to 0.1% per day.

INSTRUMENTATION

Experiments, during several temperature inversions, have established the radon and thoron ($_{86}Rn^{222}$ and $_{86}Rn^{224}$) alpha-to-coincidence count-rate ratio as being 10:1. This information will permit completion of the present development project concerning the coincidence-type alpha air monitor. The stated ratio can be modified

by varying the coincidence gate width to arrive at an optimum figure which can, materially, determine the ultimate airborne Pu^{239} detection level ability of the instrument. By selection, the optimum gate width was found to be 200 microseconds, and this permitted an accurate balance (null condition) to be obtained through several moderate inversions proving that the radon-thoron effects can be effectively cancelled electronically. Both digital and analog type readout circuits are being investigated to determine the most accurate and reliable method. All circuitry is transistorized.

Fabrication was started on one experimental prototype personally carried, alarming, selectable level, dosimeter extending from 0-200 mr with selectable alarming increments of 10 mr over this range. The unit can be read out visually at any time or read on a standard HAPO charger-reader. The instrument employs a self-reading "pencil" dosimeter, a fiber illuminator, a CdS cell detector and completely transistorized circuitry.

Experiments continued concerning the CaF_2:Mn thermoluminescent dosimeters, including obtaining data concerning response versus gamma energy from eight Kev to 100 Kev. The present experimental packaging approach gives an acceptable energy response flatness from 20 Kev to 100 Kev. It is expected that this can be improved with a new package, now in development, to aid in readout of the device. Methods were established to simplify the packaging of the dosimeters for production fabrication. With each experiment completed, the potential usefulness of the device appears more attractive.

Experimental fabrication is nearly complete on two prototype miniaturized gross alpha detector instruments employing a 0.75 inch diameter P-N silicon surface barrier diode as a detector and six transistors in an amplifier and headphone driving circuit. The complete instrument is a lucite tube one inch in diameter and about ten inches long, thereby producing an extremely compact device for general gross alpha monitoring. There are no gamma interference effects even at 10 r/hr dose rates and the alpha geometry approaches 20 percent. Tests will start within two weeks and the prototype units will then be ready for demonstration.

Experimental fabrication is nearly completed on two prototype scintillation, completely transistorized beta-gamma dose-rate meters of the miniature battery operated portable type. These units use a solid-state chopper input plus transistorized amplifier, high voltage supply, etc. The units are a linear, multi-range type with decade ranges from 0-1 mr/hr up to 0-10 r/hr or other ranges as desired. Field preference seems to be 0-5 mr/hr for the most sensitive range.

Equipment has been procured to provide a vacuum system for use in alpha energy analysis work using the P-N silicon surface barrier diodes. In addition, some 1000 ohm-cm silicon material was received to permit experimental fabrication of more units. Also, some Li^6 was received to provide material for experimental fabrication of some neutron energy analysis detectors using the same silicon diodes. Work is progressing rapidly in this field of investigation with extensive usefulness foreseen for the devices at HAPO.

All necessary components have been received and are rapidly being assembled for the experimental electron beam deflection control instrument for use with the negative ion Van de Graaff accelerator.

The experimental servo-controlled logarithmic scintillation remote area monitor is complete in bread-board form and is presently being tested. High gain RCA 6655-A phototubes will be used in an effort to cover, logarithmically, four decades from one mr/hr to ten r/hr. The only problem remaining is to successfully hold the cathode to focusing grid voltage constant with changes in overall high voltage. This can be accomplished with a shelf-life battery or with Zener diodes. In addition, an experimental compensating circuit was developed for use at high dose rates (over 2 or 3 r/hr).

An experimental transistorized circuit using 300 MC transistors was devised as a direct solid-state equivalent of the vacuum tube "White" cathode follower used for multiplier phototube work. The circuit is now being tested. The solid state unit should handle very fast pulses (one nanosecond) without difficulty.

Experimental work is progressing on a transistor-driven mechanical (miniature) chopper in an effort to reduce chopper noise and permit low level signal (d-c) currents to be used. At present, the chopper noise level is equivalent to about 10^{-9} microamperes. This is a factor of 10^{2} better than the noise level for best solid-state choppers.

The development work is nearly complete on the miniature GM tube detector, approximate dose-rate integrator device possibly to be used as a personally carried, alarming, approximate dosimeter. Experimental prototype fabrication is scheduled to start as soon as the proper miniature relay can be obtained. Investigations have started on another personally carried alarming, selectable level (0-200 mr) dosimeter using an ion chamber (25 cc) and an inverted subminiature tetrode in an effort to reduce leakage currents which contribute to reading errors.

An estimate of the cost of a study to improve the reliability of the whole body counter multichannel analyzers was prepared and sent to Radiological Physics Operation.

Consultation was given on the spectrum stripper for the whole body monitor pulse height analyzer. It was found that a simple change could overcome a design difficulty and make the system operate properly.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analyses

The mass spectrometer for this program operated at about 125 percent efficiency again this month. Three days were spent in spectrometer maintenance and testing.

Further analysis was done on the comparison of the isotopic analyses of natural uranium obtained on this spectrometer with the "best values" obtained elsewhere. The previous monthly report, HW-66644B, page B-21, erroneously credited a best value of (0.7196 ± 0.0006) atom percent to KAPL. This result is actually the best value from Oak Ridge obtained from the document K-1201. The KAPL group reported three values: 0.7223 ± 0.0009, 0.7214 ± 0.0013, and 0.7244 ± 0.0011.

The Hanford value was 0.7188 ± 0.0008. Only the Oak Ridge and

Hanford values agree within the stated errors.

This array of results indicates that a small but significant bias does result from analyses performed on different mass spectrometers.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month on a two-shift basis. There were no unscheduled shutdowns.

The NPR condensed lattice experiments for k_∞, f, p, ϵ, wet and dry and the Plutonium Recycle Program Pu-Al fuel in a 10-1/2-inch graphite lattice experiment for flux traverses were completed during the month.

The NPR "mockup lattice" experiment for k_∞, f, p, ϵ, wet and dry was started during the month.

The operation of the TTR was limited to the irradiation of one group of foils for calibration purposes in support of NPR experiments.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	84.9
24-Hour General	60	86.6
Special	123	91.1

September was warmer and drier than normal. However, there was nothing unusual or extreme.

Instrumentation and Systems Studies

The complete, closed-loop calciner temperature control system, using the corrected process model, was simulated on the analog computer. The results of tests made to determine the system responses to various types of disturbances were summarized in a memorandum. The customer (CPD) is now planning to install the recommended control equipment on the actual process.

Work has been started on an X-ray diffraction peak integrator for FPD. An effort to utilize the instrument's electronic counter was complicated by a background subtraction requirement. A mechanical counter with a subtraction solenoid has proven to be too slow. The probable solution will involve an electronic or mechanical integrator attached to the instrument peak recorder.

The reference system, for evaluating the Schaevitz DRS-100 (micro-displacement readout) system, is being slightly modified in order that it can be accurately calibrated before being placed in service as a reference system. The DRS-100 is being evaluated for the Physical Metallurgy Group and will be used for making in-reactor creep measurements.

The multi-level in-cell beta-gamma monitors and the air filter monitor for Chemical Research and Development Operation were completed, calibrated, tested, and delivered to the 325 Building for installation.

The Pu^{239} (17 Kev X-ray) Wound Probe for Records and Standards Operation, HLO, is being revised to provide better resolution and sensitivity with the four-inch diameter by three-millimeter-thick NaI crystal. Tests have shown the unit capable of detecting about 8,000 d/m Pu^{239} through one-eighth inch of flesh-simulating lucite. It is hoped to improve the sensitivity by a factor of five for field use although the present detectable amount limit is considered adequate for routine field inspection of wounds.

A scintillation, transistorized, portable gamma energy analyzer of our design, which has been in the HAPO portable instrument pool for a year, was modified to provide drive for a one-milliampere chart recorder. This work was done for the Radiation Protection Operation, HLO, to provide an alternate unit for aircraft use at the Nevada Test Site. The regular, previously designed, transistorized airborne-sensitive gamma monitor (gross) will also be used in the tests.

Ten RCA 6655-A phototubes were tested and graded according to signal-to-noise ratios, resolution, etc. for personnel at the 234-5 Building for use with their multi-channel energy analyzer.

Assistance was rendered and electronic instruments (amplifiers, high voltage supplies, etc.) were loaned to the Biology Operation for use in studies of Sr^{85} uptake in plant leaves.

Optics

Radiomatic Head for Purex Dissolver

An investigation of methods to detect a 16-square-inch 400°F body in a 200°F background is being conducted for CPD. A memo has been written describing the problem and discussing a possible solution.

Work Authorizations Received

1. Provide drawings and specifications for NPR periscopes.

2. Design length measuring device for 105-C Fuel Examination Facilities.

3. Adapt microphotometer for the Biology Operation for use in dosimetry studies.

Radiation Ratio Pyrometer

The metallograph pyrometer was installed for preliminary testing. Temperatures over the 500°C to 1000°C range were readily monitored and the output of the pyrometer was used to control the temperature of the specimen in the hot stage of the metallograph. The pyrometer is now returned to the Optical Shop for final wiring and improvement of appearance.

The FPD extrusion press pyrometer has been completed as far as the electronic and mechanical assemblies are concerned. The lenses and filters are now being installed and preparations are being made for testing the unit. Details of the design of an

aperture which will linearize the output of the pyrometer have been worked out. Circuitry which automatically phases the pyrometer with respect to the 60 cycle power line has been developed.

Shop Work

A total of 501 manhours work was performed during the four-week period (August 28 - September 25). Of this, 2% was for FPD, 8% for IPD, 21% for CPD, 59% for HLO, and 10% for Code 0710.

The work included:

1. Fabrication of 20 glass bearings for CPD.
2. Fabrication of a periscope for IPD.
3. Fabrication of one radiation ratio pyrometer.
4. Resurfacing four pump seals.
5. Fabrication of a probe for air gap measurement.
6. Modification of two telescopes for 234-5 Building.

Analog Computer Facility Operations

The major problems on the analog computers this month include:

1. PRTR Safeguards Analysis.
2. Reactor Excursion Studies.
3. NPR Pressure Confiner.
4. Speed of Control.

The tape transport units were received back on plant this month. They have been partially checked out. A complete checkout of the units against our specifications will be made during October.

The computer operations breakdown is as follows:

	Computer Operation
GEDA	52 hours up
	*92 hours idle time
	0 hours unscheduled downtime
	24 hours scheduled downtime
	168 hours total
EASE	116 hours up
	16 hours idle time
	36 hours unscheduled downtime
	0 hours scheduled downtime
	168 hours total

* 36 hours of this was because the EASE computer was not working and both computers were needed to solve the problem.

The large amount of idle time was due to the need to use the EASE computer or both computers.

Fabrication is proceeding on the amplifier test unit to be used to test the operational amplifiers in the GEDA and EASE computers. At present several EASE amplifiers are inoperative. They will be repaired with the aid of the amplifier test unit since there is no other way to power the amplifiers outside the computer.

Tests have been completed on the 51 bad 12AX7's and the 18 bad 12AU7's removed from the EASE computer 1148 amplifiers since April, 1960. No predominant malfunction was found in the tubes. Only three of the 12 AU7's showed any bad characteristics; thirty-two 12AX7's appeared poor.

Goodyear has finally agreed to sell us certain replacement components for the GEDA computer. Fourteen printed circuit cards, a stabilizer commutator assembly and patchbay board have been ordered. Fabrication of the amplifiers on the printed circuit cards will be done locally.

Instrument Evaluation

1. Acceptance tests were completed on 65 C-P instruments and on 13 Model II, 614 Building Area Monitors.

2. Field tests continued satisfactorily on the prototype Model II transistorized (line-operated) "Scintran" instruments which, by merely changing detector probes, can be used as desired for alpha, beta-gamma, and neutron monitoring.

3. Field tests continued satisfactorily on the combined (prototype) transistorized cart-poppy replacement for use with either air-proportional or scintillation probes for alpha monitoring.

4. Field tests were started on the combined alpha, beta, gamma scintillation transistorized hand and shoe counter. Tests at 100-D indicated that some lead shielding would be necessary because of extreme background (gamma) condition. The instrument, which needs no lead shield in providing adequate sensitivity in most plant locations, is now being slightly modified with the required shielding for use at 100-D and other high-background locations.

5. Drift tests were completed on the commercial Victoreen dual logarithmic count-rate meter (with a center ratio meter). The tests showed a drift of 18 percent of one decade on the log scale per day. This is too excessive for on-the-line field use; however, laboratory use under controlled conditions would be possible.

Paul F. Gast

Manager
PHYSICS AND INSTRUMENT RESEARCH
AND DEVELOPMENT
HANFORD LABORATORIES OPERATION

PF Gast:mcs

CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Radioisotopes in Reactor Effluent Water

Chemical Forms of Reactor Effluent Water Radioisotopes - Paper electrophoresis studies of Mn-56 and As-76 containing species in reactor effluent water indicate that Mn-56 is present as manganous (Mn^{++}) ion. As-76 is present as both the arsenate and the arsenite ions with arsenate the predominant ion at the time of measurement, which is several hours after leaving the reactor. The arsenite species does not migrate in the background electrolyte, which was 1×10^{-2} M NH_4NO_3 and 2×10^{-4} M NaOH.

Reactor Water Treatment Studies - A small laboratory water treatment plant modeled after the reactor water treatment plants was successfully operated at one-half gallon per minute for the month. Tests were completed on the use of aluminum nitrate flocculant as a substitute for the alum presently used. Results of these tests show that use of 26 ppm $Al(NO_3)_3 \cdot 9\ H_2O$ may reduce the arsenate in influent water by a factor of nine or more over the reduction presently obtained by the alum flocculant treatment. In order to determine if this would result in a corresponding reduction of As-76 in the reactor effluent water, one-half reactor tests with high concentrations of aluminum nitrate and alum flocculants were started this month by IPD to test the effectiveness of these treatments.

Uranium Oxidation and Fission Product Volatilization

Experimental work was continued to study the effects of irradiation level on the release of fission products from overheated uranium fuels. The irradiation level of the uranium samples now being used is about 10,000 times greater than that used in the low level work. To date there is little information which would lead to a conclusion that the concentration of fission products has any significant effect on the percentage of fission products released although there is some indication that the release of tellurium may be less and the release of strontium slightly more than predicted from trace level work.

Plans were completed and experimental equipment almost readied for the study of kinds and nature of particulate matter released from overheated fuels.

NPR Effluents

Attempts to effect removal of phosphorus from phosphoric acid reactor decontaminating solutions by passage through a bed of limestone chips were unsuccessful. The calcite increased the pH of the solution to 4.0. With an initial NaOH neutralization to pH 9.5, passage through the bed reduced the pH to 7.8 without appreciable phosphate removal. These experiments indicated that a limestone bed would be unsuitable for the predisposal treatment of phosphoric acid cleaners. Equilibrium experiments conducted with $CaCl_2$ and $CaSO_4$ indicated that up to 90 percent of the phosphorus could be removed, but only when the cleaning solution was initially neutralized with NaOH.

Reactor Effluent Treatment

The pilot scale aluminum turnings bed accumulated 840 hours of operation at a bed flow rate of 3.8 feet per minute. At this time the bed was removing 68 percent of the As-76, 87 percent of the Zn-65, 57 percent of the P-32, and about 25 percent of the Np-239. The significant removal of Np-239 was unanticipated from laboratory tests. Pressure drop had increased from about 0.1 inch per foot to 0.24 inch per foot, the increase largely due to effluent basin sludge coating the first few feet of the bed. This could likely be prevented in a full scale application but cannot be easily avoided in the pilot scale facility because of the location of the basin intake to the facility. A maximum dose rate against the bed structure of 470 mr/hour was reached. Tests were begun at a flow velocity of six feet per minute. Radiation from the tank soon reached 1100 mr/hour.

The 30-foot long bed is as effective in decontaminating reactor effluent as the laboratory work indicated, except for Np-239 which was being retained to a greater degree than was indicated in the laboratory.

SEPARATIONS PROCESSES

Feed Preparation

Dissolution of NPR Fuels - Instantaneous dissolution rate determinations were made for the dissolution of α extruded uranium in nitric acid - uranyl nitrate solutions simulating dissolution to two molar uranyl nitrate. Rates obtained were comparable to those for current production ingot uranium as well as extruded uranium containing small amounts (0.05 percent or less) of alloying constituents such as iron, silicon or zirconium. They were several-fold higher than rates similarly obtained for extruded uranium containing one to two percent zirconium.

Solvent Extraction

Solvent Evaluation Studies - A series of isoparaffinic hydrocarbons produced by the Ashland Oil and Refining Company was studied as possible diluents for use in the Purex Process solvent. These hydrocarbons are reported to be exceptionally low in olefinic content. Tag closed-cup flash points for the sixteen samples available ranged from 147 to 181 F (F.P. for Shell E-2342 = 151 F). Specific gravities ranged from 0.761 to 0.785 (Sp.Gr. Shell E-2342 = 0.801). Tests made to date indicate the Ashland Oil hydrocarbons are less susceptible than Shell E-2342 to undesirable chemical degradation on exposure to nitric acid - nitrous acid solutions. Fission product retention in solvent containing chemically degraded Ashland Oil was significantly less in batch contacts simulating Purex first cycle than when degraded Shell E-2342 was used as the diluent.

Purex First Cycle Scrub Studies - The effects of scrub nitric acid concentration and uranium concentration in the solvent on scrub section decontamination in the Purex first cycle extraction column were studied. A sample of Purex HSP (organic product from first extraction column) was found to be 0.292 M in uranium. When this organic phase was scrubbed four successive times with 1/5 volume portions of scrub solution containing 3 M HNO_3, gross gamma E_a^o values increased from 1.0 to 7.9 in the series. In similar contacts with the scrub containing 2.0 M HNO_3, gross gamma E_a^o values increased from 0.22 to 4.8. With organic uranium concentration increased to 0.38 M, gross gamma E_a^o values increased from 0.18 to 3.1 for 3 M HNO_3 scrub and from 0.16 to

2.0 for 2 M HNO_3 scrub. Both increased uranium saturation in the solvent and decreased acidity in the scrub improve scrubbing efficiency. Attempts to improve scrubbing efficiency by adding inert zirconium to the scrub solution were not successful.

WASTE TREATMENT

Semiworks Batch Waste Calciner

Three runs have been made to date in the pilot-scale batch calcination facility with pots eight inches in diameter and four feet tall. The feeds for the first two runs were simulated Purex-type acidic wastes, with sulfate to salt nitrate mole ratios of 0.5 and 1.35 for the first and second runs, respectively. (Previously reported laboratory findings indicated that a sulfate to salt nitrate ratio in the feed of greater than one is needed to form a melt at about 850 C.) The third experiment was a melt-down study of the granular Purex waste produced in a fluidized bed calciner. The simulated acid waste fed to the fluid bed calciner had a sulfate to salt nitrate ratio of 0.55. A quantity of anhydrous sodium sulfate was blended with the granular calcined waste such that the equivalent sulfate to salt nitrate ratio of the liquid feed to produce the mixture would have been 1.4.

Highlights of the pilot-scale runs are:

1. The melt formation behavior in the pilot plant is as predicted from the laboratory studies: melts formed when the sulfate to salt nitrate ratio in the waste solution (or equivalent) was about 1.4, and did not form when the ratio was 0.5.

2. Foaming is excessive when operating with a high solution level in the pot. During the second run, some foam-over occurred and the conductivity probes used to indicate solution level were shorted out by calcined foam. Foaming was not a problem in the first run where a shallow solution level was maintained.

3. A higher temperature is required to produce a melt from a sodium sulfate - fluid bed powder blend than from a melt-forming aqueous waste. Melting occurred at about 875 C in run 3 and at about 825 C in run 2.

4. Central cracks and fissures form when a melt solidifies and cools. A gap of about 20 mils was observed between the solids and the pot wall.

5. Upon solidification, a layer of yellow, crystalline solids formed above the brick-like calcine in run 3. The volume of the yellow solids was about twenty percent of the total.

6. The bulk specific gravities of the melts were 2.45 and 2.3 compared to 0.85 for the porous, non-melting calcine.

7. A thermal conductivity of 0.4 BTU/(hr)(sq.ft.)(°F/ft.) was measured for a piece of solids from the second run.

8. No significant pot corrosion was evident in any of the runs.

Fluid Bed Waste Calciner Prototype

Operation of the fluid bed calciner has continued with a feed of simulated high-acid

Purex waste solution. (Nominal feed composition is: H^+ 6.0M, Fe^{+3} 0.25M, Al^{+3} 0.10M, Na^+ 1.0M, Cr^{+3} 0.008M, Ni^{+2} 0.005M, SO_4^{-2} 0.53M, PO_4^{-3} 0.016M, NO_3^- 6.0M.)

Three runs were completed in which the feed nozzle(1) was mounted at the apex of an inverted hollow cone which in turn was mounted on the bottom of the calciner heater section. This was done to determine the feasibility of using the atomizing gas stream in the dual-purpose role of atomizing the liquid feed and fluidizing the bed. This technique would greatly reduce the volume of calciner effluent gases to be processed. The runs exhibited only limited success. This was primarily because the relatively poor atomizing gas distribution of the nozzle resulted in localized areas of quiescent bed, even at moderately high atomizing gas-to-feed volume ratios of 1000. (Feed rates were 12 to 15 liters/hour.) Other observations are:

1. Build-up of nozzle lumps does not occur at the higher atomizing air-to-feed volume ratios (approximately 1000), but does sometimes occur at lower ratios.

2. Mixing of the calcine in the cone with that in the calciner proper is adequate to prevent caking in the cone at the higher atomizing air flow ratios.

3. Calcine particle size even at the lower atomizing air rates is relatively small (approximately 60 percent of the calcine passes through a 48-mesh screen).

Two runs were performed in which the feed was injected through an extended-tip nozzle located five inches below the stagnant bed height (compared to about two inches in most previous runs). Comparisons to the previously tested nozzle position show that:

1. Powder bulk density (tapped) increased from about 1.4+ to 1.5+.

2. Fluidizing air flow rates required for operable bed agitation is increased about ten percent (to 0.7 ft/sec. superficial velocity).

3. Atomizing air-to-feed volumetric flow ratios required to prevent lumping at the nozzle increase by about thirty percent (to 450).

4. The number of particles of the larger sizes (greater than 35 mesh) that are built up in layers rather than by agglomerating appear to increase somewhat. Total large particle formation rate does not change significantly.

Another run was performed with the nozzle in the lower position but with the calcine removal from the bottom of the calciner bed rather than from an overflow line. Preliminary observations indicate no significant change in calciner performance and calcine properties compared to those with the overflow line. However, this scheme has the potential advantage of minimizing build-up of large particles in the calciner because the powder is removed from the location where the larger particles tend to accumulate.

---

(1) Spraying Systems Company set-up 4B with the outside diameter of the atomizing gas annular orifice being 0.1360 inch.

Radiation Stability of Calcined Solids

In connection with the study of radiation stability of calcined waste solids it has been necessary to obtain a measure of the efficiency with which the beam from the Van de Graaff generator is absorbed in the sample. The use of ceric sulfate dosimetry was accordingly extended to high levels (doses up to 9.5×10^6 rad) and to dose rates of 6×10^4 rad/sec. It was found that only about 30 percent of the beam current is absorbed. (The rest is presumably stopped by the window and sample holder or scattered by the air.) Conversion of beam current to absorbed dose for solid samples will be somewhat more uncertain due to lack of mixing in the sample and inability to deliver energy uniformly. Samples representing the major proposed types of waste have been prepared and irradiated, but the gases produced have not yet been measured and analyzed.

Observation Wells

The Hatch Drilling Company completed two of the three well drilling projects under Contract AT(45-1)-1607 during September. These two projects called for the construction of nine wells, three in the 200 West Area and six in the 100 Areas. All nine of these wells were drilled adjacent to new ground disposal facilities for ground water monitoring purposes.

At month end the Hatch Drilling Company had completed three of the ten wells on Project CAH-885, and were drilling on three others. Two of the three drilling rigs are being operated two shifts per day at sites 699-37-82-A and B, 20 feet apart. Here, the two wells will terminate in different aquifers showing different potentiometric head. Changes in head with time in those two aquifers can then be compared to determine the degree of interconnection between them as it might affect the potential movement of wastes at depth in the deeper aquifer.

Well 699-S-11-E12, two miles north of the 300 Area, encountered artesian water within the upper 46 feed of the basalt series. The well now flows about 1.5 gal/min. at an altitude of about 400 feet above sea level. The well lies within the area recommended as a site for a well field for a 300 Area independent water supply system.

The source of the head and the water is not known. Localities where the water table lies appreciably above 400 feet altitude, and where aquifers in the basalt are so located as to be rechargeable, completely surround the Hanford Works area but at distances greater than about eight miles. Studies are underway to determine if the waters may be originating in the Columbia Basin Irrigation District east of Hanford and passing beneath the Columbia River as cross flow and underflow. The evident continuity of the confined aquifer from the recharge area to the well site, the rate of flow, and the permeability of the aquifer are of interest as they may concern disposal of wastes within the basalt series.

Only minor changes were noted in ground water contamination patterns in the vicinity of the 200 Areas over the month. The eastward movement of contaminated ground water under the center of 200 East Area has become more pronounced. Recent increases in beta-emitter concentrations in wells north and south of the Hot Semiworks mark this location as the current eastern edge of this particular ground water contamination zone. Radioisotopes at this location originated in wastes discharged to the 216-BY scavenged waste cribs approximately one mile northwest of the Hot Semiworks. The original southward movement of the ground water from beneath the BY cribsite has reverted

to an eastward movement during the past six months. The shift is probably due to the increased effect of the 200 West Area ground water mound on the movement of contaminants under 200 East Area.

Disposal to Ground

Consultations were held with Chemical Processing Department regarding the use of the 216-T-28 crib for receipt of decontamination wastes. It was recommended that two additional wells be drilled near the crib. Some contamination has been detected with a scintillation probe in an existing well near this crib. The contamination is in a band at about 30 to 60 feet from the surface and is supposedly spread by the caliche layer. A soil column test with 2706 W decontamination waste was completed and showed no detectable Sr, Cs, or Pu breakthrough to 16 column volumes. However, more meaningful soil column work was planned to study the actual condition. These experiments will use contaminated soils from the new wells together with solutions displaced from the cascade tanks (containing Bismuth Phosphate second cycle waste) by the decontamination solutions which are led into them. In this way, the actual waste to be cribbed (tank effluent) which may be quite different from the decontamination waste (tank influent) will be studied in its reaction with the contaminated soils associated with the crib.

Laboratory equilibrium studies were made on the adsorption by soil of nuclides from the Purex organic waste going to the A-2 crib. Preliminary results indicated good adsorption of strontium, alpha emitters, and zirconium-niobium, but no removal of cobalt. Co-60 level in the samples analyzed was two to three times MPC.

TRANSURANIC ELEMENT AND FISSION PRODUCT CHEMISTRY

Strontium Recovery

Purex Plant Flowsheet Studies - Although the lead carrier - oxalate metathesis flowsheet for the recovery of a strontium rough-cut in the Purex head-end equipment gave excellent yields in laboratory experiments with synthetic 1WW, performance in hot-cell and plant runs with plant 1WW was unsatisfactory. Carrying of strontium on lead sulfate was satisfactory, but losses in the subsequent oxalate metathesis and product precipitation steps were excessive - apparently because of difficulty in dissolving the lead sulfate coupled with interference by sulfate in the later steps. A series of flowsheet modifications were explored in arriving at a solution to this problem. Approaches tested included: changed precipitation conditions (to minimize the amount of lead sulfate used), thorough study of the nitric acid-oxalic acid metathesis, caustic-tartrate dissolution of the sulfate cake, sodium hydroxide metathesis and leaching prior to oxalate precipitation, acetate leaching of lead, elimination of lead through use of a rare earth carrier, and carbonate metathesis. The carbonate metathesis proved quite satisfactory, and can be readily carried out in the Purex centrifuges. Use of hot (60 C) 1 to 1.5 M sodium carbonate removed sulfate and converted the sulfate cake to a mixture of lead, rare earth, and strontium carbonates with loss (in the laboratory) of less than one percent of the strontium. The carbonates are readily dissolved in dilute acid, and a judicious choice of solution volumes results in an oxalate supernate (strontium product) volume only one-fourth that of the initial 1WW. This volume reduction at this point eliminates the need for a strontium concentration step prior to 244-CR storage, thus effecting a significant saving in time cycle.

The two-cycle carbonate metathesis flowsheet proved entirely successful in the plant (Purex run #5). Overall strontium recovery was 85.3 percent, and decontamination factors from Zr-Nb, Ru-Rh, Ce, and Y were 15, 242, 22, and 58, respectively. The time

cycle was only three days vice 5-1/2 days previously. This shortened time cycle will make possible processing of all of the strontium from the inventory of aged metal rather than the 50 percent which would have been possible on the former flowsheet.

Further laboratory work has shown that a combined 5 M NaOH - 1 M Na_2CO_3 metathesis may be somewhat better than carbonate alone. Strontium losses are still less than one percent, but the bulk of the lead is also removed. This would be of particular advantage in an integrated flowsheet in which it was desired to recover cerium and/or promethium as well as strontium.

The major flowsheet problem remaining is determination of the best way to concentrate the strontium, after return from 244-CR, for shipment to 325-A or the Hot Semiworks. It is important to use a carrier-free precipitation to avoid complicating the purification cycle. Preliminary experiments suggest that solubility losses may be higher than are tolerable and indicate that an evaporator would be very desirable for Semiworks and B Plant use.

Laboratory Solvent Extraction Studies - Experiments were performed to develop chemical flowsheets for solvent extraction isolation and purification of strontium-90. Feed for the process is the solution which will result from "crude cut" processing of Purex 1WW. Solvent for the process is di(2-ethylhexyl) phosphoric acid (D2EHPA) in a Shell Spray Base diluent containing some TBP. Feed stability studies, single batch contact studies and mini-mixer-settler runs were made with solutions simulating those expected to result from the "crude cut" procedures.

Dilute crude cut solutions (0.25 g/l Sr) were stable toward solids formation at pH's up to three when made 0.25 M in tartrate. At higher pH's, solids believed to be tartrate salts precipitated. Similarly, solids precipitated at pH's below 2 when concentrated (2.0 g/l Sr) crude cut feeds were made 0.25 M in tartrate. Concentrated crude cut solutions were stable at pH values of four or greater when made 1.0 M in acetate or 0.3 - 0.5 M in citrate.

Single batch contact studies indicate that the first extraction cycle can be operated successfully at either low pH (ca. 2) or high pH (4-5) with acetate buffered feeds. Similar studies indicate good first cycle performance at low pH with citrate buffered feeds.

Two mini-mixer-settler runs were made in which a simulated concentrated crude cut solution, made 0.4 M in citric acid and adjusted to pH 3 with sodium hydroxide, was used as feed. The extractant was 0.4 M D2EHPA - 0.15 M TBP in Shell Spray Base. Scrub solution was 0.1 M citric acid. The mixer settler was operated with seven extraction and five scrub stages. Flow ratios were feed:scrub:organic equal 1.0:0.6:1.6. Under these conditions 99.9 percent of the calcium present and only 0.7 percent of the strontium were extracted.

In similar mini runs a concentrated crude cut solution made 1.0 M in acetate and adjusted to pH 2.8 was used as feed. Radioactive tracers were used to follow most of the elements expected in the crude cut solution. At feed:scrub:organic flow ratios of 150:30:150, about one percent of the strontium and barium, 20 percent of the ruthenium and 80 to 100 percent of the cerium and zirconium-niobium were extracted. Calcium results are not yet available. Data from these mini runs indicate that adequate separation of calcium and strontium and considerable purification of strontium can be obtained in a low pH first solvent extraction cycle.

To prepare the strontium product for shipping it is proposed to precipitate strontium carbonate from the product solution (acetate or nitrate) and filter it directly into the shipping cask. Strontium carbonate precipitated without digestion at pH 9-10 was not retained on a coarse sintered glass filter. With Celite added (one part by weight to two parts Sr) and the slurry digested 30 minutes at 80 C, greater than 99.5 percent of the strontium was retained on a coarse sintered glass filter. No changes in physical properties were noted on heating the filtered solids 36 hours at 375-550 C. The cake was easily dispersed in water with slight agitation.

Pilot Plant Solvent Extraction Studies - Scouting studies to determine the feasibility of recovering megacurie quantities of Sr-90 from Purex 1WW by solvent extraction techniques were started in 3-inch glass pulse columns. (Solvent extraction techniques and terminology are employed, but the mass transfer mechanism involved is that of ion exchange in a liquid-liquid system.) The tentative process consists of two extraction-strip cycles employing di(2 ethyl,hexyl) phosphoric acid (D2EHPA) or the sodium salt (NaD2EHP) as the extractant, a feed of simulated Purex 1WW fission product crude cut, a sodium acetate-acetic acid scrub and a nitric acid strip. In general, the process relies on the extractive and stripping behavior of the various 1WW constituents as a function of pH to enable the required degree of separation and purification of strontium from the other constituents. In the first extraction cycle the strontium, calcium, and part of the rare earths, yttrium, and some iron and lead are extracted and scrubbed at a pH of 4 to 5. In the strip column the strontium and calcium are selectively stripped back into the aqueous phase. After concentration and pH adjustment the predominately strontium-calcium solution is fed to the second cycle extraction column where the calcium is preferentially extracted at a pH of 2 to 3 and the strontium is retained in the aqueous phase. (It may be desirable, depending upon contaminant extraction characteristics and other process considerations, to reverse the above order of the extraction cycles.)

The studies to date have consisted of extraction column capacity and efficiency tests using an acetate-buffered system. The column used has a 12-foot extraction section, a 6-foot scrub section, and an all stainless steel cartridge. Feed, extractant and scrub compositions tested are as follows:

Concentrations (Molarity)

Feed	No. 1	No. 2
HNO_3	1.0	2.0
Sr	0.006	0.025
Ca	0.025	0.10
Fe	0.018	0.072
Ba	0.037	0.037
Pb	0.002	0.029
Feed Adjustment		
Tartric Acid	0.2	-
NaAc	1.0	0.5-1.0
NaOH	-	to pH 2 to 5

Extractant	No. 1	No. 2
D2EHPA	0.4	-
NaD2EHP	-	0.4
TBP	0.2	0.2
(Diluent is Shell E-2342)		

Scrub	No. 1	No. 2
HAc	0.1	0.06
NaAc	-	0.1
pH	2.7	5

Preliminary observations are:

1. A processing rate of 50 g/hr Sr in a 3-inch diameter column is assured and 75 to 100 g/hr Sr is possible (using a feed of 0.025 M Sr) with the aqueous phase continuous.

2. Column capacities with the organic phase continuous are 50 to 75 percent of those with the aqueous phase continuous.

3. The dispersion noted during aqueous-continuous operation appears more uniform and stable than that observed during organic-continuous operation. However, phase disengaging times are longer in the former case (due at least in part to the formation of an interface crud not observed during organic-continuous operation).

4. At the conditions tested with the high pH flowsheet: (a) greater than 90 percent of the Sr and Ca are extracted, (b) more than half the uncomplexed Fe and Pb are extracted, (c) stripping of the Sr and Ca is essentially complete and provides a decontamination factor from Fe of at least 20, (d) a single batch contact of the strip-column organic effluent with sodium carbonate-sodium tartrate results in greater than 95 percent removal of Fe from the organic.

5. At the conditions tested with the low pH flowsheet: (a) less than three percent of the Sr is extracted, (b) less than five percent of the Fe and Pb are extracted with tartrate-complexed feed; about half the Fe and Pb are extracted in the absence of tartrate, (c) about one-third of the calcium is extracted.

6. The primary problem encountered to date is the partial preferential wetting of the stainless steel columns internals by the organic phase.

Strontium Purification

The A-Cell run reported last month was completed. Despite formation of some precipitate in the columns early in the run (this precipitate was dissolved and further precipitation prevented by lowering the degasser temperature) and a moderate amount of gassing late in the run, excellent purification was achieved. Lead, calcium, and strontium eluted in that order with over 94 percent of the strontium recovered at a concentration of 1.2 g/l and free of any detectable trace of impurity, i.e., "spectrographically pure." These results serve to firm up the process which will be used in the 325-A production effort. The only variable which it has not been feasible to test is the possible effect of radiation on the resin; however, dosage calculations and the best available resin exposure data indicate that resin degradation should not be a serious problem.

The larger columns, feed pump, and feed and waste tanks are on order and delivery of all components is expected by mid-October. Installation should be completed by month end. Shake-down and tracer level runs are planned for November with production runs scheduled to start in early December.

An important advantage of the EDTA ion-exchange strontium purification process for future B Plant use is the fact that promethium can be purified in the same equipment with the same elutriant and very nearly the same flowsheet. Thus the equipment can serve a dual purpose.

Strontium Shipment

It was reported last month that cerium, too, loads strongly onto Decalso. Although the radiation limit associated with off-site strontium shipment in STT's has been relaxed, cerium will continue to limit strontium shipment. A number of complexing agents were investigated in an effort to prevent cerium absorption while allowing strontium to be retained. EDTA was the most effective. In the presence of as little as 5 g/l of EDTA and for pH's ranging from 3.5 to 8.0, the absorption of cerium was practically nil. The distribution coefficient, K_D, of strontium from the same solutions ranged from 7.2 at pH 3.5 to 1.26 at pH 8.0, suggesting that EDTA can be used to simultaneously prevent absorption of cerium and to control loading of strontium (to "smear" the strontium out over the entire bed to prevent hot spots).

Several strontium solids, which are candidates for filter cask use, were irradiated in the Van de Graaff generator to dosages (10^9 to 10^{10} R) comparable to those expected in shipment. Compounds tested included strontium hydroxide, strontium oxide, strontium oxalate, strontium carbonate, and strontium sulfate. None of these appeared to be entirely satisfactory.

The samples were dried in a vacuum oven under conditions simulating the projected cask drying technique, then placed in irradiation ampules, evacuated, sealed and irradiated. After irradiation, they were placed on a vacuum line, opened, the pressure build-up measured, and the evolved gas collected for mass spectrographic analysis. Total volumes of gas collected per gram of sample were as follows:

Compound	Dosage (R)	cc of Gas (STP)/g Sample
SrO	5.8×10^9	0.023
$Sr(OH)_2$	8×10^9	2.21
SrC_2O_4	5×10^9	53.5
$SrCO_3$ (Dried 100 C)	2×10^9	9.57
$SrCO_3$ (Dried 200 C)	2×10^9	7.10
$SrSO_4$	7.5×10^9	8.36

It might be noted that although strontium oxide evolved far less gas after irradiation than did the other compounds, it released copious amounts of gas and exhibited violent ebullition during sealing. It is also the most difficult compound to prepare (made by heating strontium hydroxide to 650 C).

The gas evolved by the sulfate sample was primarily water, indicating incomplete drying despite heating for several hours at 200 C under high vacuum. The strontium oxalate gave mostly CO and CO_2 as expected. The strontium hydroxide yielded water (33 percent), oxygen (46 percent), hydrogen (9 percent), and nitrogen (9 percent). The carbonate samples gave hydrogen (49 and 77 percent) and CO_2 (40 and 18 percent). Since oxygen was not found in the products of the carbonate irradiation, the hydrogen may well be due to presence of a bicarbonate.

The above results are being considered from a cask design and hazards standpoint by CPD Facilities Engineering. Consideration is probably limited to strontium carbonate and strontium sulfate since the method used to prepare strontium hydroxide (precipitation by chilling a caustic-neutralized strontium nitrate solution with ice followed by filtration, washing with alcohol, and oven drying to remove water of hydration) is not feasible for Purex use.

Promethium Purification

To supplement the A-Cell runs made several months ago on purification of promethium by the EDTA ion exchange process, a laboratory-scale run was made with Pm-147 and Am-241 tracers added. (The earlier runs had contained non-radioactive stand-ins for all of the fission product rare earths except promethium, which has no stable isotope.) The promethium concentrated, as expected, between neodymium and samarium, and the americium eluted ahead of samarium. These results substantiate the previous work and indicate that there should be no americium contamination of the product.

Slurry Drying

A heated pot, containing an agitated bed of refractory solids has been successfully used to dry a water slurry on a continuous basis. To test whether a satisfactory bed could be established in an empty pot, a heavy slurry of calcium carbonate was charged into the pot and evaporated to dryness. No lumps were found in the residual powder and there was no evidence of caking or sticking. On the basis of these tests, an agitated pot appears to be suitable for the evaporation and drying of a water slurry of refractory solids.

Salt Crystallization and Drying

An unsuccessful attempt was made to crystallize and dry a water soluble chloride salt by feeding a brine into a bed of molten sulfur contained in the agitated pot. A brine consisting of 200 g NaCl/l was fed at 10 ml/min into molten agitated sulfur maintained at 150 to 200 C. Operation was smooth and uneventful for about one hour at which time the agitator bound. Examination of the resultant bed showed that about 25 percent of the salt had dispersed into the sulfur while the remainder had settled and caked onto the bottom of the pot.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

In-Cell Gamma Spectrometer

The gamma spectrometer installed in A-Cell of the High Level Radiochemical Facility has been partially calibrated and was used to follow the results of B-Cell runs, numbers 4 and 5 (strontium recovery). In this way it was possible to determine the fraction of the Ce-144, Zr-Nb-95, and Ru-103 remaining after each step in the process. Repeated counting of samples gave values reproducible within five percent; however, correlation with Analytical Laboratories results was somewhat poorer. Nevertheless, the in-cell spectrometer has proven very valuable, even at the present state of calibration, for giving a very rapid indication of the progress of the in-cell experiments.

Flame Photometry of Calcium, Strontium and Barium

The analysis of calcium, strontium and barium by flame photometry was reviewed because of difficulty the Analytical Laboratories had experienced in assaying the samples from the A-Cell strontium purification run. Ability to determine these elements in the presence of each other, by suitable correction for interferences, was reaffirmed. Precision for calcium and strontium was well within five percent and that for barium slightly greater than five percent. All of the samples were re-analyzed and satisfactory and consistent results obtained.

Scintillating Glasses

The two samples of scintillating glasses previously described have been tested for alpha response. Quantum efficiencies for alphas for the NRL and 96 percent silica glasses, 0.07 inches thick, are about 7.5 percent and 3.2 percent that of ZnS(Ag). These are adequate for routine counting if low-noise components are used. Comparison of other characteristics include: peak-to-valley ratios of about 52 and 5.5 as compared with about 8.7 for unprotected ZnS(Ag) and about 2.8 for Teflon-covered ZnS(Ag) (as used in "contact alpha" counting), pulse height resolutions of about 48 percent and 59 percent compared with from 100 to 130 percent for ZnS(Ag), and approximately 100 percent efficiency (because of their homogeneity) as compared with approximately 50 percent efficiency for the ZnS(Ag).

With respect to alpha response the NRL glass is superior to the 96 percent silica but the latter is cheaper and probably more chemical resistant. Self-absorption of light is the main cause of the lower output of the 95 percent silica; this may perhaps be overcome by using very thin sections which are practical only for alpha counting.

Both the NRL and a low silica (50 percent) glass have shown satisfactory chemical resistance to decontamination procedures following exposure to plutonium solutions in 0.1 M HNO_3.

EQUIPMENT AND MATERIALS

Z Plant Centrifuge Tests

Efforts were made to improve the quality of the products discharged from the centrifuge when operated at 6000 RPM (3000 G). Two influencing conditions were changed: (1) the crystal size of the influent feed was increased, and (2) the residence time through the machine was increased. As a result, the effluent liquid was clear and contained only 0.08 percent solids as compared to 0.6 percent reported last month. However, the solid product discharged from the machine contained about 35 percent moisture, too high for satisfactory handling because of stickiness.

The centrifuge equipment is being modified to provide means to pass 3 cfm of 50 percent air-steam mixture at 250 C countercurrent through the machine. This is to simulate the intended plant practice wherein the calciner off-gases will discharge through the centrifuge.

234-5 Reclamation Facility Pulser

A plug-piston pulse generator equipped with a 6-inch diameter pile graphite piston, has operated 3-1/2 million cycles pulsing CAX in a simulated solvent extraction column. During this service, the pulse volume ratio has remained near unity, demonstrating that (1) the pulse leg vents adequately without special venting provisions; and (2) the simpler plug piston (as compared to the split-ring-sealed piston) is satisfactory for pulsing small pulse columns. Pulser operation will continue, to define the point at which the volume ratio changes significantly.

Non-Metallic Materials Evaluation

Aclar, a "fluoro-halocarbon" product of General Chemical, was tested in boiling 37 percent hydrochloric acid, in a boiling 1 M nitric acid - 7 M sulfuric acid solution,

and in a 47 percent nitric acid, 3.5 percent hydrofluoric acid solution at 30 C. This material swelled approximately 10 percent in the boiling solutions but was unaffected by the HF-nitric acids. Aclar is a thermoplastic sheet material suitable for tank linings. So far as is known it is presently available only as film and sheet.

Several locally heat-sealed vinyl bags were tested with Recuplex CAX. The solution softened the plastic severely and penetrated the seam after a very short time. The same test, repeated with bags made of polyethylene, showed no leakage at the seams or softening of the parent material even after 27 days.

Corrosion by Purex 1WW

Five of the experimental nickel-base alloys prepared by BMI were evaluated for use in boiling Purex waste solution (1WW). All specimens were evaluated as weldments - both self-welded and when welded to 304-L stainless steel. Tests were made in boiling synthetic 1WW. Corrosion of the base metal was not greatly less than that of 304-L. No preferential attack occurred at the fusion zone where the nickel-base alloys were welded to 304-L. Two of the self-welded samples were attacked preferentially in the weld metal, possibly because of loss of inert sparge gas during welding. The corrosivity of 1WW to 304-L and the nickel-base alloys can be reduced markedly (as much as 10-fold) by conversion of Cr(VI) present to Cr(III). One way of obtaining this reduction is to reflux 1WW which has been 0.05 M in ferrous ammonium nitrate and 0.1 M in sulfamic acid.

Anodic Passivation

Studies exploring possible applications of anodic passivation as a means of corrosion control in HAPO process equipment were initiated. Passivation of 304-L stainless steel in 67 w/o H_2SO_4 at 25 C was attained in 20 min. at a current density of 3.4 m amps/sq.cm. Once established, passivation was maintained at a current density of <3 u amps/sq.cm. No reduction in the corrosion rate of 304-L in 65 w/o HNO_3 or synthetic Purex waste (1WW) was obtained regardless of the current density (test sample anodic). The effect of small currents (<100 u amps/sq.cm.) with the test specimen either anodic or cathodic was to increase the corrosion rate for 304-L in boiling 65 w/o HNO_3.

Corrosion Resistance of Vanadium Brazed Ti-304-L Joint

Samples of joints in which A-55 titanium was joined to 304-L stainless steel with a vanadium braze were exposed to 65 w/o HNO_3 at room temperature for 72 hours. During this time the braze material was corroded so badly that the base metals had separated.

PROCESS CONTROL DEVELOPMENT

C-Column Test Facility and Studies

Modifications and improvements to the pulse column test facility were completed this month. Overall smoother operation has resulted from these changes, and the time required to make a column profile run reduced. In particular, the change has improved the ease with which the mid-column analyzers can be moved from port to port. Currently, runs are in progress to determine the degree of control that can be maintained over extended periods and the reproducibility that can be expected for runs having identical conditions.

Calciner Furnace Control System

The existing Leeds and Northrup "CAT" controller will be used to automatically control the Z section shell temperature of the K cell calciner using the control system and controller settings determined by analog simulation. A remotely driven slide wire has been ordered for use in programming the set point of the controller during automatic start-up and shut-down. Calciner feed section shell temperatures are now set by open-loop programming of the power to the furnace, whereas the finish section shell temperature will be adjusted by directly programming the controller set point. Further work remains to be done, before installation of the set point programmer, to ensure synchronization of the finish section and feed section shell temperatures during start-up and shut-down.

The automatic control system and analog computer determined controller settings will be tested in a plant run in which the controller temperature set point will be manually adjusted at the 25 F/hr rate during start-ups and shut-downs. After the remote set point programmer is installed and calibrated, it will be used to automatically adjust the set point of the controller.

Electrode Seal

A combination seal-insulator is being developed which will permit the installation of conductivity electrodes directly into a steel pipe. This design is being developed for a prototype installation in the Purex 1BP sample stream. The seal-insulator is made by increasing the diameter of the body of a "Swagelok" fitting to the inside diameter of the ferrule. The metal electrode sealed in polyethylene tubing, which serves both as a seal and insulator, is inserted into the modified fitting. A seal of this type has withstood 90 psig air pressure without leaks for a period of ten days.

NON-PRODUCTION FUEL REPROCESSING

Feed Preparation

Shear Studies - The feasibility of in-cell remote shear blade changing was explored using a General Mills manipulator and a conventional impact wrench. The in-cell blade change is believed practical, even with a standard blade bolting assembly, with the following modifications:

1. Flat-head thru-bolts rather than slotted flat-head screws should be used for blade holding.

2. The shear platen should be provided with jackbolts for breaking the blade loose.

3. A gaging fixture is required to ascertain blade position.

UO_2 Leaching Studies - Studies of nitric acid leaching of UO_2 from chopped fuel elements have been completed. A report, HW-66788, "Nitric Acid Leaching of Uranium Dioxide in a Recirculating Dissolver," is being issued.

Materials of Construction

Corrosion tests on the BMI experimental alloy HAPO-20 following heat treatment at various temperatures were made to determine the optimum annealing conditions.

Corrosion rates in boiling 1 M HNO_3 - 2 M HF and 65 w/c HNO_3 varied only slightly as the annealing temperature was varied from 1250 F to 2150 F. Test pieces (1 in. x 2 in. x 1/8 in.) were held at temperature one hour before cooling. There was no significant difference in the corrosion rates for rapid (water quench) and slow (air quench) cooled samples. Considerable grain growth occurred in samples annealed at 2150 F. An annealing temperature of 2050 F is recommended.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Fused Salt Spectrophotometry

The study of the visible and near-infrared absorption spectra of uranium(IV) in molten alkali chloride-aluminum chloride systems has been continued. In the cesium and potassium systems containing excess alkali halide the following conclusions have been tentatively drawn:

1. There are at least three species present: $UCl_6^{=}$, UCl_4, and an unidentified species having major absorption peaks at 2340, 2020, 1587 and 1215 mu.
2. The ratio $UCl_4/UCl_6^{=}$ increases with increasing temperature.
3. At 490 and 588 C, the ratio of the unknown species to $UCl_6^{=}$ is greater in $CsCl-AlCl_3$ than in $KCl-AlCl_3$.
4. Estimates of enthalpy and entropy changes for the reaction $UCl_4 + 2Cl^- \longrightarrow UCl_6^{=}$ are -1.0 kcal and 12.2 e.u., respectively.

The usefulness of the heated cell holder for the Cary Model 14 spectrophotometer emphasized the need for a matching unit for the reference beam. Despite a design problem arising from severe spatial limitations, an improved unit was built which, in preliminary tests, has performed very well.

Electrodeposition of UO_2 from Low Temperature Melts

A 1:1 molar $NaCl-CaCl_2$ eutectic, MP = 505 C was investigated as a possible melt for the salt cycle process. There was no detectable dissolution of U_3O_8 at 550 C and the melt was heated to 800 C for this step. Electrolysis at 550 C produced a fine-dendritic UO_2 deposit with an oxygen/uranium ratio of 2.131. The high ratio is in agreement with the impression that the presence of hydroxide (moisture) in the melt increases this ratio, as the $CaCl_2$ is very hydroscopic and was probably not completely dried before electrolysis.

The ternary system $NaCl-KCl-AlCl_3$ (MP $\approx$ 90 C) has been studied but without much success. Some dissolution of UO_2 occurs as a result of reaction with $AlCl_3$. At 90 C the rate is very low, even with the addition of Cl_2, but at 300 C the rate of dissolution with Cl_2 is considerably higher than that with NaCl-KCl at 700 C and even without Cl_2 it is too high to allow electrodeposition of UO_2. Depositions from a five percent solution of UO_2Cl_2 in the ternary were tried at 145 C and 350 C without success. Attack of the anode was considerable with either carbon or silica carbide anodes.

Study of the $KCl ZnCl_2$ system (eutectic MP = 235 C) is currently in progress. The rate of dissolution of UO_2 in the melt at 300 C is very slow, less than 0.1 percent in 30 minutes. Addition of one mole percent TlCl resulted in a great increase in rate which was more marked as the quantity of KCl was increased in the vicinity of the eutectic composition. These results are included in the accompanying table. In order to achieve these dissolution rates, the melt had to be thoroughly dried. Drying with Cl_2 during the dissolution does not appear to be adequate. In fact, chlorine does not appear to be as effective in drying this system as HCl. The capacity of the system for UO_2Cl_2 is considerable. Twenty weight percent of UO_2 was dissolved in a ternary containing one mole percent thallium chloride at 300 C. However, upon standing for 16 hours at this temperature, about five weight percent precipitated out and could not be re-dissolved by an extensive chlorine sparging.

Acceleration of Chlorine Dissolution of UO_2

The rates of dissolution of UO_2 by Cl_2 gas at various concentrations of TlCl were determined and are listed in the accompanying table.

Two other substances have an accelerating effect similar to that shown by TlCl: namely, $FeCl_3$ and $CuCl_2$. Their effect is also listed in the table. Like Tl^+-Tl^{+3}, the EMF's for Fe^{+2}-Fe^{+3} and Cu^+-Cu^{+2} fall between the EMF's for Cl^--1/2 Cl_2 and UO_2-UO_2^{+2}. The minimum concentrations of TlCl, $CuCl_2$ and $FeCl_3$ required to increase the rate of dissolution by a factor of 10 are 0.3, 0.45 and 0.90 mole percent, respectively.

UO_2 DISSOLUTION RATES

$ZnCl_2$.KCl System: Effect of KCl Content at 300 C

Mole Percent			U Dissolved in 30 Min., g/10 g Salt
TlCl	KCl	$ZnCl_2$	
1.0	46.5	52.5	0.27
1.0	49.5	49.5	0.34
1.0	52.5	46.5	0.46
0.0	50.0	50.0	0.01

NaCl.KCl System: Effect of Thallium Addition at 700 C

TlCl	NaCl	KCl	
6.20	46.90	46.90	14.7
3.00	48.50	48.50	10.5
1.42	49.29	49.29	6.2
0.50	49.75	49.75	1.9
0.25	49.875	49.875	0.98
0.0	50.00	50.00	0.125

UO_2 DISSOLUTION RATES (continued)

NaCl.KCl System: Effect of Copper Addition at 700 C

Mole Percent			U Dissolved in 30 Min., g/10 g Salt
$CuCl_2$	NaCl	KCl	
1.00	49.50	49.50	2.98
0.50	49.75	49.75	1.40
0.0	50.00	50.00	0.125

NaCl.KCl System: Effect of Iron Addition at 700 C

$FeCl_2$	NaCl	KCl	
2.00	49.00	49.00	4.2
1.00	49.50	49.50	1.50
0.50	49.75	49.75	0.64
0.0	50.00	50.00	0.125

Further evidence that the acceleration in rate of dissolution of UO_2 is the result of the respective cation being raised to its higher oxidation state by the chlorine, followed by oxidation of the uranium by this cation, was provided by an experiment in which a known quantity of cupric chloride was added to a suspension of UO_2 in KCl-NaCl at 700 C. After two hours, 60 percent of the stoichiometric amount of uranium had been dissolved (without the addition of chlorine).

Molten Salt Polarography

The polarographic reduction waves for the rare earth M^{+3} ions previously reported have been confirmed. The samarium wave which appears as a distorted single wave was analyzed as two waves using the Heyrovski Ilkovic equation (which assumes the reduction product has a variable activity). Two straight lines were obtained, one of which indicated an "n" value of 1.02, the other 1.99. These correspond to the reactions

$$Sm^{+3} + e^- \rightleftharpoons Sm^{+2}$$

$$Sm^{+2} + 2e^- \rightleftharpoons Sm \text{ (metal)}$$

Half-wave potentials vs. the one molal AgCl electrode were -0.672 and -0.891 volts, respectively; the latter is approximately 1.2 volts more negative than the deposition potential for UO_2, depending upon the UO_2Cl_2 concentration. This close proximity indicates care may be required to prevent deposition of samarium with UO_2.

The existence of a second reduction wave on top of the UO_2^{+2} wave has to date not been explained. It may be due to an increase in "effective electrode" area brought about by the nucleation of small crystals at less active sites at the high potential. The initial reduction wave itself does not follow a theoretical equation, but it appears to involve a two-electron change in which the product deposits at nearly constant activity.

Electrolytic Preparation of Large Single UO_2 Crystals

Efforts this month have been centered on attempts to deposit single crystals from the low-temperature melt, $ZnCl_2$.KCl, between 200 and 250 C rather than the higher melting KCl-NaCl system. Several electrodes have been tried including bright surfaced platinum, single crystals of arc-melted UO_2, and single crystals of electrolytically deposited UO_2 mounted in a platinum holder. No crystals of significant size have been obtained. Some difficulty has been experienced as the result of the transient electrical effects introduced by the on-off temperature control system. A new control system utilizing continuous proportional control will be put in service shortly.

Continuous Ion Exchange Contactor Development

Adsorption Kinetics for Thorium Nitrate Complex - As expected, increasing temperature increases the rate of adsorption of thorium nitrate complex from nitric acid solution by an anion exchanger (Permutit SK). Diffusion coefficients for adsorption from seven molar nitric acid solution containing 2.43 g/l thorium were 9.23×10^{-9} and 30.0×10^{-9} sq.cm/sec. at 24 and 65 C, respectively. At 12 g/l thorium the rates were 8.4×10^{-9} and 25×10^{-9} sq.cm/sec. for the same temperatures. The activation energy for adsorption calculated from these data is ca. 2.65 K cal/mole. This value is in the proper range to suggest an aqueous diffusion process as the rate controlling mechanism.

Elution rates were much greater than adsorption rates. Diffusion coefficients for elution increased from 0.65×10^{-7} to 8.15×10^{-7} sq.cm/sec. at 64 C as nitric acid concentration was decreased from 3.5 to 0.5 M. The elution diffusion coefficient was 5.1×10^{-7} sq.cm/sec. at 25 C and 0.5 M HNO_3.

Further equilibrium distribution data have been obtained extending the aqueous thorium concentration range to from 0.2 to 12 g/l in seven and eight molar nitric acid at 25 and 64 C. These data continue to fit the model, proposed in the August report, relating distribution coefficient to thorium loading on the resin. Distribution coefficients decrease as the temperature is increased.

Jiggler Contactor - Compaction of resin in the adsorption section of the Jiggler contactor, which exceeds that heretofore achieved, was attained this month. The pulsed resin now appears (by visual observation) to move as a completely packed bed. This action considerably increases the possibility for approaching the ultimate theoretical efficiency. The superior compaction is affected by means of a check valve installed in the raffinate jack-leg line. During the suction stroke of the pulser the liquid previously supplied in part from the jack-leg now must come from the intermediate section and the "C" column. This positive movement of liquid exerts drag on the resin beads which move into the "A" column. As a consequence of this action, an increased quantity of elution acid must be supplied to the "C" column.

Several runs simulating the plutonium anion exchange flow sheet proposed for use in 233-S Building were made to determine the operating characteristics of the "A" column alone. During these runs, eluted resin was fed to the "C" column from an outside source and loaded resin issuing from the scrub section of the "A" column was withdrawn from the system. The feed contained about 5 grams/liter thorium. The pulser operated at 6 cpm with the amplitude appropriate for the flow velocity. (The amplitude requirement increases with flow rate to overcome the tendency of the resin to fluidize with resulting turbulence and channeling.)

Two runs at about one-half Redox flow velocity equivalent (240 ml/min. feed flow rate) at an amplitude of 1.4 cm yielded waste losses of 0.60 percent and 0.03 percent at resin flow rates of 43 and 55 ml/min., respectively. During two runs at three-quarter capacity equivalent, air entered the column through leaks and caused channeling of the raffinate as evidenced by fluctuating waste loss. The second of these two runs became hydraulically stable despite the air leakage and yielded a waste loss of 2.1 percent. Resin flow rate was 65 ml/min and pulse amplitude was 1.9 cm. At full flow sheet equivalent waste loss was 0.12 percent. Resin flow rate was 174 ml/min with a pulse amplitude of 2.2 cm. These runs ranged from 4 to 6 hours in duration.

To supply the increased quantity of elution acid required (0.5 M nitric acid in this system) a constant-head, gravity-feed tank has been installed. Initial hydraulic tests indicate that this means of acid introduction can provide slip acid during the continuously changing pulse cycle in addition to that acid required for desorbing the thorium. This new technique appears preferable to that of a constant feed rate system. With the latter system, more turbulence is introduced into the resin at the bottom of the column due to the continuously changing requirement for slip acid during the pulse cycle.

Salt Cycle Process

Pilot Plant Quantities of Electrolytic UO_2 - About 90 lb. of electrolytic UO_2 have been produced since startup of the unit in July. A typical analysis of the UO_2 product produced this month from the starting material $UO_2Cl_2.H_2O$ is 30 ppm chloride, 65 ppm sodium, 80 ppm potassium, 150 ppm carbon, and an oxygen to uranium ratio of 2.015. Batch sizes have averaged 4.5 lb. of UO_2. The apparent reduction in the chloride content compared to previous values is due largely to an improved analytical technique for this low range of chloride concentrations. The carbon concentration has been lowered by careful removal of corroded graphite from the electrode before removal of the product. In one batch, 30 percent of the carbon was found in the minus 200 mesh fines which constituted less than one percent of the product.

Ceramics Evaluation - Eight ceramic crucibles were tested in the Salt Cycle process environment consisting of a hydrogen saturated molten barium-potassium-sodium chloride salt mixture. Of the eight crucibles, two were purchased off-site and six were fabricated locally. The test, unless terminated by earlier failure, was of five days' duration at 800 C. The results of the tests were as follows:

1. Norton's Mix M-208, a MgO product increased 1 percent (0.368 gm.) during the test. There was a small amount of salt outside the crucible at the completion of the test. This salt probably did not percolate through the vessel but rather, splashed over the top. The splashing occurred when the small amount of hydrogen introduced to the crucible ignited.

2. The Carborundum Company's 100 percent magnesia product, Magnifrex 0340, lost no solution by percolation and did not change weight significantly.

3. Two LRS-2 crucibles of local fabrication were tested for the full five days. Both were 90 percent MgO - 10 percent TiO. Neither changed weight to any significant extent nor was either permeable.

4. Four other locally fabricated crucibles failed immediately. They were: (a) yttria stabilized zirconia, (b) 99.99 percent yttria, (c) calcium zirconate, and (d) calcium fluoride.

The melt percolated through the first two crucibles within 24 hours. Despite a very careful, slow heat up period the CaF_2 crucible broke from thermal stress.

Salt Cycle Corrosion Studies - Samples of 406 stainless steel, INOR-8, PDRL-102, Ti-0.2 Pd, Ni-o-nel, Inconel, Elgilloy, niobium, Alfenol, Thermenol, Alumel, and Armco 17-7 PH were exposed to an HCl-sparged equimolar NaCl-KCl melt at 750-800 C. Exposure periods were about six hours in each case. Thermenol (16 percent Al - 3 percent Mo-Fe) corroded at about 100 mils/mo. Alfenol (12 percent Al-Fe) corroded at about 150 mils/mo. All the other alloys corroded at rates of 200 or more mils/mo. Further investigation of aluminum bearing alloys will be made.

RADIOACTIVE RESIDUE FIXATION

Radiant-Heat Spray Calcination

The spray calciner was returned to service after replacement of the Inconel section (which failed while processing Zirflex waste). The first several runs demonstrated the feasibility of calcining a mixture of simulated 1WW and OWW (organic wash waste). The resulting alkaline mixture calcined smoothly but various amounts of sugar were added to test its effect. Addition of TBP and diluent (which might accompany OWW) caused no difficulty, and there was no detectable corrosion of the calciner - in marked contrast to pot calcination experiments on this combined waste where very severe corrosion was experienced. The powder product from the spray calciner runs was sintered to a density of 2.0 g/cc by heating to 800 C.

Filter cloths are now available in high-temperature resistant, non-corrosive materials such as glass, quartz, aluminum silicate, aluminum oxide, etc. Their flexibility would allow a filter cake to break off easily during a blow-back cycle. An apparatus was accordingly set up to test the filtration performance of these materials with spray calciner powder. First test was with a quartz cloth. Pressure drop was quite small, 5 to 9 mm of water at 4.6 ft. $3/min.ft^2$. Initial decontamination factor was quite poor (value of 8) but improved as a coating of powder built up to a value of 700 after 25 minutes. Average decontamination factor was 21.4. Actually, performance in practice should be better than in the test since the method used to create the suspension picked up only the smallest particles. Further tests are planned.

A preliminary design has been completed for a combination spray calciner - pot calciner to be built in A-Cell of 325-A. Certain features of the in-cell spray calciner will be tested on the cold demonstration unit before the design is frozen.

Mineral Reactions

The use of mineral replacement reactions as a supplement for ion exchange on zeolites in decontaminating low-level wastes was under study. Suspended solids or organic emulsions in some low-level wastes were found to interfere seriously with zeolitic adsorption of radiostrontium. The calcite-phosphate reaction is known to be suitable for removing radiostrontium or other bone-seeking isotopes from solution and initial experiments indicated that the reaction is less affected by suspended organic material than is adsorption. A decontamination factor of 60 for Sr-90 was attained with a

100-gram bed of calcite receiving Purex waste tank condensate containing 0.01 M phosphate. This is about three times the D.F. previously attained by adsorption on clinoptilolite.

The removal of ruthenium from solution by a bed of iron filings was found to be affected by the oxygen content of the solution. The ruthenium is removed by the hydrous ferric oxide formed by corrosion of the iron. An increased corrosion rate and greater ruthenium removal was achieved by saturating the solution with oxygen.

The behavior of ruthenium in wastes is dependent on its chemical form. Experiments were performed to obtain information concerning the applicability of experiments with ruthenium tracers to waste problems. Ruthenium solutions were prepared by distilling the tetraoxide into nitric acid. The uptake of ruthenium from these solutions by iron filings at pH 2, 5, 8 and 11 followed the same trends as previously obtained with $RuCl_3$ tracer. This tends to justify these tracer experiments as a means of studying ruthenium uptake by this method.

Condensate Streams

Spot samples of Purex Tank Farm condensate waste taken over a two-month period were analyzed to further characterize the waste. Constituents present which were not previously determined included 1 to 25 ppm sodium, 1 to 12 ppm chloride, 1 to 15 ppm nitrate, and 1 to 20 ppm nitrite. During an abnormal operating period, when unneutralized high level waste was added to the high level waste tanks, a sample was taken of the aqueous phase of the condensate waste in which the pH dropped to 2.7 from the normal value of about 9. This latter sample had a nitrate concentration of 260 ppm and nitrite concentration of 1100 ppm.

In Micro Pilot Plant runs it was found that neither Canadian apatite nor 1/16 inch pellets of Linde molecular sieve type 4A were very effectual in removing strontium from the condensate waste. The strontium decontamination factors achieved were 6 and 5, respectively. The equipment was readied for an extended run at what is predicted to be optimum conditions using clinoptilolite as a bed material.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

The first three wells completed on Project CAH-885 encountered basalt on an average of 8 percent deeper than predicted, one well (699-15-15) at 72 feet deeper than the predicted 650 feet. Significant local changes in the interpreted configuration of the basalt surface and of the basalt structure have resulted. These changes may locally affect interpretation of ground water and potential waste movement both within and above the basalt series.

The simultaneous drilling of two wells, 20 feet apart, at site 699-37-82, to test the characteristics of two separate aquifers, is providing information on the relative efficiency and effectiveness of a Bucyrus Erie 22W churn drill machine (equivalent to the Speed Star 71 machine long used at Hanford) and the larger Bucyrus Erie 60L of the same general type. The Hatch Drilling Company, owner of both machines, is studying their performance as well as comparing the samples taken through use of them. Different operating characteristics may result in somewhat different samples.

Experimental results obtained from a laboratory flow model were used to check the validity of the numerical solution of a partial differential equation that was derived last month for the description of a flow system containing liquids of different densities. The theoretical and experimental density distributions did not agree well, so attempts were made to use transformed stream functions. The use of two different stream functions resulted in good agreement between calculated and experimental results. One of the solutions is preferable because the assumptions used fit a broader range of conditions. These equations will be useful in definitions of flow where waste solutions with density greater than that of water are put to ground.

Preparations were made to install experimental plastic piezometers in well W-11-2 for measurement of potential at different depths in the well. The well was perforated this month from the 325 to 510 foot depths.

The computer program for the solutions of flow equations was advanced by the finding of a system of restraints which may allow convergence to the solution for the imbibition case. Problems involving drainage and steady state had previously been solved. The partial differential equation describing partially saturated flow was extended to the three-dimensional axi-symmetrical case and the resulting expression is being incorporated into the computer program.

Soil Chemistry and Geochemistry

Kinetic measurements on the diffusion rate of cesium in clinoptilolite and erionite indicated that cation selectivities of open zeolites are not based on differences in relative diffusion rates. The diffusion rate of cesium in erionite is approximately the same as in clinoptilolite, while the latter zeolite is many times more cesium selective than erionite.

Heats of reaction for the Cs^+ - Na^+ exchange in clinoptilolite and erionite were found to be very low. Similar low heats of reaction for open zeolites were reported by other workers in the zeolite field.

Molten salt-zeolite experiments indicated that at least part of the structural water of clinoptilolite was less firmly held than comparable water of the other open zeolites. Consequently, the cation selectivities of clinoptilolite are probably based on favorable stereochemical relationships between this water, the cation adsorption site, and the exchanging cation.

Results were reported last month on the soil adsorption of ionic rare earth nuclides at pH below three. Anomalous results for promethium that were reported have been redetermined and it was found that promethium adsorption by soil is the same as that for cerium and europium adsorption at each concentration. It has now been well established that under conditions of significance in waste disposal, oxidation states of rare earth nuclides are the same. The adsorption and precipitation reactions appear to be very similar also so that, in general, soil studies with one rare earth species can be applied nearly as well to the others.

Field Apparatus Development

Arrangements were completed for inspection of several wells using stereoscopic photography. This work will be accomplished by Hill and Ingman Consulting Engineering Company in connection with a contract for similar pipe examinations on the project.

Wells were selected and contact responsibilities assigned for this work. The inspection may point out the need for well renovation but is primarily scheduled to evaluate the photographic technique in this application.

A well was extensively perforated using shaped charges preparatory to equipping it for a study of piezometric head at different depths in the water table. Assistance was given in designing the test and selecting instrumentation for the study.

Two engineers witnessed deep well formation fracturing tests near Oak Ridge. Injection of radioactive wastes into the fissures formed in high pressure hydraulic fracturing appears to have good possibilities for certain kinds of wastes at carefully selected locations.

A sensitive commercial flowmeter recently received was tested for possible use in measuring vertical currents in wells. The device proved capable of measuring fractions of a milliliter per minute with a full scale reading of 0.7 ml per minute. The test to date showed drastic shifts in the zero flow reading which may prove a serious drawback. Possible causes of this instability and correction are being investigated; other approaches to the problem were reviewed.

Micromeritics

Re-entrainment of ragweed pollen (20 u diameter) from the walls of a 1-inch aluminum pipe was measured. The pollen particles were deposited by turbulence in air streams at selected velocities. Subsequent re-entrainment into clean air at various velocities was measured. At velocities lower than about 10 ft./sec. no re-entrainment occurs, whereas at 22 ft./sec. nearly all particles are re-entrained within 20 minutes. The 20 u particles required significantly higher velocities than did 30 u lycopodium spores for re-entrainment of a given fraction. The data assisted in establishing flow rates below which larger particles will be effectively retrained; this is an important consideration in evaluating sampling line losses.

A commercial portable air monitor for particulate material was evaluated for detector efficiency and mechanical leakage past the collector. Recommendations were forwarded to the user for improvement.

A.K. Postma presented a paper at the American Industrial Hygiene Association meeting in Richland, September 9, entitled "Turbulent Deposition of Particles in Sampling Lines."

Radiation Protection Studies

Experimental determinations were made of the protection indices of 18 amino acids which predominate in animal and vegetable protein. The protection indices differed by factors larger than 1000 in some cases. The two substituent groups on these molecules showing the highest protection indices and, hence, the greatest free radical scavenging ability are the aromatic, and sulfur-containing groups.

L P Bupp

Manager
Chemical Research and Development

LP Bupp:cf

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

J. F. Cline of the Plant Nutrition and Microbiology Operation began a one-year leave of absence in August to accept an assignment with the International Atomic Energy Agency in Tunisia.

R. L. Uhler of the Plant Nutrition and Microbiology Operation began a one-year assignment with the Radiobiological Laboratory in Letcombe Regis, England, under the direction of Dr. R. Scott Russell. Dr. David Barber of the Laboratory in England began his one year assignment in this laboratory in the first exchange program.

P. L. Hackett and B. J. McClanahan of the Biological Analyses Operation began one-year leaves of absences to take post-graduate studies at Washington State University.

D. H. Willard of Pharmacology began post-graduate studies at Wayne University in August under a fellowship.

Dr. H. V. Koontz from the University of California at Davis joined the Plant Nutrition and Microbiology Operation on Sept. 1 for a one-year temporary assignment.

Dr. W. H. Rickard, from the University of New Mexico at Las Vegas, joined the Radioecology Operation on September 13, 1960.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

Concentrations of I^{131} in the thyroid glands of jackrabbits 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
Prosser Barricade	7×10^{-4}	8×10^{-4}	+ 2
2 mi SW Redox	2×10^{-4}	3×10^{-4}	- 4
Wahluke Slope	1×10^{-4}	2×10^{-4}	-

Columbia River Contamination

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

Location	Organisms	μc/g Wet Weight Average	μc/g Wet Weight Maximum	Trend Factor
Hanford	Minnows (entire)	5×10^{-2}	8×10^{-2}	+ 2

Fallout Contamination

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

Sample Type	Total Beta Average μc/g Wet Material	Trend Factor
Bone	9×10^{-6}	-9
Feces	7×10^{-6}	-3
Liver	6×10^{-6}	-3
Muscle	5×10^{-6}	-4

Effect of Reactor Effluent on Aquatic Organisms

New equipment needed for resumption of tests on toxicity of reactor effluent is not yet in place at the 100-KE laboratory.

Salmon Survey

Aerial survey of salmon spawning in the main stem of the Columbia River in the environs of the Hanford Operations were initiated. Spawning was started approximately three weeks earlier than usual. On September 28, 40 nests were observed, all of which were in between Priest Rapids and the 100 K reactor area.

C. columnaris

Extensive sampling of a wide variety of minnows from the Columbia River drainage and some of the associated storage areas failed to show wide-spread infection of the fish by columnaris. In this particular sampling, infected fish were obtained only near the mouth of the Snake River. No infected fish were obtained from the 100-H Area where fish infected with columnaris had previously been identified. Water temperatures were close to 70° F.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Zinc

Experiments were initiated to study the intracellular distribution of Zn^{65}. These experiments are designed to evaluate the possible effects of short range radiation from heavy concentrations of zinc within the cell. The temporal sequence of zinc distribution is being determined in the livers of partially hepatectomized, starved, and control rats. Attention is also being directed at the dorso-lateral prostate. Autoradiographic, cytochemical, and electron microscopic techniques will be employed.

Strontium

The technique of in vivo perfusion of rat intestine is being employed in experiments to study the absorption of calcium and strontium from the intestine and the excretion of these elements into the intestine. Preliminary results indicate that the ratio of strontium to calcium absorbed is a function of the calcium content of the perfusate. Primary effort has been directed toward the development of the method and the study of such factors as flow rate and perfusate volume.

Radioanalysis of tissues of trout administered Sr^{90}-Y^{90} orally for 21 weeks showed that the strontium distributed essentially as expected. The concentration in hard tissues was on the order of 1000 fold higher than in the soft tissues; and the concentration in plasma was about twice that of whole blood. The isotope was administered at three different levels (0.5, 0.05, and 0.005 μc/g of body weight per day) and the resulting concentrations in the fish were in reasonable proportion to the rate of administration. While this indicates that the mechanisms involved in uptake and deposition were not grossly altered even at the highest level, it is anticipated that more exacting studies in this area will demonstrate differences caused by radiation damage.

An improved method of tattooing trout for identification of individuals is under development. Progress was made in the development of a metabolism tube technique for trout.

A review of the chronic toxicity study in miniature swine resulted in a modification of the bleeding schedule and of the supplemental vitamin and iron compound administration to young pigs. The frequency of bleeding was reduced so that, in the future, sampling will be done at six weeks, three months and six months of age, and thereafter at six-month intervals. When hematological changes occur, more frequent bleeding will be scheduled.

The vitamin supplement will be discontinued when animals reach thirty months of age since hypervitaminosis-D might result with continuation of the supplement. Following injection with commercially available injectable compounds of iron-dextran, some young animals died with what appeared to be a hypersensitive reaction or iron toxicity manifestation. The type of compound and time of injection were changed and the dose reduced.

(A number of sows have shown a severe temperature rise within 24 to 48 hours after farrowing. The cause of the fever has not been evident in all cases. In three cases, however, it was shown to be a mastitis. Bacterial culture and antibiotic sensitivity testing revealed the causative organism to be an Aerobacter aerogenes strain, susceptible only to chloromycetin. The three sows had been housed together and two were litter mates.)

Cesium

The effect of soil moisture on uptake of Cs^{137} was studied using bean plants growing in Cinebar soil. Plants were grown initially on soil held to a uniformly high moisture content, and near the end of the experiment some of the soils were allowed to dry to previously determined moisture contents. In this way, data were obtained for uptake by plants grown on dried soil as compared with plants grown throughout

their cycle on fully moistened soil. Cesium content per unit dry weight of plant tissue was clearly increased by drying the soil. The greatest increase was noted in stem tissue indicating that this may be an effect of translocation within the plant as well as total uptake. No data were obtained from roots since it was impossible to free them from the soil.

These results are in general agreement with those reported last month when the moisture stress was applied by using NaCl to increase osmotic pressure in the substrate.

Neptunium

Over a 21-day period of observation, retention of intravenously injected Np^{237} followed a pattern very similar to that observed for plutonium. At the end of the 21-day period, 43 per cent of the initially injected dose was retained in the animals.

There was no significantly measurable absorption of neptunium from "Paducah Dust" fed to rats as either the dry dust or a water suspension. From these preliminary studies, a maximal absorption of 1 per cent could be inferred.

Fifteen rats were exposed, by inhalation, to "Paducah Dust". The total dose is not known; however, one rat died after one week and another after two weeks. Chemical toxicity of some of the "impurities" is suggested rather than radiations from Np^{237}.

Plutonium

Additional studies of the effect of EDTA on the decontamination of plutonium-contaminated wounds in rats have given results which are less clearly indicative of an enhanced absorption from the wound site. Difficulty in producing reproducible wounds and wound treatment procedures results in quite large variations between animals. It seems safe to conclude that EDTA will result in no great harm and probably produce no great benefit. The scab which forms at the wound site contained approximately 70 per cent of the plutonium remaining after decontamination.

Such observations were similar to those obtained from work with pigs. Up to 90 per cent of the intradermally injected dose of one or five μc of Pu^{239} appeared to be readily removed with the scab mass which appeared during the first week after administration. About 50 to 60 per cent of the administered dose (0.2 or 0.004 μc) remained at the site of injection at three weeks post-injection. Three months post-injection 30 to 40 per cent of the administered dose remained. These values were obtained by external monitoring of different animals, using a thin sodium iodide crystal and a single channel analyzer.

Applying this monitor, a preliminary study was made of the probable effects of energy and indirectly the depth of injection on counting efficiency. Using a constant window width count rates from an unshielded Pu^{239} source were compared with those obtained when the source was shielded with paper one-quarter of an inch thick. The count rate from the shielded source was 70 per cent for lower energy

counting and 95 per cent for higher energy levels, as compared with counts from the unshielded source. Because of the low energy of gamma radiation from Pu^{239} (17 Kev) these results suggest that at the higher energy levels only radiation from the contaminants of the plutonium was being monitored. By using absorbers and counting at different energy levels, however, it may be possible to determine the amount of Pu^{239} present.

Radioactive Particles

Despite controlled visitor and employee traffic through the dog colony area, puppies born this summer, have become infested with ear mites and ascarid ova. Infestation of the puppies either occurred from the bitches or from migration of parasites from adjacent runs. The latter can be corrected with installation of proper barriers. Otherwise, the puppies are healthy and show a good weight gain. All dogs are being treated for parasites.

Solubility tests of CeO_2 particles are being completed prior to exposure of dogs and rats to $Ce^{144}O_2$ aerosols. A thermal precipitator was designed for collecting aerosol samples from exposure chambers directly on electron-microscope grids. Several features not found in commercial instruments were incorporated in the design to facilitate collection of radioactive aerosols from a chamber near the position of intake by the experimental animals without loss of particles by impaction on walls of the collecting tubes.

Results of studies with dogs inhaling plutonium dioxide suggest greater retention when plutonium was inhaled as a dust than when inhaled as a fog. There was no significant difference in the initial deposition. The fraction excreted in urine was greater for plutonium inhaled as 0.2 micron particles than for one micron particles and also increased inversely to the total plutonium deposited. In several dogs the total percentage of the dose excreted in urine one week after exposure to 0.2 micron particles reached 6 per cent, compared to a maximum of 0.6 per cent for one micron particles. This observation requires confirmation because of its possible bearing on the interpretation of human bioassay results. This was initiated by the exposure of three dogs. Nine others will be exposed next month.

Gastrointestinal Irradiation Injury

Seventy-two rats were employed in studies to complete the investigation of the effects of radiation on PVP excretion via the gastrointestinal tract. Briefly, these studies have indicated that the enhanced loss of PVP via the intestine is occasioned only when a portion of the gut is directly exposed. Indirect effects due to histamine release may enhance the effect. Administration of cysteine will prevent the PVP loss. Removal of bile by means of a fistula reduces PVP excretion probably as an indirect effect of the resulting dehydration, and because PVP, which reaches the lumen of the intestine, is not flushed out. Radiation apparently has no effect on absorption of PVP from the intestine.

Microbiological Studies

The difference in retention of cytoplasmic constituents by haploid and diploid yeasts was duplicated this month. To further evaluate the possibility that retentivity is under direct nuclear control, cells were treated with cysteine. Under the conditions used, the cysteine produced no effect on survival, but did modify the retentivity of materials by the cells. These data suggest that there is no direct relationship between survival and retentivity.

Project Chariot

Field operations at Chariot site during the ice-free season were completed. Processing of data and samples collected during the field operation was initiated.

HA Kornberg

Manager
BIOLOGY LABORATORY

HA Kornberg:es

C. Lectures

a. Papers Presented at Meetings

P. A. Olson, "Toxicity of Hexavalent Chromium to Fish," Annual Meeting of the Pacific Northwest Local Section of the American Industrial Hygiene Assoc., Richland, Washington, September 9, 1960.

R. F. Foster, "Inadequacies of MPC's for the Control of Radiation in the Environment," September 10, 1960, Annual Meeting of the Pacific Northwest Local Section of the American Industrial Hygiene Assoc., Richland, Washington (presented by J. W. Vanderbeek).

M. P. Fujihara, "Laboratory Transmission of C. columnaris to Trout and Salmon," Society of American Bacteriologists, September 9, 1960, Gonzaga University, Spokane, Washington.

R. T. O'Brien, "The Effects of X-ray Doses on Retentivity of Haploid and Diploid Yeast," September 9, 1960, Society of American Bacteriologists, Gonzaga University, Spokane, Washington.

L. K. Bustad, "Radiation and Aging," Annual Meeting of Pacific Northwest Section of the Industrial Hygiene Association on September 10, Richland, Wash.

b. Off-Site Seminars

H. A. Kornberg, "Fallout," September 1, 1960 - AEC Fallout Meeting, Health and Safety Laboratory, New York, N.Y.

c. Seminars (Biology)

L. K. Bustad, "Effects of Radiation on the Central Nervous System," Sept. 20.

R. C. Thompson, "Report on Conference on Biological Aspects of Metal Binding," Sept. 20, 1960.

Dr. Harry Kroll, "Removal of Radiostrontium from Rats with Chelating Agents," Sept. 28 (Research Director of Eltex Research Corporation, Providence, R.I.)

d. Seminars (other than Biology)

L. K. Bustad, "Biological Effects of Radiation," Research and Development Unit of Naval Reserve, Camp Hanford, September 13.

D. Publications

a. HW Publications

Horstman, V. G., G. S. Rhyneer and L. K. Bustad, "Thyroid Uptake in Lambs Following Administration of In Vitro and In Vivo I^{131}-Labeled Milk," Document HW-66817 (UNCLASSIFIED) September 1, 1960 (in press).

b. Open Literature

Hackett, P. L., T. W. Galbraith, C. A. Bennett, and L. K. Bustad, "Changes in Blood Constituents in Sheep Following Prolonged Daily Administration of I^{131}," Am. J. Vet. Res. 21 (84): 775-781 (1960).

Sullivan, M. F., P. L. Hackett, L. A. George, and R. C. Thompson, "Irradiation of the Intestine by Radioisotopes," Radiation Research 13, 343-355 (1960).

Thompson, R. C. and R. F. Palmer, "Strontium-Calcium Interrelationships in the Mature Rat," Am. Journal of Plant Physiology 199, 94-102 (1960).

Hungate, F. P. and R. L. Uhler, "Relative Availability of Some Sr^{90} Compounds in Soil," Nature 187, 252-253 (1960).

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - SEPTEMBER, 1960

ORGANIZATION AND PERSONNEL

Effective September 26, W. L. Nicholson accepted an assignment as Visiting Associate Professor of Mathematics at the University of Idaho. He will be at the University until approximately the end of January.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Simulation Model

First calculations supporting a simplified model have been made. The results, in general, pointed out the need for a reasonable theoretical relationship to be established before converting the data to linear form. More data have been collected and learning curve theory has been reviewed in an attempt to establish such a relationship.

Business Systems Studies

Three meetings of the Plant Improvement Task Force were attended. A modification of the form of last year's submittal has been generally agreed on. Revisions of the category definitions as outlined in the related OPG are underway.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

IBM summarization of data has been completed for data from all Quality Certification tubes measured to date. Analyses will be performed on the data during October.

Optimization of Reactor Operations

Preliminary work was done in connection with scheduling of reactor outages to result in greater time operated efficiencies. This will involve exploring means of decreasing the number of unscheduled outages which should result in greater efficiency in performing outage work.

Process Tube Leaks

A mathematical model has been developed to relate probolog activities to external corrosion leak rates. Some of the assumptions made in the development of the model are based primarily on supposition in the absence of pertinent data. The model is intended to indicate qualitatively the effect on future leak rates of following a given probolog schedule, and to point out which data, required for a complete analysis, are missing. A rough draft report is being prepared.

Z Plant Information Study

Programming for the developmental computer system is continuing. Revision and modifications to accommodate process specification change have caused some delay. This aspect of computer programming will continue until final implementation design is reached for the Z Plant process system.

Reliability Studies

Statistical and mathematical analysis of a proposed NPR prototype safety circuit system has been completed and reported. The methods used were motivated by the theory of Markov Chains and consists of a set of matrix "operations" on given error probability matrices for the component devices. Error probabilities were evaluated for existing systems and for four proposed systems.

Diffusion Studies

An investigation was begun to develop numerical techniques appropriate for obtaining approximate solutions to the nonlinear diffusion equation when applied to relatively simple geometries and standard boundary conditions.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Assistance was provided in designing a test to determine a can-core annulus optimum with respect to fuel element characteristics of interst. This represents an extension of preliminary experimental work performed in this area last year.

A proposed experimental procedure was outlined in connection with the determination of optimum canning cycles for use with four-inch I and E enriched fuel elements.

Data were analyzed from an experiment conducted to determine the effects on braze layer porosity of hydrogen content in the fuel element core. In reporting the results, it was pointed out that the consistent appearance of low "F-ratios," when testing for differences between ingots, and the knowledge of error estimates from previous work indicated the existence of a lack of randomness among the experimental units, probably due to too large a block size. This obscured any differences between ingots having different hydrogen contents that may have existed. Subsequently, assistance was given in the design of additional tests to investigate this effect.

Irradiation Processing Department

During discussions concerning the acceptance sampling of panellit gages it was found that the operating characteristic curves presently being used were prepared several years ago, and are no longer applicable due to changes in the acceptance sampling procedures. Revised curves will be prepared.

Two tubes of nickel plated fuel elements were measured at C-basin, once before and once after cleaning, in order to estimate film losses. This also afforded an estimate of the reproducibility of the C-basin profilometer, since the true dimensions should be little affected by the presence or absence of film. These reproducibility data were evaluated and the results submitted to appropriate IPD personnel for action.

Work on the theoretical corrosion model for I and E fuel elements is continuing. Difficulties encountered arise from the implicit form of the relationships. It is expected that the eventual solution will depend on utilizing an electronic computer.

A series of meetings was held to discuss the construction of a mathematical model of a reactor suitable for studying the phenomena of perturbations and cycling.

Continued mathematical aid was given in connection with studies which employ linear programming as a tool.

A document has been issued which discusses a mathematical method of evaluating the maximum number of coolant pressure gages which may be simultaneously by-passed and tripped without invalidating a scram signal on any other unby-passed gage. This study was made to determine the effect of removing the coolant pressure monitor row relays on the number of by-passable gages in a proposed coolant pressure monitor system.

Chemical Processing Department

The first two of a proposed series of meetings were held with 234-5 Development personnel to acquaint them with statistical aspects of experimental design.

A document proposing the use of part-by-part acceptance of final product parts was issued. The consumer has been notified of the change in demonstrating conformance to specifications.

Assistance is being provided personnel engaged in analyzing count data from the 256 channel analyzer. Initially, this will consist of recommending a course of action with respect to the desirability of obtaining a special purpose computer to assist in the data analyses. It is anticipated that assistance of a more general nature will be provided at a later date.

Further work in connection with the analysis of EPID data to compare present methods with the minimum variance inventory method is being delayed until the first part of 1961 to permit the accumulation of more data.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Corrosion Studies

Work continued on the analysis of Al-Ni-Fe alloy corrosion experiment. The analysis should substantiate the aluminum corrosion parabolic-linear theory and will estimate the individual sample induction times.

Chemical Development

Work continued on the construction of mathematical models for the loading and unloading of resin spheres which have been immersed in thorium solutions.

Fuels Development

Study of the mathematical theory of the metallurgically-idealized continuously dislocated crystal continued.

4000 Program

Swelling Studies

Work continues on the rough draft final report in connection with evaluation of electron micrographs of cross sectioned irradiated uranium specimens.

Nondestructive Testing

Further consultations were held on mathematical methods of interpreting thermal signals received from certain nondestructive fuel element tests.

Chemical Effluent Technology

An attempt is being made to obtain solutions to the hydrodynamic problem of flow on an inclined water table in the presence of a contaminated source.

6000 Program

Biology

Application of the multicompartment migration model to data from a rat experiment involving a single administration of W-185 was completed, with the emergence of several facts which should be of significant interest in planning similar experiments in the future.

General

The results of a six-day pilot work sampling study of the Analytical Laboratories weekly salaried personnel were analyzed. It was found that the procedure outlined for conducting the full scale study was satisfactory and this study was initiated.

Analysis continued of data from high energy anti-coincident gas sample counting instruments to devise a good method of estimating background.

MISCELLANEOUS

An informal lecture was given to interested plant personnel on the philosophy, structure, and possible applications of the General Electric Manufacturing Simulator.

Robert Y Dean
for

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:mw

PROGRAMMING OPERATION
SEPTEMBER 1960

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. Testing of the Monte Carlo with energy group importance weights was carried out during the month. This indicated the need for small revisions in the expectation beam routines, which were incorporated. The only remaining changes contemplated in the main portions of RBU before distribution of the code through the SHARE organization are a few revisions in the information supplied to the output tape, which will make possible a more intelligible output list. The output code will require slight revision to conform to these changes. The RBU Monitor is currently being modified to accommodate some special input error routines which were written during the month. The input code is still not completely debugged, but with the new error routines the remaining development should proceed more rapidly than has previously been possible.

The Meleager code was changed so as to allow a print-out of reactor fuel compositions at six month intervals. This change permits an easier economic analysis, as AEC use charges are set up on a six month interval.

The spectrum computation method of re-evaluating Westcott g and s factors described previously was successfully compiled on the IBM-709 and is now ready for use.

The Puck code development for analyzing equilibrium plutonium recycle in a broad spectrum of reactors is being debugged before major runs are made. In addition to updating the reactor physics portion (GPR) to be comparable with the Meleager code, changes are being made in the sequence of operations to achieve a more efficient over-all program. At the same time, the nomenclature in the code itself is being defined so that others can use the code with more ease.

The general logic applied in HLO fuel cycle analysis to date and the new codes being developed were reviewed by J. L. Wheeler of Argonne National Laboratory in a recent visit.

Fuel Cycle Analysis. A preliminary study has been completed which investigates the feasibility of extending exposure lifetime by more efficient irradiation of fuel elements. The plan consists of making two or three long sections of fuel element and placing the sections in a time-constant flux distribution. After a certain total exposure, the column would be

removed and re-assembled - putting new sections in for the highly burned parts and reversing (end-for-end) the lesser burned sections. Results indicated up to 18% higher total exposure in some cases.

An estimate was made of plutonium production from power reactors (non-military), both here and abroad. The estimates will be used to calculate the probable total amount of plutonium which will become available during the next ten years.

The neutron economy of thermal reactors is adversely affected by the introduction of stainless steel and other alloys of significant cross section which tend to offset their value in reactors. Consequently a method was developed of rapidly evaluating the allowable amount of specific materials in a variety of thermal reactors with various economic climates.

Analyses of alternative jacketing materials should be made with each set of conditions optimized. Even so, the answers are affected by the nuclear reactor type (neutron savings) and by the economic model (dollar savings). As a consequence, an endeavor was made in this study to optimize and to examine the exchange of zirconium and stainless steel in a variety of generalized reactors and economic climates so as to bracket the feasibility of such exchanges.

One of the simplest analysis that can be used assumes a "bogey" fuel exposure and equates the total fuel cycle costs for zirconium and alternatively jacketed fuel and solves for the allowable difference in jacketing material prices.

This study compares fuel costs that are minimized for each set of basic economic and nuclear parameters. From plots of the minimum fuel cost of a reactor as a function of the thermal utilization as affected by various jacketing materials and corresponding costs, constant fuel costs lines are drawn from which allowable jacketing costs can be determined. Table I is a selected summary for a 19 element UO_2 cluster, water cooled and variously jacketed, with D_2O moderator.

TABLE I

Allowable Jacketing Thickness at Canning
Cost of $19.50/lb. Uranium

Material	Depreciating Asset Interest Rates 12%	4%
Aluminum	0.266"	0.313"
Iron	0.017"	0.020"
Stainless Steel	0.015"	0.017"
Nickel	0.009"	0.010"

Table II shows various combinations of cladding materials and interest rates that will yield the same minimized fuel cost as zirconium jacketing at $50/lb uranium fuel fabrication and jacketing charge. The table is based on $19.50/lb uranium assumed jacketing cost of the alternate materials.

TABLE II

Jacket Material	Minimized Total Fuel Cost[a] Mills/Kwh	f_o[b] Thermal Utilization Factor	Enrichment at Minimized Total Fuel Cost Wt. % U^{235}	Exposure[c] at Minimized Total Fuel Cost MWD/T U	Fuel Element Fabricating & Jacketing Cost $/lb U
Stainless Steel	2.84	0.81	1.35	13,700	19.50
Zirconium	2.84	0.95	1.06	17,209	50.00

(a) Fuel cost is computed for: graded discharge, current uranium price schedule, $15/gram fissile plutonium credit, 15%/year depreciating assets cost, and 12%/year non-depreciating asset cost.

(b) f_o = thermal utilization computed for hot clean natural uranium enrichment.

(c) (There are coincidences, of course, where the minimum fuel costs will occur at essentially the same exposure.)

Also note, as summarized in Table II, that the minimum fuel cost occurs at a different enrichment and a different fuel exposure for each set of conditions. Different answers would result if the same fuel exposure were used for stainless and zirconium jacketing. The fact that the fuel exposure for a minimized fuel cost is less for stainless steel than for zirconium is often overlooked. If the cost of jacketing with stainless is the same as with zirconium, then the fuel exposure at minimized fuel cost would be greater for stainless steel as well as the fuel cost itself. It is pertinent to note from Table I that with lower interest rates a greater thickness of jacketing material can be used for the same total minimized fuel cost. This sensitivity to interest rate is related to the cost of enrichment in the reactor which is also reflected in the specific power. The higher the specific power the lower the enrichment costs per Kwh which will permit greater use of parasitic materials. Over the data range reported here, the relationships are highly linearized by virtue of examining the minimized fuel cost. The amount of parasitic absorber cannot be increased forever in a nuclear reactor by merely paying greater enrichment costs. The neutron yields of the fissile isotopes are fixed and enrichment beyond certain levels (5 to 10% fissile) cannot raise the reactivity any further to compensate for unlimited parasitic absorption.

Other Activities

The first quantity (100 grams) of high exposure (16% Pu-240) plutonium was received for use in the Plutonium Recycle Program physics tests.

Although the exact schedule for procurement of the kilogram quantities of 20% Pu-240 compositions plus other multigram amounts of even more highly exposed material has not been firmly established, extensive contact with Savannah River and ORNL people improved our understanding of the possibilities for obtaining a firm schedule in the near future. If agreement is reached by others that the ORNL facilities can be used when available early next year, the MTR-ETR, specific assemblies at Savannah River, and special "dregs" of earlier campaigns at ORNL can then be processed and obtained under schedules satisfactory for the Plutonium Recycle Program. In addition the possibility of availability of Canadian material has arisen. Although the latter material is not essential to the program, it could be very useful particularly if its Pu-240 content is high.

Activities related to PRTR startup included review and analysis of process specifications, operating procedures, and power tests. Investigation of long term reactivity effects was undertaken to provide integration of the initial power test phase with the long range program of reactor operation in support of the Plutonium Recycle Program.

The final draft of the Plutonium Recycle Program Annual Report, Fiscal Year 1960, was completed. Local distribution should take place about October 15. Off-site distribution will be held up for patent clearance.

A study of representative non-aqueous chemical separation processes (pryo processes) from the waste volume standpoint was completed. The report is ready for issuance. A significant conclusion is that these processes are insufficiently defined from a process engineering standpoint to permit an adequate estimate of waste volumes. However, with the information at hand these volumes expressed as ranges appear to be generally much higher than today's aqueous process wastes, and especially so, if the latter wastes were to be calcined to solids. Further laboratory results are needed before a more precise and adequate basis is at hand to assure satisfactory process comparison.

2. SPECIFIC FUEL CYCLE ANALYSIS

Fuel Cycle Analysis

The results of the Meleager computations of batch recycle cases for the Advanced Pressurized Water Reactor (APWR) have been edited and placed in tabular form on duplimats. A preliminary write-up of the physics portion of the program as well as a few typical graphs have been prepared. Final preparation of the report involves incorporation of the economics section and final editing.

The detailed generalized nuclear process code being developed for specific fuel cycle evaluation is undergoing initial debugging and checks against the simplified code, "Quick". Comparable output has been obtained but because of "Quick's" logic simplifications exact agreement is not possible. A rigorous hand calculation debug of this problem and more sophisticated problems will be made before using the code.

The APWR study results reported last month were augmented by analyzing the affect on plutonium value of various uranium price schedules, fuel element fabricating and jacketing costs, and interest rates. As indicated by this and other studies, the value of plutonium is essentially proportional to the value of top U-235 product and hence to various uranium price schedules. Plutonium values in the APWR range in the vicinity of $14 to $16/gram fissile material as nitrate with the present price schedule. If the price schedule is reduced 25%, the calculated values in the APWR drops 25% or down to $10.50 to $12/gram as nitrate. The value of plutonium is scarcely altered by changing the use charge from 4 to 5%. The use of a uranium price schedule with natural uranium at 50% of the present price and uranium cascade separative duty at 75% of its present value yields plutonium values on the APWR of $8.40 to $9.60/gram fissile as nitrate. Additional fabricating costs for plutonium-bearing fuel have less effect on the value of plutonium in a plutonium enriched APWR than in most reactors studied because of the relatively high enrichment level of the APWR (3.5 wt. %).

With the present uranium price schedule, the value of plutonium in the APWR drops from $14/gram fissile uranium with no plutonium fabrication premium to $7/gram fissile at a $70/lb uranium plutonium fuel fabrication premium. Reductions in the uranium price schedule seriously alter the allowable fuel fabrication premium as this premium applies after the price schedule alteration is taken into account.

Previous to this month, APWR economic results were computed by hand. To permit more rapid and precise comparisons the analysis with some refinements was programmed for the IBM-709, debugged and applied to secure the foregoing results. The code is named "Quick" and determines fuel costs for batch irradiations by summing the following items:

1. Reactor burnup costs (net)
2. Pu-241 decay costs
3. AEC use charges
4. Separations costs
5. Process losses
6. Fuel element fabricating and jacketing costs
7. Economic interest costs.

The sum of these terms is then divided into charges that are independent of plutonium value (term A below), charges which are a function of the unknown value of plutonium into the reactor (term B), and the charges depending upon the unknown value of plutonium out of the reactor in term C.

$$F_i = A_i + B_i X_{i-1} - C_i X_i$$

Where F_i = fuel cost, mills/Kwh

X_{i-1} = plutonium batch value into reactor at step i

X_i = plutonium batch value discharged from reactor at step i

(X_{i-1} and X_i are generally different)

A, B, and C are coefficients which depend upon the fuel exposure, fabricating charges, interest rates, etc. This relationship is the major output of the "Quick" code as punched cards for processing in code "Puve" which determines the value of each plutonium batch. Puve achieves this by simultaneously solving the foregoing equation for a sequential series of plutonium recycles in a specific reactor starting with a uranium enriched case with boundary conditions that the total fuel cost Fi will be the same for a given series and either; the final two plutonium batch values must be equal, or the final plutonium batch value is set to a more arbitrary condition such as zero or $22.50/gram (the latter is an estimated value of plutonium in fast breeders with the present uranium price schedule). In addition to analyzing the effect on plutonium value of varying the uranium price schedule and fuel fabrication and jacketing, variations were made of the separations cost, ratio of Pu-241 to Pu-239 values and operating efficiencies.

Other Activities

A study of the processing costs for the fuel from the "Russian Superheat Reactor" was completed. After the graphite sections have been stripped from the fuel assemblies, this stainless steel clad fuel may be processed by conventional techniques - Sulfex or chopping and nitric dissolution followed by TBP type solvent extraction in the conceptual plant. No problem is anticipated during the dissolution of the magnesium matrix type fuel or in the solvent extraction of the magnesium-uranium solution in TBP. A fuel processing campaign on an annual basis is more economical than more frequent campaigns.

B. OTHER ACTIVITIES

Assistance was rendered in arranging 39 visits (involving 326 persons) through HAPO and HLO facilities.

LH McEwen

Manager, Programming

LH McEwen:dl

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF SEPTEMBER, 1960

A. ORGANIZATION AND PERSONNEL

J. R. Bovingdon, D. McConnon, and L. D. Williams were added to the rolls of the Radiation Monitoring Operation during the month. One employee was transferred within Radiation Protection Operation to provide additional job experience. The force of the Radiation Protection Operation totals 138.

B. ACTIVITIES

High-level ground contamination up to 15 rads/hr and personnel contamination up to 150 mrads/hr occurred during the course of line testing at the 151-A Diversion Box at the Purex Plant on September 30. A leaking connector in the Diversion Box permitted steam which was being used to apply pressure to the line under test to escape resulting in dispersal of contaminated steam and air to the surrounding vicinity. Spotty particulate contamination was discovered several thousand feet down wind from the Diversion Box including the 200-E main gate area. Eleven employees at the Diversion Box site had skin and nasal contamination. Skin decontamination and nasal irrigation were successful in removing all external contamination from the involved employees. Examination of the 11 employees in the Whole Body Counter showed the presence of measurable amounts of Zr^{95} and Ce^{144}. The maximum amount of either radionuclide detected was less than one per cent of the maximum permissible body burden. It was necessary to barricade roads and reroute traffic until the roads within the 200-E Area and main highway 4S could be decontaminated. The roads were released and opened to traffic on the afternoon of October 1. Slight particulate contamination on some buses which were in the vicinity of 200-E main badge house on day shift was reason for the checking of 13 homes in Richland for people who had been working in 200-E Area at the time of the contamination spread. All of the homes and subsequent surveys of private vehicles were found to be free of contamination. Temporary sprinklers were set up at the Diversion Box site to prevent further spread of the contaminant after the incident.

Three cases of contaminated minor injuries occurred. One case involved a contaminated sliver in a slight wound in a CPD employee. Removal of the plutonium sliver and excision of the wound area removed all but 0.002 μc. Two other minor cases of plutonium deposition were confirmed bringing the total on record to 264 of which 259 occurred at HAPO. There are 190 employees currently on the active rolls with plutonium deposition.

Five employees were examined in the Whole Body Counter as a result of plant incidents where facial and nasal contamination resulted. In all cases, no significant internal deposition of radionuclides was detectable.

A substantial modification of the Whole Body Counter instrumentation has been the addition of a spectrum stripper. This device permits the use of the full 256 channels of the analyzer by taking a background count and then subtracting it from the gross count. Previous practice has been to use 128 channels of the analyzer for the background count, store this count, and eventually subtract it from the gross count which was made on the other 128 channels. This improvement now permits improved detection of higher energy gamma emitters. Since the spectrum stripper has been in full operation, small amounts ranging from two to eleven millimicrocuries of Na^{24} have been detected in several 100 Area employees during their routine checks in the Whole Body Counter. This amount is less than one-tenth of a per cent of the maximum permissible body burden. The source of the Na^{24} is the 100 Area sanitary drinking water.

A detailed background survey of the PRTR site, to include evaluation of air, water, and vegetation samples; particulate deposition; background dose rates; and counting of assigned personnel in the Whole Body Counter was scoped and initiated. The study will be conducted over a four to five week period to allow an evaluation of related meteorological phenomena.

The resident Radiation Monitoring staff was assigned to the PRTR facility. The comprehensive building Radiation Work Procedure for the PRTR was approved and issued. Radiation Work Procedures for design tests and several Radiation Work Procedures for criticality tests were completed.

Appropriate contacts with supervision have been scheduled after a review of radiation generating machines in the 300 Area revealed that approximately 80 per cent were being operated with outdated or nonexistent Radiation Work Procedures.

I^{131} emission to the environs exceeded the weekly control limit of 10 curies from August 14 through September 17, 1960. The average weekly emission rate was 15.96 curies with a maximum weekly emission rate of about 20 curies.

A proposal that certain project roads be made available to the public was reviewed. The findings of the June 1959 comprehensive study on specified routes through the project were applicable to this most recent proposal with certain exceptions. One of the proposed routes in the latter proposal is not desirable because of heavy traffic of project vehicles hauling radioactive liquids.

A study of emergency limits for Columbia River water concentrations in conjunction with suggested actions was completed. Conclusions of particular interest from the study were: 1) I^{131} is the controlling radionuclide. 2) Considerationsof young children result in the most restrictive limit. 3) The most important control is prevention of significant concentrations of I^{131} from being introduced into sanitary water systems. This latter control can be accomplished by alerting downstream users of river water. A study to identify current users was started.

A Film Dosimetry Information Exchange meeting was held at HAPO on September 20, 21, and 22, 1960. Personnel from ten AEC sites presented their respective film dosimetry programs. A reference paper entitled "Film Dosimetry Information Exchange" presenting the HAPO film dosimetry system was prepared for the meeting.

The study of the latent image fading of Du Pont 508 and 555 film indicated that there is less than 10 per cent fading in a 12-week period for radium gamma doses from 120 mr to 1,000 mr. Studies of other properties of Du Pont 508 and 555 films are continuing. A 25-mil thick tantalum filter in front of Du Pont 508 film was found to exhibit a linear density-dose relationship of 60 Kev to 1 Mev. The two most promising approaches to discriminate mixed doses to various gamma and beta energies are being thoroughly studied. Preliminary tests indicate that the neutron tract NTB film is about 15 per cent more sensitive than the NTA film for 1.25 Mev neutrons. An investigation was started to determine the influence of gamma energy response of the neutron track films.

Neptunium bioassay procedure development continued. The current initial extraction procedure carries only about one-half of the neptunium present in the solution. A change in the reduction step either in technique or to a more vigorous reducing agent was planned as a means of making this method more quantitative.

Development of small volume sample urinanalysis methods continued. Unacceptable variation by a factor of two in the distribution of results from preliminary sets was partially ascribed to errors in technique and insufficient training of technicians. The end objective of this effort is to permit on-plant sampling for the bioassay program for the majority of the samples.

The rate of elimination of Cs^{137} was studied for two persons. The elimination appeared to be exponential with half-lives of 63 and 95 days.

A Seminar on the USAEC vs. Northway-McVey litigation, popularly referred to as the Kellogg Incident, was conducted by Mr. J. R. Horan, Director - Health and Safety, Idaho Operations Office. The health physics aspects of this case, in particular, the use of radiation protection records indicated the value for a critical review of the quality and purpose of radiation protection records at HAPO.

The new RPO display was completed and shown at the regional meeting of the American Industrial Hygiene Association held in Richland this month. The display was moved to the Desert Inn at the request of Community Relations where it will remain for about one month.

A detailed proposal was submitted to the Counsel's office concerning contractual control of radiation protection matters of any collateral contractor having employees at Hanford.

C. EMPLOYEE RELATIONS

Four suggestions were submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to 31. Four suggestions were evaluated and rejected. Ten suggestions submitted by RPO personnel are pending evaluation.

There were four medical treatment injuries during the month for a frequency of 1.81. No security violations occurred during September.

Radiation Protection Training included: Exempt personnel attending lectures and meetings on PRTR training, USAEC vs. Northway-McVey Seminar, demonstration of Model II Scintran, and HAPO Geology and Hydrology lecture conducted by R. E. Brown.

D. SIGNIFICANT REPORTS

HW-66026 "MPC's for Ingestion of Rare Earths in Columbia River Water" by M. W. McConiga.

HW-66287 "Evaluation of Radiological Conditions in the Vicinity of Hanford" April through June, 1960, by Radiological Evaluation Working Group.

HW-66778 "Analysis of Radiological Data for the Month of August, 1960" by R. L. Junkins.

HW-66979 "Monthly Report - September 1960, Radiation Monitoring Operation" by A. J. Stevens.

"Waste Control at the Hanford Plutonium Production Plant" by R. F. Foster, R. L. Junkins, and C. E. Linderoth for presentation by R. F. Foster at the Water Pollution Control Federation Meeting in Philadelphia on October 2-6, 1960.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-August 1960 - Mid-September 1960)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.7	% MPC_w-GI*
Separations Areas	Gross Beta	8.6×10^{-8}	µc/cc
Pasco	Isotopic	5.3	% MPC_w-GI**
Kennewick	Isotopic	< 0.7	% MPC_w-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	1.3	% MPC_w-GI*
Hanford	Isotopic	2.0	% MPC_w-GI*
Pasco	Isotopic	^{14}	% MPC_w-GI**
McNary Dam	Gross Beta	1.0×10^{-6}	µc/cc
Vancouver, Washington	Isotopic	< 0.3	% MPC_w-GI**
Atmosphere			
I^{131} Separations Areas	I^{131}	5.7×10^{-13}	µc/cc
I^{131} Separations Stacks	I^{131}	1.8	Combined curies/day
Active Particles - Project	--	3.5	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}	3.9×10^{-6}	µc/g
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Eastern Washington and Oregon	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Fission Products less I^{131} - Wash. and Ore.	Gamma Emitters	$< 1.0 \times 10^{-5}$	µc/g

*The % MPC_w-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_w-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
September	0	0
1960 to Date	1	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
September	10,898	393	7	4
1960 to Date	136,094	2,089	37	12

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	Average Dose Per Film Packet mr(s)
September	10,861	1,049	229	46	36	14.23	19.74
1960 to Date	101,750	8,223	1,526	379	516	11.29	17.89

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
September	3,216	0	0	0	10
1960 to Date	11,245	3	0	0	44
Fast Neutron					
September	370	67	2	0	0
1960 to Date	1,580	143	32	0	21

Whole Body Counter

	Male	Female	September	1960 to Date
GE Employees				
Routine	70	9	79	647
Special	17	0	17	37
Terminal	0	0	0	1
Nonemployees	5	1	6	41
Pre-employment	2	0	2	10
Total	94	10	104	736

Bioassay

		September	1960 to Date
Plutonium:	Samples Assayed	675	5,918
	Results above 2.2×10^{-8} µc/sample	45	370
Fission Products:	Samples Assayed	635	5,799
	Results above 3.1×10^{-5} µc FP/sample	13	23
Uranium:	Samples Assayed	161	2,428
Confirmed Plutonium Deposition Cases		2	15*

*Bringing the total number of plutonium deposition cases which have occurred at Hanford to 259.

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	7.6	2.2	43	5.3	1.7	45
Fuels Preparation*	0	0	0	0	0	0
Hanford Laboratories	18	4.2	30	12	3.2	31
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	1.4	1.4	1	1.9	1.3	3
Chemical Processing*	6.2	5.8	2	3.6	2.7	2
Special Incidents	0	0	0	-	-	-
Random	1.4	0.9	4	-	-	-

*Samples taken prior to and after a specific job during work week.

Thyroid Checks	September	1960 to Date
Checks Taken	0	179
Checks above Detection Limit	0	5
Hand Checks		
Checks Taken - Alpha	33,303	285,229
- Beta-gamma	41,209	402,753
Skin Contamination		
Plutonium	29	200
Fission Products	48	352
Uranium	3	39

CALIBRATIONS

	Number of Units Calibrated September	1960 to Date
Portable Instruments		
CP Meter	983	8,254
Juno	272	2,642
GM	776	7,053
Other	193	1,621
Total	2,224	19,570
Personnel Meters		
Badge Film	600	11,902
Pencils	-	1,912
Other	337	3,724
Total	937	17,538
Miscellaneous Special Services	832	5,223
Total Number of Calibrations	3,993	42,331

A R Keene
Manager
Radiation Protection

AR Keene:kc

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - SEPTEMBER, 1960

GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 1.97, which is considerably below average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 24,354 hours. This includes 17,154 hours performed in the Technical Shops, 4,545 hours assigned to Minor Construction, 198 hours assigned to other project shops and 2,457 hours assigned to off-site vendors. Total shop backlog is 22,103 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 4.5% (883 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	5,193	21.3
Irradiation Processing Department	1,663	6.8
Chemical Processing Department	764	3.1
Hanford Laboratories Operation	14,800	60.8
Construction Engineering & Utilities	1,623	6.7
Miscellaneous	311	1.3

Requests for emergency service declined to a more normal level, requiring an overtime rate of 4.5%.

One machinist was added to the shop force with no current open requisitions.

The subcontracting of work to outside shops continues to be used as a means of leveling off peak work loads. The cost and quality of work produced in the Technical Shops and work produced by outside shops are comparable.

Security performance was considered satisfactory with no violations. There were five medical treatment injuries, which is on the low side of the level forecasted for this period.

RADIOGRAPHIC TESTING OPERATION

Accomplishments

A total of 5,165 tests were made, of which 999 were radiographic (including x-ray and gamma-ray) and 4,166 were supplementary tests. Out of a total of 2,725 man-hours, 749 (27.5%) were in connection with radiographic tests, and 1,946 (72.5%) were used on supplementary tests. The supplementary test work included: penetrant (fluorescent O.D. and I.D.); stress analysis; surface treatment (steam-detergent cleaning and vapor degreasing); and ultrasonic (flaw detection, core integrity, bond testing, and thickness measurements).

The number of pieces handled this month totaled 3,055 items. The feet of material represented by these items amounted to 36,496 feet. Work on tubular components continued to amount to account for a large percentage of the footage of material tested.

Work was done for 18 organizational components representing most of the operating departments and service organizations. A total of 43 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 37 different occasions for advise and information on general testing theory and applications for other than the jobs tabulated in Part - II Testing Statistics.

It is anticipated that preliminary pickling and autoclaving of a full size NPR process tube will be accomplished soon. The No. 1 autoclave and the pickling system was successfully cleaned and tested using coupons. Fourteen pieces of zircaloy were pickled and autoclaved using a 36 hour cycle. Examination of the pieces for film integrity was encouraging in that the desirable black oxide coating was achieved without staining. Upon completion of several minor equipment modification items on the pickling system it will be possible to condition a number of full-sized tubes by pickling (those having numerous penetrant indications). It is hoped this pickling experience will be helpful in training the Kaiser craftsmen to assure successful operation at the pickling station.

With termination of the contractor work at the PRTR and with J. A. Jones completing remaining work, RTO is now involved in actual radiographic work in addition to the liaison work which has been done to date. A considerable contribution is being made by RTO field crews at the reactor areas in stress analysis work. Currently, jobs are going on at F, DR, and H reactors.

Considerable development effort has been expended on the ultrasonic testing of sheath tubes to demonstrate equal reliability of the test throughout the tube wall (i.e., equivalent signals from outside and inside surface discontinuities) and to demonstrate acceptance of minor surface irregularities (i.e., scratches, dents, etc.). Success has been achieved in reliably and reproducibly recording 4 mil I.D. and O.D. standard notches at the same time resolving 2 mil notches on the same surfaces at the same instrument settings.

The laboratory facilities in the 306 Building have been occupied. Assembly of the 2 mev Van de Graaff x-ray unit has been started and progress to date has been encouraging.

Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces	Description
CE&U	353	177	353	Film interpretation of radiographs by weld-X Corporation of California at the PRTR site.
CPD	30	2	2	Radiograph long seam on filter unit (Fission Products Transport) 4' long x 2' O.D. x 1/2" wall, Carbon Steel; Radiograph welds on filter unit 40" long x 18" O.D. Carbon Steel.
FPD	2	2	4	Al Clad U Fuel Elements.
HLO	3,588	33,114	2,481	.505" I.D., zr-4 fuel samples; 9/16" O.D., zr-2 Clad UO_2; Thermocouple in U fuel: Thermocouple clusters; 3/4" O.D., s/s tubing weld: 1/2" O.D., zr-4 clad Pu Fuel; Unfinished TPU Rods; Finished TPU rods; .680" I.D., zr-4 tubes; .495" I.D., zr-4 tubes; Inconel, Monel s/s tubes, .505" dia. x 10' long 2" dia. x 4' long; Develop exposure techniques on std radiographic specimens; Make set of density stds; Perform audigage survey of s/s pressure vessels in the 300 Area; One vessel in 314 building; 21 vessels in 325 building.

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces	Description
IPD	1,104	3,158	207	Radiograph welds on 2-1/2" Sch 80 "Tee" in 1706 KER Bldg; Cell #1, 2, 3. 316 s/s; Radiograph one 2-1/2" Sch 80 pipe weld from cell #4, A & B pos. 316 s/s located in 1706 KE Bldg; Radiograph welds on Elmo-8 Ion-Exchanger Columns. 6" & 3" Sch xx Strong, Carbon Steel; Radiograph welds on 2-1/2" Sch 80 lug ring sleeves, four positions, single wall, carbon steel; Radiograph welds on two 105-C aluminum charge seaters; 3-1/4" O.D. x 57'-6" long zirc tubes NPR type; Stress analysis on the crossheaders, risers, & downcomer of 105-DR reactor.
JA Jones	88	43	8	Radiograph weld qualification coupons A & B positions; Radiograph 3/16" instr leads at bottom (Calandria-PRTR site).
Totals	5,165	36,496	3,055	

CONSTRUCTION OPERATION

There were 65 existing J.A. Jones Company orders at the beginning of the month with a total unexpended balance of $163,293. Fifty-six new orders, eight supplements and adjustments for underruns amounted to $257,691. Expenditures during the month on HLO work were $143,835 (Includes C.O. Cost). Total J. A. Jones backlog at month's end was $277,149.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of mo.	63	155,684	2	7,609
Issued during the mo. (Inc.Sup.& Adj.)	56	257,691	0	
J.A. Jones Expenditures during mo. (Inc. C.O. Costs)		143,835		
Balance at month's end	46	277,149	1	7,609
Orders closed during month	73	67,213*	1	132,475

* Face Value of Orders Closed

J.A. Jones pipefitters returned to work 10-3-60.

FACILITIES ENGINEERING OPERATION

There were 13 authorized projects at month's end with total authorized funds of $2,741,265. The total estimated cost of these projects and those awaiting AEC approval is $5,966,000. There were two new projects authorized, one new project proposal submitted to the Commission, and five projects completed this month.

The following summarizes the status of HLO project activity:

Number of authorized projects at month's end 13

Number of new projects authorized during the month: 2
- CAH-901 Structural Material Irradiation Test Equipment
- CGH-907 Strontium-90 Interim Program

Projects completed during the month: 5
- CA-744 Metallurgy Development Facility-306 Building Addition
- CGH-860 Access for PRTR Fuel Elements-327 Building
- CAH-864 Shielded Animal Monitoring Studies, 100-F
- CGH-877 Pyrochemical Test Facility, 321-A Building
- CAH-878 Additional Facilities for Isotope Studies on Animals 141-C Building Addition

New project proposals submitted to AEC during month 1
- CAH-914 Rattlesnake Springs Radioecology Facility

New projects awaiting AEC approval: 4
- CGH-832 Full Scale Physical Constants Test Reactor
- CGH-874 Consolidation of Plutonium Metallurgy Facility
- CGH-902 Uranium Scrap Burning Facility
- CAH-914 Rattlesnake Springs Radioecology 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 progressing to completion. Pipefitter dispute has delayed completion.
Pressure Vessel and Code Piping-Engineering & Inspection Service	This is a continuing work program on HLO vessels, pressure systems and related safety devices. Periodic audiogaging is nearly 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 88% complete.
Fire Detection System - 314 Bldg.	Installation work essentially complete.
Criticality Alarm - 300 Area	Installation work about 95% complete.
Improvement to Animal Waste Disposal System	Design work complete. Field work in progress. Pit complete & conveyor to be installed during October.
Horizontal Control Rod and Drive for Tamper Tank (Critical Mass)	Design work is in progress.
Basement Access Enclosure - 325 Bldg.	Engineering complete.
Air Conditioning Study-222-U Bldg.	Engineering work is complete.
Operating Spare Parts - 308 Bldg.	List of spares has been completed.
Irradiation Studies Loop	Design complete. Fabrication in progress.
Breakaway Corrosion Loop	Design in progress. Procurement has started.
Review of Pressure Systems, PRTR	Primary and secondary systems nearing completion. Helium system is also being examined.
Misc.Animal Quarters & Pasture 100-F	Field work in progress.
Canopy Design - 100-F	Design complete.
Design special dust filters - 306	Design in progress.
Intercom System - 231-Z Building	Design has started.
Coolant Systems Development Lab.	Conceptual design has started.
Cooling System - 314 Building	Design is complete. Costs are being reviewed.

Drafting and Design Services

Effective October 1, 1960, all drafting requests will be by work order form. Work load in central drafting room (3706 Bldg.) is constant with heavey backlog. Branch offices in 306 and 308 Buildings have steady work loads with heavy backlog in 308 office, and some work being supplied to 306 office from central drafting room.

Major design and drafting work in progress includes the following:

1. High Level Utility Cell - 327 Bldg. - Special Tools (50% complete).
2. PRP Critical Facility - Detail of in-cell piping, ventilation, instrumentation and electrical work (19 dwgs. - 90% complete).
3. Physical and Mechanical Properties Test Cell - 327 Building - Special equipment design (35 dwgs. - 50% complete).
4. Structural Materials Irradiation Test Facility - design - (25 dwgs. required - 30% complete).
5. Loading Dock Enclosure - 321 Building (3 dwgs. - completed).
6. Test Equipment for Gas Cooled Reactor - (10 dwgs. required - 100% complete).
7. Strontium Purification Project - Work underway.
8. Fuel Element Wire Wrapping Machine (12 dwgs. required - 93% complete).
9. Shipping Cask - 500 gal. capacity - complete.
10. Split-half mechanism, Critical Mass Laboratory.
11. Control rod mechanism, Critical Mass Laboratory.
12. Thermal precipitator - (5 dwgs. required - 20% complete).
13. PRTR special tools - (approx. 45 dwgs. - 25% complete).

In addition to the above work, miscellaneous small design-drafting jobs are in progress.

Approximately 150 drawings including sketches, work sheets, and formal drawings were completed during the month of September.

Plant Maintenance and Operation Costs

	August	% of Forecast
Bldg. & Mach. Maint.	$ 24,474	91.0
General Maint.	6,224	121.0
Improvement Maint.	3,596	142.0
Total Maint.	$ 34,294	101.0
Janitor Services	$ 16,573	97.0
Operators	12,178	93.0
Utilities - Steam.	$ 11,617	92.0
- Elect.	7,118	101.0
- Other	21,046	112.0
Total Utilities	$ 39,781	103.0
Engrg. Serv. & As-Builts	$ 4,483	118.0
Administration	3,000	100.0
TOTAL	$110,309	105.0

Analysis of Costs

The costs for the second month of the fiscal year are slightly above the forecasted amount. However, these expenditures were on planned work which is being performed now because of availability of manpower.

Miscellaneous

Approximately 24,000 square feet of prints were reproduced during the month.

The total estimated value of the 10 requisitions issued during the month was $10,500.

Intensive rehabilitation of 306 Building heating and ventilating system continued during the month.

Air balance in 329 Building is in progress.

Additional ventilating air is being added to 325 Building basement mezzanine.

A system for renovating steam control valves for better building temperature control is being formulated.

Clean-up of the south side of 314 Building has begun. The cyclone separators and miscellaneous unused equipment was removed to burial or controlled storage.

The exterior trim of buildings 3714, 3730, 3745-A and 321 have been painted.

Studies have been initiated for filtration of the exhaust from beryllium hoods.

An investigation was made of 308 Building waste disposal, and a crib waste line has been designed to connect 308 with the grid by 325 Building.

A survey was conducted to determine the quantity and quality of future water requirements for the 300 Area HLO laboratories.

Maintenance budget items were reviewed with AEC representatives.

Work was initiated to re-roof four buildings during the second quarter.

TECHNICAL INFORMATION OPERATION

Progress was made on the proposed new access system for the control of access to documents in the Classified Files. A meeting was held with HOO personnel at which a tentative outline of the new system, prepared by Technical Information, was discussed. A number of revisions were agreed upon, and will be incorporated into a second outline now in preparation. Another meeting with the HOO is scheduled for October.

During the month a cumulative list of unaccounted for R & D documents from other AEC installations was received and checked against Files' records. Out of 184 document titles listed, Classified Files found that 2 had been declassified and 1 had been destroyed.

Revisions of the Hanford Guide topic covering neutron spectra were proposed. Since the epithermal and fast neutron spectra for the older Hanford reactors can be computed from unclassified data, classifying the spectra does not appear justifiable.

Routine inventory of Files' holdings has been discontinued for an indefinite period and the inventory clerks have been assigned to the Files' microfilming program. They are presently devoting their time to (1) preparing documents for microfilming and (2) destroying a large number of process run books, shift supervisor's log books, dispatcher's log books, etc. which are of no further record value and will not be microfilmed. Microfilming is scheduled to begin October 3.

R & D documents which had been backlogged in 300 Area Duplicating are reaching Files in larger quantities than can be handled. One day 8 documents were received in Files. Internal copies are being distributed as soon as the report is received; external copies are being mailed out as fast as they can be wrapped. Two overtime periods were worked to help handle the load.

In September the Library began using a new form, "Request for Library Procurement - Subscriptions". The form has enabled the Library to introduce a greatly improved subscription ordering routine. All three parts of the new pre-carboned form can be completed with a single typing. The first part replaces the old procurement card. The second part replaces the purchase requisition. The third part replaces the two-part "Subscription Receipt Acknowledgement" form on which the recipient of an assigned periodical informs the Library that it is being received. Formerly each of these forms had to be completed separately. Under the new procedures the second (requisition) copy of the form goes directly to the buyer in Purchasing, reaching him the day after being completed in the Library.

Work Volume Statistics

	August	September
Document Distribution and Files		
Documents routed and discharged (copies)	19,347	14,453
Documents issued (copies)	12,566	15,227
Documents sent off-site (copies)	7,597	6,597
Document reserves filled (copies)	667	586
Documents picked up and delivered	20,764	16,679
Document Accountability		
Holders of classified documents whose files were inventoried	307	425
Documents inventoried in Files (copies)	25,530	0
Documents destroyed or retired (copies)	4,561	8,349
Documents revised (copies)	1,164	1,078
Documents pulled and documents filed (copies)	8,041	10,511
Documents reclassified	663	467
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	215,465	212,761

	August	September
Reference and Publication		
Books cataloged (new titles)	127	26
Books added to the collection (volumes)	296	136
Ready reference questions answered by professional staff	100	235
Literature searches by professional staff	89	67
Reports abstracted (titles)	304	242
Formal reports prepared (titles)	17	17
Off-site requests for HAPO reports (copies)	450	277
Reports released to CAP (titles)	48	42
Library Acquisitions and Circulation		
Books ordered (volumes)	244	493
Periodicals ordered	58	91
Books circulated (volumes)	1,676	2,148
Periodicals circulated (issues)	3,221	4,745
Inter-Library loans	72	92
Films borrowed or rented	12	22
Industrial film showings	65	83
Bound periodicals added to the collection	88	293

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	30,027	8,536	1,666	2,016	42,245
No. of bound periodicals	14,221	9	1,686	97	16,013
	44,248	8,545	3,352	2,113	58,258

Classification and Declassification	August	September
Documents, including drawings and photographs reviewed for downgrading or declassification	696	203
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	40	39
Documents submitted to Declassification Branch, Oak Ridge	265	75

Manager
Laboratory Auxiliaries

JL Boyd:jw

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960

HW-66960 DEL

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-731	Critical Mass Laboratory	$990,000	1,000,000 3-29-59	100 100	100 100	5-22-58 3-20-59	--- 6-30-60	2-26-59 6-30-60
		USING COMPONENT: Physics & Instruments R & D				FEO ENGINEER Project Engineer: DS Jackson DL Ballard		

REMARKS:

A schedule was received from Allied Engineering indicating they plan to start testing the reactor control system on September 30, finish testing on October 7, and barring further difficulties dismantle and ship it on October 10, 1960.

CA-744	Metallurgical Development Facility 306 Building Addition	$2,650,000	2,685,000 11-5-58	100 100	100 100	6-30-58 3-20-59	--- 9-1-60	9-30-59 9-1-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER Project Engineer: KA Clark JT Hall		

REMARKS:

Acceptance testing of ventilation and piping systems in the chemical processing area are in progress. There is a temperature problem with the fume exhauster motors which is being investigated.

The crane hoist for the chemical processing area is being installed and tested. Correction of ventilation deficiencies have not been completed. They are being expedited. Vacuum tube annealing furnace vendor deficiencies are scheduled for correction by October 15, 1960.

Cost plus Commitments to 9/18/60 $1,248,370 -

CAH-822	Pressurized Gas Cooled Facility	$995,000	$995,000 100	100 100	NS 8	8-19-59 ---	--- 7-31-60	4-29-60 ---
		USING COMPONENT: Reactor & Fuels R & D				HLO ENGINEER: DP Schively		

REMARKS:

The Phase "A" package by Struther-Wells is approximately 99% complete. Helium leak testing of the ex-reactor piping and equipment is in progress. The gas loop completion date has been extended to 6/30/61, by AEC Directive No. AEC-145 Mod. 4, dated September 13, 1960.

Cost plus Commitments to 9/18/60 $770,750

BUDGET CLASSIFICATION Plutonium Recycle Test Reactor Facilities - 58-e-15

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960

HW-66960 DEL

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-841	High Pressure Loop	$1,175,000		0 0	0 0	4-22-59 NS	--- None	NS None
		USING COMPONENT: Reactor & Fuels R & D				HLO ENGINEER: JC Fox		

REMARKS:

A revised project proposal was processed by the Commission cancelling this project. It will no longer be carried in this report.

Cost plus Commitments to 9/18/60 $0

CAH-842	Critical Reactivity Measuring Facility	$360,000	360,000	98 89	0 0	11-17-59 ---	--- 4-30-61	11-18-60 4-30-61
		USING COMPONENT: Reactor & Fuels R & D				HLO ENGINEER: WS Kelly		

REMARKS:

Bids were opened August 17, 1960. George Grant Company was the low bidder and the contract was awarded to them September 19, 1960. The Bid has been placed with Henry Pratt and Co. on the fuel transfer lock.

Cost plus Commitments to 9/18/60 $48,411

CAH-867	Fuel Element Rupture Test Loop	$1,500,000	730,000 7-26-60	32 39	0 0	8-1-60 NS	--- ---	2-1-61 ---
		USING COMPONENT: Reactor & Fuels R & D				HLO ENGINEER: PC Walkup		

REMARKS:

The design is 32% complete on the GE portion. Negotiations are in process for the architect-engineer design of the water plant.

Cost plus Commitments to 9/18/60 $97,261

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 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 / DATE	DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	DESIGN / CONST.	DESIGN / CONST.	DESIGN / CONST.
CGH-819	Increased Laboratory Waste Facilities-300 Area	$193,000	$193,765 / 2-19-60	100 / 100	39 / 39	2-5-60 / 6-8-60	--- / 5-31-61	5-1-60 / 2-1-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: KA Clark		

REMARKS:
The last concrete pour for the storage building sub-structure was made on 9-26-60. Erection of the loadout building is nearly complete, with the storage building to follow as soon as the concrete base is ready.

Coordination between construction and facility operations has been good.

Cost plus Commitments to 9/18/60 $119,577

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 / DATE	DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	DESIGN / CONST.	DESIGN / CONST.	DESIGN / CONST.
CGH-860	Access for PRTR Fuel Elements - 327 Building	$81,000	$81,000 / 10-8-59	100 / 100	100 / 100	10-19-59 / 1-4-60	--- / 8-15-60	4-1-60 / 9-15-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: KA Clark		

REMARKS:
This project is physically complete and will no longer be reported.

Cost plus Commitments to 9/18/60 $72,301

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 / DATE	DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	DESIGN / CONST.	DESIGN / CONST.	DESIGN / CONST.
CAH-864	Shielded Animal Monitoring Station 100 F	$49,000	$52,000 / 4-18-60	100 / 100	100 / 100	10-22-59 / 5-5-60	--- / 8-1-60	2-4-60 / 9-23-60
		USING COMPONENT: Biology				FEO ENGINEER: JT Lloyd		

REMARKS:
A final inspection was made on 9-23-60 and the construction work was accepted from the contractor. The AEC will consider increasing the present 5'-0" headroom to the air conditioning unit if operation of the facility requires it. AEC will have the service contractor install telephone conduit to locations.

Cost plus Commitments to 9/18/60 $11,268

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960 — HW-56960 DEL

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	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CGH-874	Consolidation of Plutonium Metallurgy Facilities	$285,000	None	0	0	1*	---	5*
			None	0	0	2*	---	11*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: JT Lloyd

REMARKS:
A review is underway of requirements for release of space in Building 234-5 to CPD, and provision of additional laboratory areas in Building 231-Z for plutonium metallurgy facilities. This information may be submitted to the AEC as a supplement to the project proposal currently awaiting AEC authorization.

* Months after Authorization

Cost plus Commitments to 9/18/60 $ 0

CGH-877	Pyrochemical Test Facility 321-A Building		70,000	100	100	12-8-59		4-17-60
		$70,000	11-17-59	100	100	2-17-60	9-30-60	9-30-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: RC Ingersoll

REMARKS:
The project is complete with minor exceptions. Minor adjustments and startup remain and it is expected that these items will be completed by 10-15-60. A physical completion notice is being prepared. This project will no longer be carried in this report.

Cost plus Commitments to 9/18/60 $65,161

CAH-878	Additional Facilities for Isotope Studies on Animals - 141 C Building Addition		$66,000	100	100	12-7-59	---	4-17-60
		$65,000	4-18-60	100	100	5-5-60	8-1-60	10-1-60

USING COMPONENT: Biology

FEO ENGINEER: JT Lloyd

REMARKS:
A final inspection was made on 9-23-60 and the construction work was accepted from the contractor. The AEC has been requested to have Minor Construction correct deficiencies in construction and design. These are under consideration.

Cost plus Commitments to 9/18/60 $ 6,575

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960

HW-66900 DEL

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	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CAH-885	Geological & Hydrological Wells - FY 1960		$69,000	100	35	2-15-60	---	4-1-60
		$69,000	2-5-60	100	38	6-8-60	*	2-15-61

USING COMPONENT: Chemical R & D

FEO ENGINEER: HE Ralph

REMARKS:

One rig is operating on a 10-hour shift, the other two rigs are operating two (2) eight-hour shifts each. This is equivalent to a 5-rig operation.

Project Status: CAH-885 - 38%
CAC-843 0 100% Complete
CGI-791 - 100% Complete

* Commission is extending the directive completion date from 11-15-60 to 3-15-61 because of additional footage added to the projects included in this contract.

Cost plus Commitments to 9/18/60 $ 5,819

CGH-896	Stress Rupture Test Facility		$7,500*	55	NS	7-29-60	---	10-30-60
		$80,000	6-14-60	50	0			

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RK Waldman

REMARKS:

Design is slightly behind schedule, however, it is anticipated that it will be completed within the original scheduled time.

* Interim authorization for Design only.

Cost + Commitments to 9/18/60 $ 5,513

Improvements to Production and Supporting Facilities - 60-a-1

CAH-866	Shielded Analytical Laboratory 325 Building		$60,000	62	0	6-27-60	NS	11-31-60
		$750,000	5-31-60	80	0	---	---	1-1-62

USING COMPONENT: Chemical R & D

FEO ENGINEER: RW Dascenzo

REMARKS:

Design is continuing. Sixteen specifications have been issued for comment. All the drawings have been started and the majority are 70-90% completed.

Cost + Commitments to 9/18/60 $9,471

BUDGET CLASSIFICATION: Improvements to Production and Supporting Facilities - 60-a-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960

HW-66960 DEL

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-870	Facilities for Recovery of Radioactive Materials - 325-A Building	$486,000	$486,000 / 3-22-60	100 / 100	55 / 50	9-18-59 / 6-1-60	--- / 6-1-61	3-1-60 / 6-1-61

USING COMPONENT: Chemical R & D

FEO ENGINEER: RW Dascenzo

REMARKS: 1) Formed, placed resteel, lift anchors, and placed concrete for some of the 4" floor precast slabs. 2) North concrete wall was scored, chipped and blockouts removed to place flanges of structural steel. 3) All structural steel was delivered to site and is being erected. 4) Vault "B" liner was placed and both liners checked for weld defects and corrected and sags removed from liner bottoms. 5) Forms and resteel were placed around Vault "A" and concrete placed in 2 lefts. 6) Vault liner "C" arrived 9-23-60, and is being placed. 7) Interior work in Building 325-A is being coordinated with operations since it affects their air control and impedes normal operations.

Installation for Support of Bio-Medical Research 60-h-1

Cost + Commitments to 9/18/60 $25,459

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-888	Biology Laboratory Improvements	$340,000	$40,000 / 9-2-60	--- / 15*	--- / ---	8-8-60** /	/	2-1-60** /

USING COMPONENT: Biology

FEO ENGINEER: JT Lloyd

REMARKS:

All phases of design are underway. B. D. Bohna expects to complete preliminary design drawings on 9-30-60. Photograph prints and negatives and drawings of source capsules received from ANL were sent to B. D. Bohna & Co.

* Estimated

** Title I scheduled and estimated complete 10-1-60. Title II started 8-8-60. Title II scheduled and estimated complete 2-1-60.

Improvements to Production and Supporting Facilities - 61-a-1

Cost + Commitments to 9/18/60 $8,187

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-832	Full Scale Physical Constants Testing Reactor	$915,000	None / None	0 / 0	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. This project is dependent upon AEC accepting the Hanford Plant Improvement Program.

Cost + Commitments to 9/18/60 $ 0

AM-7300-019 (4-60)

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 61-a-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960

HW 66960 DEL

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	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CGH-907	Strontium-90 Interim Program	$420,000	$420,000	25	5	9-8-60	---	3-1-61
			9-6-60	25	5	9-8-60	3-1-61	3-1-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: H. Radow		

REMARKS:
Field progress was very favorable and the source of the leak in the underground line isolated and necessary repair ready to start. However, with no pipefitters on the job since Sept. 19, because of a jurisdictional dispute, field work has come to a virtual halt. Every effort is being made to accomplish what is possible without relying on fitters, but unless this dispute is resolved in the very near future, no further work can be done.

General Plant Projects - FY 1961

Cost + Commitments to 9/18/60 $40,387

CGH-902	Uranium Scrap Burning Facility	$36,000	None	0	0	2*	---	8*
			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

Equipment Not Included in Construction Projects Program Class 2900

Cost + Commitments to 9/18/60 $ 0

CG-785	In-Reactor Studies Equipment - 105 K Area	$325,000	$325,000	90*	75*	1-5-59	---	11-1-60
			9-9-60	90*	75*	3-22-60	12-31-60	3-1-61*
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H. Radow		

REMARKS:
Acceptance testing of the instrumentation components has begun. Design of the helium conservation modification is underway.

* Based on the additional work authorized by Directive HW-450, Mod. 2.

Cost + Commitments to 9/18/60 $257,265

AM-7300-019 (4-60)

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960

HW-66960 DEL

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 / DATE	DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	DESIGN / CONST.	DESIGN / CONST.	DESIGN / CONST.
CGH-805	High Temperature Tensile Testing Cell-327 Building	$170,000	$170,000 / 9-9-60	100 / 100	1 / 1	8-26-58 / 8-20-60	--- / 4-1-61	6-15-59 / 4-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: KA Clark		

REMARKS:
Delivery of the cell castings has fallen behind schedule. Their completion is now scheduled for 11-11-60. Other items of equipment are being expedited to assure their delivery in time for incorporation into the work.

The concrete pedestal for the tensile testing machine is being constructed.

Cost + Commitments to 9/18/60 $146,851

CGH-834	Modifications & Additions to High Pressure Heat Transfer Apparatus 189-D Building	$700,000	$700,000 / 4-8-59	100 / 99**	98 / 85*	4-20-59 / 4-22-59	/ 10-15-60	7-1-60** / 3-1-61*
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H. Radow		

REMARKS: The latest liaison report indicated that shipment of the water storage vessel will not be before Nov. 14. It will therefore not be possible to resume field activity until Dec. 1, and meeting the directive completion date will be impossible. Accordingly, a project proposal revision requesting an extension of the completion data has been prepared and is being circulated for signatures. Off-site fabrication of the remaining vessel has also lagged and an ultimatum has been issued to the fabricator of the heat exchangers, indicating that this order will be in default unless shipped by Nov. 1.
* The revised project proposal requests extension of the completion date to 3-1-61.
** Final phase of design cannot be completed until vendors design of the quick acting valve assembly is complete.

Cost + Commitments to 9/18/60 $670,143

CGH-857	Physical and Mechanical Properties Testing Cell - 327 Building	$500,000	$75,000 / 10-1-59	80 / 70	0 / 0	10-20-59 / NS	--- / ---	12-1-60 / 7-1-63
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: RW Dascenzo		

REMARKS: Detail design of the cell structure is continuing.
The status of the equipment design is as follows:
1. Impact testing machine - 98% (some changes made in hammer removal)
2. Universal testing machine - 60%
3. Fatigue testing machine - 51%
4. Creep testing machine - 91%
5. Electrical Resistivity testing machine - 0%
6. Dilatometer testing machine - 0%

Cost + Commitments to 9/18/60 $25,226

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending September 30, 1960

HW-66960 DEL

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	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CGH-858	High Level Utility Cell - 327 Building	$500,000	$70,000	59*	0	10-20-59	---	1-1-61*
			10-1-59	61	0	NS	---	1-1-62

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RW Dascenzo

REMARKS:

A consultation with the Central Research Laboratory engineer, Mr. Dimetrios Gelatio, was held on 9-23-60, concerning manipulator for this cell. 90% of the cell structure design has been submitted for comments and some comments have been made. All of the milling machine design has been commented upon, but there are still several critical mechanisms that have to be settled upon before the comments can be incorporated into the design. Nothing has been done on the lathe since the scope design was commented upon.

* Previous design schedule recalled, extended and resubmitted to AEC.

Cost + Commitments to 9/18/60 $29,164

CAH-901	Structural Material Irradiation Test Equipment - "ETR"	$125,000	$125,000	0	0	9-15-60	---	3-1-61
			9-2-60	0	0	4-15-61*	None	10-1-61*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: DS Jackson

REMARKS:

Title I was initiated September 15, 1960.

* Estimated only. To be established between AEC-HOO, AEC-100, and Phillips Petroleum at Arco, Idaho.

Cost + Commitments to 9/18/60 $ 0

CGH-914	Rattlesnake Springs Radioecology Facility	$72,000	None	0	0	1*		
			None	0	0	2*		

USING COMPONENT: Biology

FEO ENGINEER: H. E. Ralph

REMARKS:

Project proposal submitted to HOO-AEC on 9-15-60.

* Months after authorization

Cost + Commitments to 9/18/60 $ 0

AM-7300-019 (4-60)

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of September 30, 1960, the staff of the Hanford Laboratories totalled 1372 employees, including 667 exempt and 705 weekly salaried. Of the total, 572 possessed technical degrees, including 345 B.S., 124 M.S., and 103 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for September was 1.21 as compared with 1.48 for the preceding month. There were no disabling injuries or serious accidents during the month. There was one security violation, bringing the total for the year to date to 24, as compared with 33 for the corresponding period last year.

R. H. Scott served as technical session chairman for the Fifth Annual Conference, Pacific Northwest Section of the American Industrial Hygiene Association held in Richland, September 9.

PROFESSIONAL PLACEMENT

During September there were two visits by Ph.D. candidates seeking employment. Three offers were rejected, including an IPD offer to an inexperienced Ph.D. physicist and HLO offers to an experienced Ph.D. physiological chemist and an inexperienced Ph.D. metallurgist.

Plans are essentially complete for the participation of HAPO scientists and engineers in Ph.D. recruiting at 21 campuses this fall. HAPO will coordinate Company Ph.D. recruiting at six campuses.

Four Technical Graduates were added to the rolls, four accepted permanent assignment and three terminated, including one Engineering and Science Program member, and two returning to school. At month's end there were 75 Technical Graduates on the roll, including 5 members of the Engineering and Science Program. Over-all Company requirements for engineers and scientists in engineering, manufacturing, and marketing appear at this time to be about the same as those for last year.

EMPLOYMENT

There were 16 weekly salaried vacancies filled during the month, including three internal transfers. At month's end, there were 24 weekly salaried vacancies in HLO.

TRAINING

A second seminar in Business Operations in our Changing Environment was begun with 16 participants, including one from CPD and one from the AEC.

T. G. Marshall, Manager, Professional Placement and Relations Practices, transferred to General Engineering Laboratory on September 30, 1960.

Acting Manager
Professional Placement
and Relations Practices

RS Himmelright:lmh

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Aug.	Sept.
Requisitions		
At end of month	22	24
Cancelled	1	2
Received	19	20
Filled	23	16

Nonexempt Transfer Request	Aug.	Sept.
Transfers		
Active cases at end of mo.	77	81
Cancelled	1	0
New	0	4
Effected	1	0

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1960 to Date

	Cases Considered	Visits to Richland			Offers			On the Roll
		Invited	Visited	To Visit	Extended	Accepted	Open	
PhD.	105	29	3	6	5	-	2	-
Exp. BS/MS	64	14	10	1	6	5	-	-
Prog. BS/MS	12	-	-	-	-	-	-	-

B. Technical Recruiting Activity - HLO - September 1, 1960 to Date

	Cases Considered	Visits to Richland			Offers			On the Roll
		Invited	Visited	To Visit	Extended	Accepted	Open	
PhD.	105	29	3	6	2	-	-	-
Exp. BS/MS	9	3	2	1	2	1	-	1

In addition to the above activity, 3 exempt employees have transferred into HLO from other HAPO departments and 2 technical graduates have accepted Off-Program placement in HLO to date.

UNCLASSIFIED

C - Technical Graduate Program
Month ending September 30, 1960

	TG Program
Number of Personnel on Assignment	75
(HAPO Tech Grad Program 70	
(Western District E.P. 5	
Distribution of Assignments by Departments	
IPD	29
HLO	19
FPD	11
CPD	10
CE&UO	4
C&AO	2
Distribution of Assignments by Function	
R&D or Engineering	47
Other	28

FINANCIAL OPERATION MONTHLY REPORT
SEPTEMBER 1960

Personnel

There were no personnel changes during September.

Activities

GENERAL ACCOUNTING

Arrangements were made for HLO employees in the 700 Area to pick up cash advances and travel tickets in the 703 Building.

Travel for FY 1961 is running approximately 10 percent ahead of the year earlier level attributable entirely to increasing travel to professional society meetings as shown below:

	1st Quarter FY 1961	1st Quarter FY 1960
Trips	314	286
Costs	$63 890	$63 680
Professional Society Travel	$11 000	$ 5 400

Funds available for off-site courses were 76 percent spent and committed at the end of the first quarter.

Classification activity for the month included the review of 837 purchase requisitions and 853 work orders for capital or expense determination, compounding, work review, whether taxable or nontaxable and for reimbursability. This represents a sharp increase over the previous two months.

Project unitization reports were issued during the month on the following projects:

CGH-879	High Pressure, High Temperature Autoclave Facility, 306 Building	$ 45 633
CGH-661	Additional Heat Generation Facility, 189-D Building	$471 334
CGH-840	Sheet Metal Shop Annex, 328 Building	$ 35 373
CGH-848	Geological and Hydrological Wells	$ 52 172

Following approval of Project CGH-907 - Strontium 90 Interium Program, it was necessary to change the status of the Hot-Semi-Works Facility to Plant and Equipment In Service. This facility had only recently been reclassified in a Laid-Up status of Condition IV - Plant and Equipment Not Used and Currently Not Useful - Dead Storage.

In connection with the physical inventory of the Hot-Semi-Works facility the physical count is complete and the reconciliation is in progress. This inventory included all fixed property within the perimeter of the Hot-Semi-Works exclusion area fence, including movable property and the buildings which house

such property. The physical count was taken by C&AO and HLO Financial personnel assisted by HLO custodial personnel. A report of results will be issued upon completion of the reconciliation which is currently being performed by C&AO.

All field work in connection with the inventory of movable cataloged equipment in the custody of the Radiation Protection Operation is complete and the reconciliation is in progress.

Nuclear Materials Accounting advised us of the forthcoming Survey 18 of which Part I will consist of a verification of HAPO inventories of normal uranium, tritium, deuterium, and enriched lithium as of the end of October 1960.

Fifty-five items valued at $21,456 were received at the Laboratory Equipment Pool during the month of September. Five items valued at $3,906 were withdrawn by the custodians and sixteen items valued at $8,266 were placed in lieu of placement of requisition. There were 482 items valued at $192,364 in the Pool at month end.

Equipment activity initiated this fiscal year is running well ahead of last fiscal year. A comparison of Appropriation Requests processed through the first quarter of both years is shown below:

	FY 1961	FY 1960	Net Gain
Number of AR's	68	38	30
Value of AR's	$ 643 500	$ 382 950	$ 260 550
Total Allocation	$2 837 000	$2 310 500	$ 526 500
% of New Activity to Allocation	23%	17%	

We currently have approximately 65 percent of our total allocation expended or committed. Based on recent contacts with the R&D components, it is anticipated that October's activity will substantially increase this percentage.

The Financial Plan for Plant Acquisition and Construction has been received by Contract and Accounting. Hanford Laboratories' portion for FY 1961 other than General Plant Projects, which are on a first come - first served basis, includes the following:

FY 1961 Super General Plant (HAPO Total)	$6 116 000
HLO Portion - Shielded Analytical Laboratory	750 000
PRTR - Increased to $13,500,000	
Directive to be received shortly covering increase	
Biology Improvement Project	$ 340 000

The Financial Plan for the operating budget, which includes equipment funds, has been received by the local AEC. The information will probably be forwarded to GE during the second week of October.

COST ACCOUNTING

A revised authorization was received from HOO-AEC during the month for the Gas-Cooled Reactor Program. An additional $306,000 was authorized, increasing the total amount to $1,006,000. Authority to proceed on the proposed long term irradiation and creep measurement activities was granted in this supplement. Changes in authorized funds for other programs are anticipated when HOO-AEC issues a revised Financial Plan to HAPO.

The request for preparation of the FY 1960 Mid-Year Budget Review was received from Contract Accounting. A letter was issued to Hanford Laboratories management explaining the requirements and the manner in which the review will be accomplished. The September Personnel Forecast, submitted on September 30, will represent the personnel requirements, upon approval by the General Manager - HAPO. Current plans indicate that the budget will be submitted to the Manager - Hanford Laboratories for his review by October 21, 1960.

Three special requests from off-site were received by Hanford Laboratories during September as follow:

(1) An additional $45,000 for Plutonium Inhalation Studies, sponsored by the U.S. Air Force. This increases the FY 1961 authorization to $67,000.

(2) To fabricate 335 Pu-Al foils for Edgerton, Germeshausen, and Greer, Inc. in the amount of $15,000.

(3) For shipment of two graphite bars to California Institute of Technology in the amount of $50.

One program code was established and the title of another was changed during the month of September. They are as follow:

Program Code	Title	Remarks
.57	Experimental Gas-Cooled Reactor	Revised authorization of research and development program sponsored by Division of Reactor Development.
.77	Gas-Cooled Reactors - Other	Title changed from Reactor Graphite Studies.

Conversion of cost accounting practices from manual applications to electronic data processing is progressing satisfactorily. All arrangements and procedures have been completed to place the distribution of Drafting Operation costs on the HAPO work order system, effective October 3, 1960. Other components within Hanford Laboratories that perform services for other on-site components, and are not already utilizing the HAPO work order system, will be placed on this system in the near future. Special accumulation codes for prototype costs will also be placed in the EDP system, effective October 3, 1960.

Action as indicated occurred on the following projects during the month:

New Funds Authorized HLO

CG-785	In-Reactor Studies Equipment, 100-K	$ 49 000
CGH-805	High Temperature Tensile Testing Cell, 327 Bldg.	20 000
CAH-888	Biology Laboratory Improvements	(20 000)*
CAH-901	Structural Materials Irradiation Test Equipment-"ETR"	104 000
CGH-907	Strontium-90 Interim Program	420 000

*Detailed design to be performed by an AEC, A-E Contractor.

Physical Completion Notices Issued

CGH-860	Access for PRTR Fuel Elements, 327 Building
CA-744	Metallurgical Development Facility, 306 Building Addition*

*AEM services only.

Construction Completion and Cost Closing Statements Issued

CGH-840	Sheet Metal Shop Annex, 328 Building

There were 56 new authorizations for $235,284 and 8 supplements for $22,407, issued to J.A. Jones Construction Company during the month. These authorizations include a release for $125,000 on Project CGH-907, Strontium-90 Interim Program. Work was physically completed on 74 authorizations and 47 authorizations amounting to $277,149 were still open at month-end.

GENERAL

Work continued on the review of Research and Development stature in Hanford Laboratories. Interview discussions were completed with six scientists and data assembled according to the study plan. Cooperation by the contributors has been excellent.

There was one security violation during September.

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Number on Payroll at Beginning of Month	1 412	680	732
Additions and Transfers In	29	15	14
Removals and Transfers Out	69	28	41
Employees on Payroll at Month-End	1 372	667	705

Overtime Payments During Month	September	August
Exempt	$ 8 825	$ 5 196
Non-Exempt	18 417	17 428
Total	$27 242	$22 624

Gross Payroll Paid During Month	September	August
Exempt	$ 581 436	$583 584
Non-Exempt	431 505	356 048
Total	$1 012 941	$939 632

Participation in Employee Benefit Plans at Month End	September Number	September Percent	August Number	August Percent
Pension Plan	1 215	99.4	1 223	99.5
Insurance Plan				
Personal Coverage	1 363	99.8	1 369	99.8
Dependent Coverage	976		979	
U.S. Savings Bonds				
Stock Bonus Plan	75	37.1	77	38.5
Savings Plan	91	6.6	90	6.4
Savings and Security Plan	1 054	85.9	1 060	83.7
Personal Accident Insurance	795	58.0	789	57.3

Insurance Claims	September Number	September Amount	August Number	August Amount
Employee Benefits				
Life Insurance	0	0	1	14 781
Weekly Sickness and Accident	5	317	16	855
Comprehensive Medical	94	4 431	28	2 715
Dependent Benefits				
Comprehensive Medical	125	13 956	57	5 038
Total	224	$18 704	102	$23 389

Good Neighbor Fund	September	August
Number Participating	947	953
Percent Participating	69.0%	67.5%

A. H. Parsley

Acting Manager - Finance
October 12, 1960

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
E. J. Middlebrough	Underwater Impeller, 9-2-60
R. F. Maness	A Multi-Purpose Alloy Composition
M. C. Lambert	Method for Increasing the Rate of Dissolution of Uranium Oxides by Chlorine Gas in Fused Salt.
F. R. Zaloudek	A Device to Improve the Function of Thermometric Devices in Long Tubes and Thermometer Wells.

A. P. Bupp

for Manager
Hanford Laboratories

END

DATE FILMED

1/7/93