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# HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

## OCTOBER, 1960

NOVEMBER 15, 1960

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### HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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This document consists of 166 pages.

HANFORD LABORATORIES OPERATION  
MONTHLY ACTIVITIES REPORT  
OCTOBER, 1960

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Compiled by  
Operation Managers

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By Authority of PR-24  
D.S. Lewis 8-4-92 November 15, 1960  
By J. Tang 8-20-92  
PM Eick 8-20-92

*[Redacted Signature]*  
By *[Redacted]*  
*[Redacted]*  
AEC Division of Classification

HANFORD ATOMIC PRODUCTS OPERATION  
RICHLAND, WASHINGTON

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*[Redacted]*

PRELIMINARY REPORT

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

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

	DATE <u>October 31, 1960</u>									
	At close of month		At beginning of month		Additions		Separations			
	Exempt	NonExempt	Exempt	NonExempt	Exempt	NonExempt	Exempt	NonExempt		
Chemical Research and Development	129	116	245	131	110	241	0	6	2	0
Reactor & Fuels Research & Development	200	182	382	198	178	376	3	4	1	0
Physics & Instrument Research & Development	82	38	120	77	39	116	5	0	0	1
Biology Operation	36	48	84	36	45	81	0	3	0	0
Operation Res. & Syn.	16	4	20	16	4	20	1	0	1	0
Radiation Protection	38	98	136	39	99	138	0	0	1	1
Laboratory Auxiliaries	53	199	252	53	197	250	1	4	1	2
Financial	14	15	29	15	15	30	0	0	1	0
Prof. Placmt & R.P.	79	11	90	83	11	94	4	0	8	0
Programming	14	4	18	18	4	22	0	0	4	0
General Totals	<u>1</u> 662	<u>3</u> 718	<u>4</u> 1380	<u>1</u> 667	<u>3</u> 705	<u>4</u> 1372	<u>0</u> 14*	<u>0</u> 17	<u>0</u> 19	<u>0</u> 4*
Totals excluding internal transfers	662	718	1380	667	705	1372	4	17	10	3

\* Includes 1 nonexempt to exempt.

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BUDGETS AND COSTS

October operating costs totaled \$2,116,000; fiscal year-to-date costs are \$8,209,000 or 31 percent of the \$26,244,000 control budget.

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

(Dollars in Thousands)	Cost			Budget-a)	% Spent
	Current Month	Last Month	FY To Date		
HLO Programs					
02 Program	\$ (11)	\$ 68	\$ 198	\$ 597	33%
04 Program	763	888	2 941	9 622	31
05 Program	61	78	253	796	32
06 Program	208	201	807	2 372	34
	<u>1 021</u>	<u>1 235</u>	<u>4 199</u>	<u>13 387</u>	<u>31</u>
IFD Sponsored	281	300	1 066	3 100	34
CFD Sponsored	<u>218</u>	<u>158</u>	<u>650</u>	<u>1 658</u>	<u>39</u>
Total	<u>\$1 520</u>	<u>\$1 693</u>	<u>\$5 915</u>	<u>\$18 145</u>	<u>33%</u>

RESEARCH AND DEVELOPMENT1. Reactor and Fuels

The Phase III-A portion of the PRTR (remaining construction items not completed by the Phase III contractor or not included in his contract) being completed by the J.A. Jones Construction Company, CFF contractor to the AEC, is estimated to be 20 percent complete. Work was delayed because of a two-week jurisdictional strike by pipefitters. Pre-startup tests have been performed on the communications and alarms system, the raw water and effluent systems, the heating and ventilation system, unit motion installation, air sampling and building radiation system, and portions of the electrical and annunciator systems.

Design completion of the PRP Critical Facility is estimated at 95 percent versus 100 percent scheduled. Design completion of the PRTR Rupture Loop is about 47 percent versus 63 percent scheduled.

The spare PRTR primary process pump has operated for 2710 hours with no indication of seal trouble following vendor revisions of several months ago. This performance represents over one-half of the 5000-hour goal.

All Process Specifications required for the initial startup and critical testing of the PRTR have been approved by the Startup Council.

Additional calculations for the PRTR safeguards analysis are proceeding in respect to the Critical Facility and the Gas Loop. It was found that containment within the Critical Facility can be preserved for the case of complete coolant loss to a fuel element if the heat generation rate of the fuel element is limited to six kilowatts.

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Satisfactory welds of beryllium caps to tube stock have been achieved using the magnetic force welder.

Remote fabrication of a fuel element behind shielding was successfully accomplished. Vibratory compaction and electrolytically produced  $UO_2$  were employed.

Swaged  $UO_2$  capsules have achieved an estimated exposure of approximately 19,000 MWD/T in the MTR/ETR without failure.

Little activity was released to the coolant stream by a seven-rod swaged cluster element defected with six holes. Two rods were of Zr-4 and five were of Zr-2. Prolonged ETR irradiation at high heat rates, at high and low temperatures, and with reactor cycling was satisfactorily achieved. The loop did not require decontamination after the test. The irradiation in a Hanford reactor of defected Zr-2 and Zr-4-clad sintered  $UO_2$  continued with little or no evidence of activity release to the coolant.

Gamma radiation at 2-1/2 inches from a Pu-Al fuel core containing plutonium with 29 w/o Pu-240 was measured as eight to ten times that from a similar core containing plutonium with five percent Pu-240. At ten inches, the gamma radiation from the high Pu-240 content material was the same as that of low Pu-240 material at 2-1/2 inches.

A seven-rod PRTR prototype Pu-Al cluster which operated five months in a high pressure, high temperature KER loop has been disassembled, examined, and found to be in good condition.

A three-rod cluster of three w/o Pu-Al successfully completed 34 effective full power days in the ETR at a surface heat flux of 576,000 Btu/hr-ft<sup>2</sup>.

It is believed that new techniques have minimized density variations previously found in pre-welded cold swage compacted  $UO_2$ - $PuO_2$  fuel rods. Rods of greater than 90 percent density are being analyzed to precisely define the distribution of the plutonium content.

$PuO_2$  produced from oxalate calcined at various temperatures remained as  $PuO_2$  after sintering in hydrogen at 1100 C for one hour. Similar material sintered at 1500 C for one hour showed partial reduction of  $PuO_2$  to alpha and beta  $Pu_2O_3$  at the pellet surface.

$PuO_2$  pellets heated in dry hydrogen for 75 hours at 1750 C completely vanished.  $UO_2$  and  $UO_2$ -20 w/o and 40 w/o  $PuO_2$  pellets flowed plastically while  $UO_2$ -60 w/o and 80 w/o  $PuO_2$  pellets did not deform.

Two sections of irradiated Zircaloy-2 pressure tubing removed from KER-1 were burst at room temperature at 16,500 psi and 17,000 psi internal pressure, which compares with approximately 14,200 psi for comparable unirradiated tubes.

The first few NPR Zircaloy-2 process tubes fabricated by Harvey Aluminum are of excellent quality, based on nondestructive tests made at the vendor's plant.

Stored energy in CSF graphite irradiated at 30 C to 10,500 MWD/AT has apparently saturated at 647 calories/gram.

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NPR inner elements prepared with an iron bearing braze material have been readied for MTR irradiation. This test is part of a program searching for a braze material which melts at a lower temperature than Be-Zr.

A KER tube/tube fuel element successfully withstood 1790 MWD/T irradiation in the ETR. The heat flux was 1,300,000 Btu/hr-ft<sup>2</sup>, and the maximum fuel temperature was 580 C. The test conditions were considerably more severe than those contemplated in NPR.

Technology for crimping steel wear shoes to NPR Zircaloy fuel supports has been perfected. Attachment of supports by welding Zircaloy studs to the jacket followed by attachment of all-steel supports is also fully developed.

It has been shown that under very nominal stress (750 psi) that uranium metal will permanently strain approximately 0.07 percent with each temperature cycle between room temperature and 300 C.

A new technique for studying the strain distribution in fuel cladding has been developed. Twenty-two thousand five hundred (22,500) squares per square inch are photo-engraved on the Zircaloy jacket furnishing a reference grid for measurement of strain after reactor testing.

Successful coextrusion of dual enrichment fuel stock was accomplished. The specimens, however, did show excessive Zircaloy-uranium interface roughness which can be corrected by the proper adjustment of heat treatment variables.

Additional data were obtained in the heat transfer laboratory which show that eccentric positioning of I&E fuel elements within reactor process tubes can reduce significantly the heat generation rates at which boiling burnout occurs.

Testing work on the shielding properties of iron-serpentine concrete of two densities as a function of baking temperature is complete. On an overall basis, considering cost as well as shielding effectiveness, the lower density material appears to be superior, confirming previous predictions. The first known application of this concrete will be in the NPR front and rear biological shields.

EGCR graphite samples were in excellent condition after irradiation at about 700 C for four cycles in the GETR, and will be re-inserted for additional exposure. Length contraction in the direction perpendicular to the extrusion axis was about one-third that of CSF graphite control samples.

SiC-coated graphite samples which had been irradiated to 3000 MWD/AT at 500 C, were exposed in air for approximately 500 hours at 1000 C without indication of failure.

## 2. Chemical Research and Development

Study of fission product release from heated irradiated uranium now includes specimens with a range of exposure from 10<sup>14</sup> to 10<sup>18</sup> nvt. Evolution of noble gases is virtually 100 percent complete when uranium having higher exposure is completely oxidized at the high ambient temperatures. This extends and modifies earlier work with low exposure uranium (~10<sup>14</sup> nvt) where it was found that some large fraction of the noble gases remained with the transformed uranium oxide.

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High level waste fixation work continues on simulated feeds in batch, fluid bed, and radiant heat spray calciner tests. Overall de-entrainment for the fluid bed unit utilizing steam was determined to be greater than 10,000. Van de Graaff irradiation of calcined products showed sulfate and phosphate matrix solids to be reasonably stable. Nitrate salts, as expected, evolved large volumes of gas.

Both research and development activity on strontium-90 recovery was intensive during the month. Analysis of Purex strontium-90 rich crude solution showed barium concentration to be gratifyingly low and the calcium to strontium ratio to be favorable. Although the absolute strontium-90 concentration in the plant solution is low, the isotopic analysis was 57 percent strontium-90 compared to the theoretical 62 percent for pure fission product material. To concentrate and purify the plant crude solution, the A-Cell in the High Level Radiochemistry Facility was outfitted with ion exchange columns and accessory equipment to allow shakedown tests before purification runs begin in December. Paralleling this effort, the Hot Semiworks is being prepared for solvent extraction recovery and purification of strontium to begin early in the Spring. The solvent, di-2 ethyl-hexyl phosphoric acid (D2EHPA) was utilized in pilot mini-mixer settler studies to establish optimum chemistry for feeds typical of the Purex crude solutions. Some study is reported also on filtration of strontium precipitates likely to be used as purified products for shipment offsite.

A precise analytical method was developed to determine strontium at very low concentrations in the presence of lead and zirconium. The scheme uses X-ray emission technique and is capable of determining strontium within  $\pm 5$  percent at concentration ranges down to 10 ppm.

Salt Cycle research and development continues and work during the month was done to explore lower melting salt media which might be applicable to the system chemistry. Potassium chloride-lead chloride eutectic mixtures are adequately fluid in the range 450-500 C and satisfactory  $UO_2$  electrodeposition was demonstrated in this temperature range. A pilot-scale Salt Cycle system was set up and several batches of  $UO_2$  were produced. Oxygen to uranium ratios for the pilot scale material were encouragingly low with one 25 pound batch at 2.015. Electrodeposition in the larger scale equipment proceeded well.

Arrangements were made and soil samples shipped to the University of California where tests are in progress to determine the capillary conductivity and relationship between moisture content and capillary pressure. This work relates to a better fundamental understanding of waste disposal to ground.

A method of absorbing ruthenium on a mineral bed was reported. The system involves the generation of hematite ( $Fe_2O_3$ ) on a calcite bed and may present an effective way of decontaminating aqueous solutions containing radioruthenium.

A cooperative program with the Pharmacology Operation to further examine erio-glauanine as a chemical protective agent was scaled to include dogs as test animals. This work will extend results beyond earlier tests utilizing rats. The persistence of blue coloration in dogs injected with erio-glauanine lasts for several days compared with rats wherein the coloration disappeared in a few hours.

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### 3. Physics and Instrument Research and Development

In the NPR program, apparent disagreements between various measurements of the physics parameters have been reconciled and a memorandum recording the results was sent to IPD. Possible eventual need for additional enrichment to achieve the full production capability of the reactor is being evaluated by them. Meanwhile, technical planning progressed on an experiment to determine the effect of moderator temperature on the reactivity. Also, assistance was provided in the design of the primary loop by simulation of temperature and flow behavior on one analog computer. Planning was started for simulation of the entire system as a training aid for NPR Operations.

Other work in support of production reactors included collection of data and initiation of analog studies for the development of automatic control and the continued effort at adapting existing computer codes for local application.

The cask for transfer of irradiated NPR fuel elements will be safe from the nuclear standpoint because its dimensions limit the maximum number of elements that it can contain, according to application of critical mass data reported last month. Other work in the nuclear safety field included continued experiments on 3 percent enriched solutions and on improved correlation of calculation methods with previous plutonium solution experiments. While unreflected assemblies can be satisfactorily handled by the methods tried, reflected cases continue to give trouble.

In the Plutonium Recycle Program, planning for PRTR startup continued with the issue of a revised schedule of critical tests, completion of detailed procedures for three of them, and final checkouts of instrumentation and foils for use in the tests. Work on computer code development continued with RBU and the cycle analysis code, LOLA, being in the final debugging stages. Satisfactory progress was also made on the last ditch safety system for the PRCF.

Downwind dosage from a ground level source of contamination can be estimated up to sixteen miles with 50 percent accuracy from knowledge of wind speed and atmospheric stability alone according to analysis of atmospheric diffusion data previously obtained. These conclusions apply only for stable atmospheric conditions.

The cases of Na-24 deposition previously reported are part of the regular pattern in which most 100 Area people show traces of the isotope, according to further results obtained at the Whole Body Counter.

Improvements in the convenience of alpha monitoring in the 234-5 Building are promised by the use of miniature monitors, one of which is currently performing satisfactorily in field tests. Satisfactory progress was also made in other radiation instrument development including a miniature dose rate monitor and a high sensitivity alpha air monitor.

In the basic data field, information continues to be obtained on the scattering of low energy neutrons from water and on the rate at which thermal neutrons achieve equilibrium while migrating through moderators at different temperatures. HLO data on the fissioning of "non-fissionable" isotopes by low energy neutrons has been reviewed and organized for presentation at a forthcoming American Physical Society meeting.

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#### 4. Biology

Biological monitoring activities markedly increased to improve assessment of the safety of Hanford effluents, especially reactor effluent. Twelve percent of 200 samples of waterfowl were slightly above background contamination.

Aerial salmon surveys showed dams upstream from Hanford caused water level fluctuation that destroyed two salmon-nesting areas.

Columnaris infected fish have been found in large numbers in an artificial salmon spawning channel just below McNary Dam, adding to the evidence that Hanford is not contributing to the disease.

The GI absorption coefficient for Np-237 was found to be 0.35 percent, which is greater than that for plutonium, and significantly greater than the 0.01 percent used by the ICRP.

#### 5. Programming

The first draft of the AFWR study results was prepared and orally presented to AEC Division of Reactor Development personnel on October 19, 1960.

In order to provide a basis for more accurate control of decontamination in the separations processes, factors which influence total gamma activity of the feed were reviewed. It was shown that more complete information on production efficiency would assist in achieving improved separations process control since the study showed that a 40 percent variation in gamma activity could result for ranges of production efficiency normally encountered.

A laboratory course in Nuclear Engineering involving the use of an operable reactor is planned during 1961 at the Center for Graduate Study. Preliminary analysis of the course requirements indicates the suitability of HLO's Thermal Test Reactor. Administrative arrangements and integration of a similar course to be conducted at the University of Washington are under study in cooperation with university representatives.

Assistance was provided in making arrangements for 31 visits involving 200 persons including 18 persons from foreign countries. Of special interest was the visit of Dr. V.K. Moorthy of the Indian Atomic Energy Establishment, Mr. I. Ishikawa, Commissioner of the Japanese AEC, and the US-UK Conference on Uranium Dioxide.

#### TECHNICAL AND OTHER SERVICES

Initial analyses performed on data from approximately 2000 fuel elements measured under the Quality Certification Program have yielded some very significant results. One report has been issued dealing with the relationship between warp and hot spots and pointing out distinct variations in "metal quality." It is also evident that significant relationships will be found when dimensional instability is expressed as a function of reactor operating variables.

A new and improved dose density relationship has been obtained to relate film badge density readings to dose. The use of this relationship will simplify

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calibration procedures and will enable the establishment of a "standard curve" which, with some decrease in precision, can be used for all film badges in order to allow more rapid interpretation of results.

A new method of completing a contour description so as to satisfy certain "smoothness" criteria has been developed. The method is based on the theory of the elastic behavior of an idealized spline. Since it involves the generous use of elliptic integrals it presents computational difficulties.

Work was begun on the construction of a simple linear kinetic model to describe the behavior of radiiodine within the biological system. The differential equations of the system have been written and the feasibility of an analogue computer system is being explored.

For the two-week period beginning September 26, R.L. Junkins served as a consultant for the International Atomic Energy Agency (IAEA) in Vienna, Austria. While on this assignment, he assisted in preparing papers for the Panel on "Radioactive Waste Disposal into Fresh Waters."

There was one new case of plutonium deposition confirmed in October. The total number of deposition cases that have occurred at HAPO is 260, of which 190 are currently employed.

There are currently active projects having combined authorized funds in the amount of \$17,576,000. The total estimated cost of these projects is \$21,133,000. All but six (6) of these projects are on or ahead of schedule and five (5) are more than 3 percent behind schedule.

Project CA-744, Metallurgical Development Facility, 306 Building Addition, was completed during the month. The final cost will be within one percent of the authorized funds of \$2,685,000. Total elapsed time for design and construction was 26 months. Completion was on the schedule established in the basic directive.

Two full length NPR process tubes were pickled and one was autoclaved as a preliminary evaluation of the pickling and autoclave process. Unfortunately, erratic autoclave operation did not permit final conclusions as to the success of the procedure.

Microfilming of the Classified Files document holdings began on October 3. To date, 1,521 documents have been microfilmed, which is satisfactory progress. Fireproof cabinets for storing the completed "jackets" have been received in 300 Area as has the Minnesota Mining Reader-Printer. Trial runs on the latter are producing excellent reproductions from the microfilm.

#### SUPPORTING FUNCTIONS

Approvals received during the month from HOO-AEC included (1) O.J. Wick to serve as a member of the Review Committee for Metallurgical Engineering at ANL, and (2) W.L. Nicholson to teach at the University of Idaho during the period 9/1/60 through 1/31/61.

Personnel forecasted for the Mid-Year Budget Review indicate the same level at year-end that is currently on the roll. Some reduction due to attrition may have to take place if certain funding problems are not resolved.

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The general increase of 3 percent, effective October 3, 1960, to non-bargaining employees will increase our annual rate of payroll by approximately \$96,000.

The inventory of moveable cataloged equipment in the custody of Radiation Protection Operation is complete. All of the equipment on record at the time of the inventory was physically located.

As of October 31, 1960, the staff of the Hanford Laboratories totaled 1380 employees, including 662 exempt and 718 weekly salaried. Of the total, 568 possess technical degrees, including 341 B.S., 123 M.S., and 104 Ph.D.

The medical treatment frequency for October was 1.80 as compared with 1.21 for the preceding month. There were no disabling injuries or serious accidents during the month. There were 4 security violations, bringing the total for the year to date to 28, compared with 40 for the corresponding period last year.

Hanford Laboratories qualified for the Manager's Safety Award on October 19, in recognition of 321 accident-free days.

During October there were two visits by Ph.D. candidates seeking employment, and an inexperienced Ph.D. theoretical physicist reported for work in Hanford Laboratories. Hanford Laboratories extended an offer to an experienced Ph.D. chemist.

Comments from four HAPO scientists and engineers who participated in Ph.D. recruiting at four midwestern universities indicate that greatly increased competition for top Ph.D. graduates can be expected from academic institutions this year.

Fall campus recruiting at the BS/MS level at 15 colleges and universities in the West and Southwest has been completed. Offers are being extended to select mid-year graduates for the HAPO Program, while direct placement candidates contacted are being invited for HAPO interviews.

Three Technical Graduates were added to the rolls including two members of the Company Engineering and Science Program, seven accepted permanent assignments including one Engineering and Science Program member, and one terminated for military service.

The Company's starting rate structure for inexperienced Technical Graduates will be increased 2-1/2 percent over last year's rates.

The recruiting booklet, "General Electric at Hanford," was turned over to the Commercial Artist for layout following completion of photography, copy and captions.

Ray Watts spent several days in Schenectady reviewing the Creative Approach Seminar with Engineering Services people. The course notes have been updated in preparation for a class to be conducted for Laboratories engineers and scientists starting the latter part of November.

There were 17 weekly salaried vacancies filled during the month and 15 requisitions for additional weekly salaried personnel received. As of October 31, 21 weekly salaried vacancies existed.

*L. P. Bupp*  
for Manager  
Hanford Laboratories

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATIONTECHNICAL ACTIVITIESA. FISSIONABLE MATERIALS - 2000 PROGRAM1. METALLURGY PROGRAMCorrosion Studies

Hydriding of Zircaloy in Simulated NPR Gas. A group of vapor-blasted, vacuum-annealed Zircaloy-2 coupons were exposed at 400 C to a gas whose analysis indicated 99.4% He, 0.4% H<sub>2</sub> and 0.2% CO. The H<sub>2</sub>O partial pressure started at about 0.02 mm, but rose to about one mm twice during the exposure due to equipment failure. Thus, the exposure was in gas thought to be hydriding part of the time and protective part of the time. The experiment is to be repeated; however, the data are of interest because protection was achieved and little hydriding, other than corrosion hydrogen, was observed.

Time, hours	2	24	78	120	170
Hydrogen Pickup, ppm	35	35	45	100	115
% Theoretical Corrosion H	145	24	19	30	30

Wear of Zircaloy-2 by Graphite. The wear resistance of the oxide film on autoclaved Zircaloy-2 to graphite under conditions of sliding friction was determined in a stirring autoclave. A stationary reactor-grade graphite rod was allowed to wear on a rotating pre-autoclaved Zircaloy-2 disc with a contact pressure of 45 psi. The temperature was maintained at 300 C, and the atmosphere was commercial-purity argon. The rotational speed of the disc was 70 rpm, and the duration of the run was 24 hours. The autoclaved disc appeared to be in perfect condition at the end of the run. The graphite rod showed no appreciable wear.

Autoclaving of Beryllium-Brazed Fuel Elements. Two batches of fifteen fuel elements with beryllium-brazed end closures have been autoclave-tested for Fuels Development Operation. These elements were etched and autoclaved for 40 hours in 300 C, 1500 psi water. After inspection, they were further autoclaved in 400 C, 1500 psi superheated steam.

Approximately 90% of the weld areas were visibly gray after the water cycle and turned white after the superheated steam cycle. The white oxide did seem quite adherent; however, some white oxide was removed by wiping the thickest deposits.

Autoclaving Conditions. Measurements of weight gain and hydrogen pickup have been made on 1" x 1" x 0.030" Zircaloy-2 coupons autoclaved for 72 hours in 400 C static superheated steam. These tests were made in steam generated from water originally adjusted to pH 7, 8, 9, and 10 with NaOH. They have shown a slight increase in weight gain and a small decrease in H<sub>2</sub> pickup with increasing pH, up to pH 9. No stains

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were noted with pH's of from six to nine. The samples autoclaved at pH 10 were stained, but weight data are not yet available.

Zircaloy-2 - Sheffield Steel Galvanic Couples. Following three months of exposure in 300 C, pH 10 water, Zircaloy-2 - Sheffield steel rods threaded together appear to show a small galvanic corrosion effect. Although the effect cannot be detected visually, a definite difference in weight gains is detectable between the Zircaloy-2 and Sheffield steel couples and the uncoupled control samples. The weight gains for the galvanic couples are 22.7 mg/dm<sup>2</sup> for the Sheffield steel and 21.6 mg/dm<sup>2</sup> for the Zircaloy as compared to 14.6 mg/dm<sup>2</sup> and 18.5 mg/dm<sup>2</sup> for the respective control samples.

#### Radiometallurgy Laboratory Studies

A few voids were found in the uranium under the nickel diffusion barrier of a hot pressed I&E aluminum clad element. The condition of the bonding of this element was much better than the previous element examined (RM-705).

No positive indication of a leak was found in examination of the end cap of the second thermocouple fuel element. Further examination is in progress (RM-571).

High exposure uranium from the Swelling Program cracked severely during an 880 C anneal and disintegrated during subsequent handling. The low exposure material, also annealed, is being replicated for electron microscopy studies (RM-265).

Techniques for etching and replicating small special shaped uranium specimens for metallography studies have been developed (RM-284).

Metallography revealed that core metal in the inner tube of an enriched KER tube-in-tube element was badly fragmented and that additional cracking had probably occurred in the uranium after discharge. However, the core to clad bond was excellent (RM-569).

Room temperature tensile tests were conducted and densities determined on four out of five thorium-uranium samples. The fifth sample had been completely oxidized 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

Mechanical and Physical Properties of Materials. The evaluation of zirconium - 2 a/o niobium - 2 a/o tin alloy for fuel element cladding applications has continued. Heat treatments designed to simulate the material condition expected in the cladding of beta treated fuel elements have been given to Zr - 2 a/o Nb - 2 a/o Sn alloy specimens.

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The heat treatments consisted of oil quenching from 660 C, 700 C, 740 C, and 780 C after a suitable holding time at temperature. Tensile strengths attained at room temperature range from 86,700 psi to 110,500 psi; at 300 C tensile strengths range from 57,000 to 75,600 psi. The highest strengths correspond to highest temperature of quenching.

The study of the mechanisms of strengthening during heat treatment of Zr - 2 a/o Nb - 2 a/o Sn is being carried out. Metallographic examination has revealed a two-phase microstructure consisting of primary alpha and transformed beta in alloy specimens quenched from 800 C and 925 C. Transformed beta exists alone at quenching temperatures above 950 C, while quenching temperatures below 775 C reveal an optically single phase structure. X-ray diffraction studies show that all specimens contain two phases. The combinations of tensile strength and ductility attainable in this alloy depend upon the character and distribution of primary alpha, transformed beta and intermetallic compounds.

Corrosion studies are being carried out in 680 F water and 750 F steam on alloy specimens in the above conditions of heat treatment. Ten-day weight gains in 680 F water range from 30.0 mg/dm<sup>2</sup> for material quenched from 660 C to 50.1 mg/dm<sup>2</sup> for material quenched from 780 C.

Electron and Optical Microscopy. A prototype capsule containing flux and temperature monitors has been irradiated in a Snout Facility. No charging or discharging problems were experienced. The flux in the facility has been determined, and the maximum temperature of specimens contained in a capsule has been established to be less than 100 C. Eighteen additional capsules have been submitted for charging in the facility. The capsules contain bulk and pre-thinned foils and electron microscopy tensile specimens of annealed and cold worked, high purity aluminum. They will be irradiated to various exposures to establish radiation damage mechanisms in aluminum. The preparation of Zircaloy-2, nickel and steel foils thin enough for transmission electron microscopy has continued. Reasonable success has been achieved. Foils of Zircaloy-2 rapidly oxidize during examination in the Philips 100 B electron microscope. From observations on only a relatively few foils of Zircaloy-2, it would appear that a finely dispersed second phase or precipitate is present. The particles are rod shaped with a diameter of approximately 400 A and a length of approximately 1000 A. The validity of this observation will be checked in additional foils of zirconium and Zircaloy-2.

Attempts to prepare metallic films of uranium by electron beam evaporation techniques have not been successful. A 10 w/o U-Pd alloy has been used as a source material, and the evaporated layer has been collected on a carbon substrate as a free surface and has also been sandwiched between carbon and WO<sub>3</sub>. Other metallic sandwich layers will be used with the evaporated 10 w/o U-Pd alloy. The applicability of these techniques to the preparation of thin metallic uranium films will be evaluated.

Experiments on the collection of material from a UO<sub>2</sub> film onto carbon films small distances from the UO<sub>2</sub> during irradiation are being

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performed. After exposures up to  $4 \times 10^{18}$  nvt in either a vacuum or air environment, the material deposited on the collector is in the form of small particles, approximately 400 A in diameter. Although insufficient material is present for conducting electron diffraction analysis, gamma ray spectrometry indicates that typical fission products are present. It should be recalled that after an exposure of  $4 \times 10^{18}$  nvt (thermal), particles on the collector were identified in evacuated capsules as being  $UO_2$ , and large rosettes in air filled capsules were identified by electron diffraction as  $U_3O_8$ . A higher exposure,  $4 \times 10^{19}$  nvt (thermal), converts the material on the collector into dense, rounded particles and filaments which do not yield an electron diffraction pattern. Since the amount of fission product activity on the collector increases with increasing exposure and the activity on the collector is independent of the environment, air or vacuum, it must be concluded that (1) sublimation of  $UO_2$  from  $UO_2$  films occurs during thermal neutron bombardment in vacuum, and (2) similar sublimation occurs during irradiation in an air environment, but the species is converted to  $U_3O_8$  prior to, during, or after the sublimation. Since the vapor pressure of  $UO_2$  and  $U_3O_8$  are not identical, the sublimation rates should differ and yield different amounts of deposits during equivalent exposures. Since this is apparently not the case, and since the source  $UO_2$  film is not converted to  $U_3O_8$  during air environment irradiations, it can be concluded that a major mechanism for transport of material is sublimation of  $UO_2$ , and that the energy required to sublime  $UO_2$  molecules is supplied by the individual fission events. During air irradiations, oxidation of the  $UO_2$  sublimate occurs during and/or after sublimation has occurred.

Irradiation and subsequent electron microscope examination of multiple films containing fissionable  $UO_2$  has continued. Since fission fragment trajectories are seen by virtue of a depletion of scattering material in the vicinity of a fission path, experiments were conducted in which the fissionable material had no free surface. Evaporated films of the form C- $UO_2$ -X were irradiated to exposures of  $2 \times 10^{16}$  nvt (thermal), where X was Al, Ag, Ge, C, and  $WO_3$ . In all instances, fission fragment tracks could be seen, but their contrast, shapes, and uniformity varied markedly. The platinum layer appears to have suffered the greatest damage, and in an irregular way. Along the path of the fission fragment large isolated areas, four times the normal area associated with the damage region of a fission fragment, form in the Pt multi-layered films. Many tracks which appeared in the multiple layered films show discrete circular regions depleted in material (partial holes), and many tracks exhibit a short length of high depletion of material (possible origin of the fission fragments). A general conclusion covering the usefulness of free surface  $UO_2$  films versus internal free surface  $UO_2$  film irradiations is premature.

X-Ray Diffraction Studies. Orientation of extruded uranium rods and tubes with various fabrication and heat treatment histories is being determined by various methods. Small uranium bullets 0.2 inch in diameter have been machined from a portion of uranium tubing (FPD extrusion No. 7). Complete pole figure determinations of (110), (111), (021), and (020) were

made using only one bullet. These pole figures determined from one sample provide a complete description of orientation in extruded uranium. When accurate texture information is needed, this method is to be preferred over the method of growth indices. A duplex texture with strong 110 orientation perpendicular to the extrusion direction is indicated by the pole figures. A strong c-axis texture exists in the tangential direction, a b-axis texture in the radial direction, and an a-axis is approximately  $20^\circ$  to the extrusion direction. A 130 recrystallization texture parallel to the tube surface is inferred from the data.

Line broadening data for cold worked molybdenum have been collected for the 110, 200, 112, 220, 400, and 224 diffraction peaks of samples cold rolled 10%, 20%, 30%, and 40%. Some data have also been gathered for a partially annealed sample, and for samples rolled to 60% and 90% reduction. Fourier coefficients have been computed for the 110, 200, and 400 lines. These coefficients are being separated into particle size and strain broadening coefficients. The strains appear to be uniform over distances of 20 to 60 A for the rolled specimens. Strains in the partially annealed sample extend over approximately 40 A.

The strain behavior at smaller distances cannot be satisfactorily measured since it depends upon coefficients which, because of termination errors, are least reliable. These errors are due mainly to the difficulty in separating the long "tails" of the peaks from the background.

#### Metallic Fuel Development

Tubular Fuel Elements. Tubular components for Production Test IP-364A were given a dual cycle autoclave test to establish clad and end closure integrity. The dual cycle consisted of first a 72-hour, 300 C water test followed by a 48-hour, 400 C - 1500 psig steam test. Both cycles were under static conditions and a visual inspection was made between cycles. The primary purpose of the water cycle is to detect surface contamination such as iron or copper inclusions. The steam cycle tests weld integrity and provides the necessary protective oxide film. The oxide film produced by the dual cycle is equivalent to that formed by the standard 72-hour, 400 C - 1500 psig steam test. During the testing the following observations were made:

1. Scratches made in the thin water cycle film did not heal during the steam cycle, resulting in white oxide formation.
2. White oxide formed around the base of the Zircaloy studs used for pinning of iron support rails. The oxide formation was attributed to the inability to completely rinse the etch solution from beneath the metal flashing formed during projection welding.
3. One outer tube was autoclaved with the iron supports attached. The supports were attached using a "white glove" technique after the studded tube was etched. The piece autoclaved satisfactorily with the iron supports developing a dull black oxide film.

Production Test IF-364A covers the irradiation of KER size tube-in-tube elements with 12% Fe - 4% Be - 84 Zr-2 alloy brazed end closures. Core material is 1.6% enriched 2 w/o Zr alloyed uranium.

The two NPR inner tubular fuel elements to test the effect of radiation on the brazed closure have been shipped to the MTR. These elements, designated as GEH-4-57, 58, were brazed with the 12 Fe + 4 Be + Zry-2 braze alloy and were electron beam welded. Specific power was calculated at 105 kw/ft with a surface temperature of 93 C and a core temperature of 375 C. These elements will be examined after one cycle of irradiation in the MTR.

Two KER unalloyed normal tube-tube elements are being prepared for irradiation in the 6x9 facility of the ETR. This will be a very severe test due to the high specific power of 300 kw/ft and the high temperature.

Two enriched KER 1.6% Zr tube-tube elements have been prepared for irradiation in the 3x3 facility of the ETR. Calculations have not been completed. These elements are closed with the 12 Fe + 4 Be + Zry-2 braze alloy and electron beam weld.

Thirty samples of NPR inner tube, extrusion 34 (20-mil inner and outer clad, 1.420" OD, 0.513" ID), have been obtained for studies on the effects of various beta heat treatments on grain size and uniformity, grain orientation, and external dimensions.

Metallography shows that in the as-extruded condition, the uranium has a thick band of large grains around the inner wall. The grain size decreases with increasing distance from the inner wall until a very fine grain structure is found halfway between the inner wall and the outer wall. This fine grain size extends almost to the outer wall, where a very narrow band of slightly larger grains appears. In order to produce a fuel element suitable for irradiation, a heat treatment must be found which will break up this structure to give a uniform grain size and a random orientation. Toward this end, thirty different heat treatments have been performed by using combinations of the following variables:

1. Beta temperature - 10 minutes at 675° (Houghton 980 salt bath), 705 and 730 C (NuSal salt bath).
2. Air delay before quenching - 10, 20, and 30 seconds.
3. Quench media - oil (Houghton Quench "G") at room temperature, hot water (75-80 C), and low temperature salt bath (Houghton Draw Temp 275) at 250, 325, and 400 C.

Heating and cooling curves have been obtained by recording temperatures from thermocouples embedded in the midwall of the samples. Cooling rates for the various heat treatments have been calculated. Metallography is in progress to determine the effect of the various heat treatments on the grain size and uniformity, and samples are being

sectioned for x-ray diffraction studies to determine the degree of preferred orientation remaining after heat treatment.

The fabrication of fuel elements from two FPD coextrusions of 1.6% enriched KER size single component fuel tubes has been completed. A selected number of the finished elements, the operating conditions of which will be prototypical of NPR tube-tube geometry, are to be loaded in-reactor early in November. These elements are closed with Be-Zr eutectic braze material and are supported by mild steel rails fastened to the fuel tube with Zircaloy-2 studs. Fuel tubes which have been rejected at various steps in the processing are being examined both destructively and nondestructively to characterize the material and the elements as much as possible. Nondestructive testing will include exposure in ex-reactor ELMO-7 loop to high temperature, high pressure water for the determination of long term corrosion behavior.

The specific power of an NPR inner tube irradiated in a KER loop is approximately 90% of that predicted for the NPR. Nine NPR inner tube elements were completed in October. These elements are 16 inches long and were prepared from FPD extrusion #36. The outer clad is 0.035 inch and the inner clad 0.022 inch thick Zircaloy-2. The support rails are made of low carbon steel and are held in place by studs of Zircaloy-2 which are welded to the fuel clad. All of the elements passed 300 C water and 400 C steam autoclave corrosion testing.

A KER T/T coextruded fuel element is being irradiated in the ETR 6x9 loop. The 36-inch long fuel element is uranium - 2 w/o zirconium clad in 0.020-inch Zircaloy-2. The power output of the element is approximately 800 kw, with the power of the central element very close to the predicted 354 kw/ft. The maximum heat flux is 1,300,000 BTU/hr-ft<sup>2</sup> and the maximum fuel temperature is 580 C. The element will be removed from the reactor after a maximum exposure of 1790 MWD/T.

Further work was done by Radiometallurgy on the ruptured inner tube from a KER test which failed at 3200 MWD/T. A metallographic section near the clad split established localized thinning of the Zircaloy-2 clad was responsible for the failure. In all cases where cracks in the uranium core propagated into the clad, the cracks contained uranium oxide; cracks which failed to propagate into the clad contained no uranium oxide. These observations establish the fact that fragmenting of the fuel core occurred after water had penetrated the clad.

Component Fabrication. Tooling has been set up in the 700-ton vertical press in the 306 Building to forward-extrude 3-1/2 and 4-inch billets. Six billets were successfully extruded, consisting of four solid copper billets and two composite uranium-Zircaloy-2 billets.

The two composite billets were extruded into NPR inner tube size (1.430 OD by 0.520 ID) at an extrusion ratio of 9.1 to 1 to test the equipment for coextrusion work and to determine the feasibility of coextruding at low extrusion ratios. The new NPR inner tube size could be extruded at an extrusion ratio of approximately 12 to 1.

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The billets were preheated to 625 C and were extruded at a ram speed of 30 inches per minute. Subsequent metallographic examinations showed a very rough uranium/Zircaloy interface, especially at the inner wall. The clad thickness varied from 0.011 to 0.029 with an average of 0.020 inch. Although the uranium core had been given a triple beta heat treatment before finish machining, it apparently did not erase the effect of the large grains.

Peel tests following the extrusion indicate that the Zircaloy-2/uranium bond was of fair to poor quality, although the interface appeared reasonably clean.

The Mark II tongs for crimping steel wear shoes to 1/4" wide Zircaloy-2 supports have been fabricated, and the tooling for forming the 0.030" x 1/4" x 2" Zircaloy supports is also ready. The blanking and forming dies for the steel shoe pre-forms are about 85% complete and should be finished by October 28, 1960. The steel-covered supports are to be tested to determine: (1) load carrying capacity, (2) collapsed height, (3) forces required to dislodge shoes, (4) scratching characteristics.

Coextruded rods 0.600" diameter, having a 0.020" Zircaloy-2 cladding with a 0.026" simulated enriched layer of uranium directly beneath the cladding, have been made. These rods were fabricated by casting the billets and coextruding the triple beta quenched castings. Zirconium-uranium interface roughness measurements taken on three of the four extrusions, using two samples and ten readings from each sample, show a total variation from peak to valley of 0.004" to 0.008". It is believed that improvements may be made in correcting the zirconium-uranium interface roughness through changes in melting and fabricating techniques. These changes incorporate the use of arc melted uranium billets to be heat-treated and extruded into components for final co-extrusion. The grain refining effect of the additional working should reduce the roughness observed on the cast, heat treated, and coextruded rods reported above.

Test elements of NPR inner tube stock 1.430 OD x 0.520 ID with 0.040 inch outer clad and 0.025 inch inner clad were processed for a variable heat treatment test to be irradiated in the KER loops. Twelve 18-inch long sections of FFD extrusion T-71 were processed through inspection, copper removal, and heat treatments in which heating and cooling curves were obtained. At this point it was determined that excessively dirty clad-uranium interfaces had led either to spotty diffusion during heat treatment or to physical separation of the outer clad during cooling. Nondestructive bond tests of the elements indicated unbond condition for all the test sections. Although the elements will not be used for irradiation tests, the heat treatment data obtained can be used to advantage. Additional stock was obtained and is being processed to replace these elements. FFD extrusions T-60 and T-61, NPR inner tube 1.263 OD x 0.433 ID with 0.035 to 0.040 OD clad and 0.030 ID clad, are being used. Sections of the material have been examined in the as-extruded and heat-treated condition and appear satisfactory for reactor use.

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Closure and Joining. The brazed KER tube-tube 1.6% enriched, 2 w/o zirconium production test has been completed. These fuel elements were brazed with an alloy composed of 12 Fe + 4 Be + 84 Zry-2. A total of seven acceptable tube-tube elements were completed plus an additional four outer tubes which will be used as heater elements in another test. Some difficulty was encountered in brazing the outer tubes due to non-wetting of the uranium surface. This was overcome by heating to 950 C and holding for 90 seconds. After 45 seconds at temperature the cap was mechanically forced down onto the uranium and the vacuum valve closed. After 60 seconds the chamber was back-filled with helium to atmospheric pressure. This operation insured seating of the cap and complete filling of all voids with braze metal. All of the elements were welded by the electron beam process. A 1/32" x 1/32" groove was machined around the braze zone and a single pass weld made in this groove. After welding, the supports were welded onto the inner tubular elements and the projections for fastening the iron rails were welded onto the outer tubular elements. The elements were then dual cycle autoclaved for 72 hours in 300 C water, then 48 hours in 400 C steam. All of the elements passed the autoclave test. The iron-beryllium-Zircaloy braze develops a very dark autoclave film, slightly duller than that obtained on Zircaloy-2, but much darker than that of the beryllium-zirconium braze alloy.

Two new brazing chambers are being designed. These chambers will allow complete investigation of all forms of braze closure that are now known. Also, a circuit has been designed to control the temperature of the brazing cycle. Several of the alternate brazing alloys have been obtained from Oregon Metallurgical Corporation. These alloys all melt below 1000 C, most of them below 900 C. These alloys include the following:

81.5 Zr + 17 Fe + 1.5 Sn  
 84 Zr + 16 Fe  
 85 Zr + 10 Fe + 5 Sn  
 84 Zr + 8 Cr + 8 Ni.

Molds have been fabricated which will allow the direct shape casting of the various braze alloys. Feasibility of this process will be determined as soon as the effect of carbon in the braze alloy is determined.

Two uranium electrodes for the arc melt furnace are in the process of being fabricated from bar stock and from rod stock. The rod stock has been tack-welded by the TIG process in air into a 7-rod cluster. The bar stock has been laid brick fashion and welded full length by the electron beam vacuum process. Threaded adapters remain to be attached to both electrodes. These electrodes are intended for use both in setting up the arc melt furnace for operation and in the development of the welding processes involved in fabricating and compositing electrodes of enriched or special materials.

Use of steel supports on Zircaloy-clad fuel elements necessitates the development of joining methods for these dissimilar materials. One such method, employing the resistance welded Zircaloy stud, has been applied to several lots of elements. The equipment has been modified to attach

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both studs at once, thus reducing placement problems, and at the same time speeding up the process. The same modified equipment is being used to attach Zircaloy supports.

Another type of steel support consists of a Zircaloy member with a crimped-on steel shoe. These are attached in the same manner as Zircaloy supports.

A corrosion test is in progress in ELMO-7 loop on a simulated element having four of each type of support.

An inert atmosphere bottle, now under construction in Technical Shops, is designed to eliminate the problem of atmosphere contamination of the fuel element closure welds when welded by the metallic inert gas process. The bottle will replace the present vacuum chamber, thus permitting more rapid welding of the fuel elements. The metallic inert gas process is now under investigation as a method by which the final closure of the fuel elements can be made.

It had been experimentally determined previously that under the conditions used in forming the "Extrusion Closure" (715-730 C, ~70 tsi, ~20 sec), copper bonds well to both uranium and Zircaloy; iron bonds well to uranium; and nickel bonds well to zirconium. Thus, it appears that a thin copper layer interposed between the uranium core and the Zircaloy cap, and extending a short distance outward between the annular cap and the jacket walls would effect a sound bond between all components. Similarly, a nickel-clad iron shim placed between cap and core, with the nickel extending outward between cap and jacket walls should bond all components soundly. Tools and techniques were developed for making copper cap faces, and ten copper-faced caps were prepared. These caps have been welded into the chemically milled ends of test specimens and the assemblies are to be put through the remainder of the extrusion-closure process during the coming week. These specimens are to be evaluated for bond integrity by metallographic study and by high-temperature autoclaving of intentionally defected primary closures. Work has been started on the preparation of nickel-clad iron facings for more of the Zircaloy caps, to make a similar test lot of specimens with iron-nickel interfaces for evaluation.

Allied Fuel Studies. Localized straining in Zircaloy-clad uranium has resulted in fuel element failures. The localized plastic straining occurred with very little associated uniform elongation of the cladding material. A model for the fuel element has been formulated which should predict the ability of various cladding thicknesses to resist fuel material expansions in tubular fuel elements. The necessary mathematical relations, method of analysis, and computer program have been obtained. The computer program is being debugged.

Constant load tests are in progress on uranium samples undergoing large temperature cycles (~300 C). A test on a specimen loaded to 750 psi and cycled between 155-435 C has been completed. After 19 cycles, 1.55% strain occurred. The mean strain per cycle was approximately 0.07%. A test on a specimen loaded to 1000 psi and cycled between 150-435 C is in

progress. The initial data indicate that the mean strain per cycle is approximately 0.08%.

Several types of material have been brazed with the 12 Fe + 4 Be + 84 Zry-2 braze alloy for exposure to decontamination solutions. This material includes both KER size mockup tube-tube elements with brazed and welded end closures and brazed Zircaloy-2 corrosion coupons. It has now been steam autoclaved for 48 hours at 400 C. The specimens will be exposed to up to four decontamination cycles to determine the effect of the decontamination solutions on the brazing alloy.

Two NPR inner tubular elements brazed with the 5 w/o Be + 95 w/o Zr-2 braze alloy were placed in the EILMO-7 thermal cycling facility. These pieces have operated successfully through several cycles from 300 C to 20 C.

The radiometallurgy examination of the second thermocoupled fuel element has been completed. The stainless steel-to-Zircaloy-2 braze joints were examined and the braze layer in each joint was found to be free of cracks or voids which could have admitted water. Some voids were found in the braze layer of one of the three joints, but the voids ended in sound braze material and did not penetrate into the interior of the joint. A third thermocoupled fuel rod has been completed and is ready to be shipped to the reactor.

Ductile cladding failures of Zircaloy-2 clad uranium rods and tubes have occurred in high exposure NaK capsule and high temperature recirculating water loop irradiations. From the appearance of the failures, the same mechanism was apparently operating in all the cladding failures.

Examination of three additional Zr-2 clad fuel rods irradiated in NaK capsule to 1100 MWD/T has been started in the Radiometallurgy Operation. It is of interest to know if any evidence of the clad thinning or necking, as observed in the previously mentioned higher exposure irradiations, can be seen in these elements.

To establish further the effects of cladding thickness variations on the susceptibility to failure, a series of NaK capsule irradiations of Zry-2 clad fuel rods is planned for the Hanford reactors. This experiment will use fuel rods with cladding thicknesses of 0.030 and 0.040-inch with striations machined in the outer surface of the cladding. Cladding surface temperatures of 240, 280, and 320 C are to be investigated. The cladding surfaces and thicknesses will be carefully pre-characterized before irradiation. Calculations and designs for the experimental assemblies is complete. Melting and casting of the fuel billets for the extrusions has been started. The other components for the fuel rod extrusion are now complete.

Two improvements in steel self-supports were made during the report period. The first was series welding of two Zircaloy-2 attachment studs instead of one-at-a-time welding. The advantage in the new method is that one operation attaches two studs and the necessary accurate stud spacing is

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built into the welding head. The second improvement was use of a flat faced carbide tool rotating at 5000 rpm to upset the studs over the supports. The friction heat and the rotary motion causes the studs to upset at loads of 100 to 200 pounds.

One of the problems in the study of the effect of biaxiality of stresses on the necking and fracture of Zircaloy-2 cladding is measurement of strain. A checkerboard pattern, 150 squares to the inch, was photo-engraved on a piece of Zircaloy tubing, and the tubing was strained under a tangential to longitudinal stress ratio of 1/2 (internal pressure only would have been a ratio of two). The resulting strain ratio was easily determined from the spacing of interference fringes produced when the original screen was placed over the strained specimen. The engraved pattern on another specimen withstood autoclave treatment, thus indicating that this technique could also be used to study cladding strain in fuel elements caused by swelling of the uranium.

Facilities and Equipment. Measuring equipment has been developed to characterize the external surface of cylindrical fuel elements. Radial displacement and diameter readings are continuously recorded while the fuel element is rotated. KER test fuel elements are being characterized using this measurement system.

## 2. REACTOR PROGRAM

### Coolant Systems Development

Effect of Surface Treatment on Aluminum Corrosion. Initial corrosion of aluminum is greater for samples either etched in HF-HNO<sub>3</sub> or cleaned in H<sub>3</sub>PO<sub>4</sub>-Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>-HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>. Samples employed in these ex-reactor mockup tube tests were solid dummy fuel elements with C-64 alloy jackets. After 200 hours of exposure to 130 C process water at 20 gpm in a full scale process tube, penetrations were 0.71 mil for the etched sample and 0.27 mil for the cleaned sample, compared with only 0.12 mil for the autoclaved sample.

Aluminum Alloy Development. Aluminum alloy C-810 (Al, 1.0 Ni, 0.5 Fe, 0.1 Ti) showed slightly less corrosion than X-8001 alloy after one month of exposure in 120 C process water at 35 gpm flow in a full-scale ex-reactor process tube. Samples employed were sections of fuel-element jackets mounted so that only outside surfaces were exposed. Total penetrations after one month were 2.7 mils for C-810 alloy and 3.1 mils for X-8001.

Caustic Stress Cracking. Examination was completed on a Zr-2 stress-crevice coupon exposed for four weeks at 290 C in concentrated LiOH solution (150 g/l). Extensive hydriding had occurred and was estimated at 200 to 400 ppm from photomicrographs. A weight gain of 230 mg/dm<sup>2</sup> was obtained, and the coupon was observed to be covered with a heavy film of white oxide. The test was repeated and similar data were obtained after two weeks. No untoward corrosion occurred on stressed 304 stainless steel.

Another test is being performed using 1 g/l LiOH to determine the concentrations at which LiOH solutions become corrosive to Zr-2.

Fuel Element Rupture Tests in ELMO-4. A variety of pre-defected fuel rods were rupture tested ex-reactor in hot water at 300 C, 15 fps, and 1700 psi. The rods were all coextruded U-Zr-2 with an OD of 0.590 inch and 6-1/4 inches long. Four of the rods were used to determine the effect of carbon content in the uranium core: two rods with 62 ppm C, and the other two with 1675 ppm C. The 62 ppm C rods developed several ruptured mounds after one hour, and by the end of four hours, the rods were completely ruptured over the entire surface and almost all the uranium core had reacted with the water. The 1675 ppm rods developed only one initial rupture mound after one hour, and after four hours each rod had only four small rupture mounds. The high carbon content rods were superior in rupture performance to the low carbon content rods.

Four rods containing 1.0 w/o Zr and 1.8 w/o Zr in the uranium core were tested at 300 C. The 1.0 w/o Zr alloy core pieces exhibited only a single 1/4 inch diameter raised and torn mound after four hours. The 1.8 w/o Zr alloy core pieces had only a 1/8 inch raised area after two hours, but after four hours one of the rods had ruptured quite severely with a 1-3/4-inch long torn area. The other rod had a 1/2-inch raised mound which was torn open at the top rather than around the base of the mound.

Four fuel rods were rupture-tested after being subjected to various beta heat treatments as follows: (1) oil quenched, (2) 350 C lead-bath quench, (3) water quenched 1/2 hour, (4) annealed at 500 C. After rupture testing for four hours, the rods all appeared the same. Each had a single raised and torn mound which originally developed during the first hour. Weight loss after four hours for each rod was about 59 grams.

Four other rods had Zr-2 clad thicknesses as follows: (1) 0.010 inch, (2) 0.015 inch, (3) 0.020 inch, and (4) 0.025 inch. After rupture testing for one hour all four rods exhibited a single ruptured mound which developed into about five to eight mounds after four hours. Although there was not much visible difference, the 0.020 inch clad was slightly better than the other three.

Two KER inner tubes of coextruded U-Zr-2 with hot-headed end closures were tested at 300 C, 15 fps, and 1700 psi. After one hour the end caps were off each tube, and after two hours the tubes were very severely ruptured. They were stuck in a KER-size outer tube and had to be pounded before they could be removed. Each was ruptured and swollen over the entire surface for about 3-1/2 inches in length. The raised areas were large and typical of the AlSi bonded ruptures.

Single Pass Decontamination Studies. Several single-pass decontamination tests have been made in the 242-B Single Pass Decontamination Facility during the past month. A new decontaminant, Turco-4306 C, was tested at three and six oz/gal. When employed at 66 C, six oz/gal concentration for 24 minutes, the material was moderately effective, but not nearly as effective as Turco-4306-B. However, the corrosion rates were lower by a factor of approximately 100. The most satisfactory decontaminant appears to be the inhibited sulfuric-oxalic mixture (0.3M H<sub>2</sub>SO<sub>4</sub>, 0.1M H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>, 0.0025 M phenyl thiourea).

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Dissolution of Uranium Dioxide. Further laboratory tests were made using a solution of 40 gm/liter  $\text{KMnO}_4$ , 27 gm/liter  $\text{Na}_2\text{CO}_3$ , to dissolve  $\text{UO}_2$ . Dissolution is pH dependent, 9.5 to 10 being the most effective range for the carbonate complex which is assumed to be formed. These additional tests show the uranium concentration in solution was in excess of 10 gm/liter, which is about three times higher than attained with the usual  $\text{H}_2\text{O}_2$ - $\text{CO}_3$  solution.

The feasibility of using this  $\text{KMnO}_4$ -carbonate solution to dissolve the  $\text{UO}_2$  and then adding  $\text{NaOH}$  directly to this solution for the film conditioning step was investigated. The  $\text{NaOH}$  precipitated out about 99% of the uranium probably as  $\text{Na}_2\text{U}_2\text{O}_7$ . The use of Versene (EDTA) to prevent this precipitation was unsuccessful. However, it was determined that this precipitate remains well suspended in solution, e.g., there was no significant settling after 30 minutes and less than 10% after 90 minutes. Thus, draining and flushing the system should remove the suspended uranium nearly as effectively as if it were in solution. Consequently, the combining of the  $\text{UO}_2$  dissolution step and the film-conditioning step during decontamination may prove feasible.

The solubility of this precipitate in the final acid step of a decontamination process was also investigated. Solutions (5%) of Turco 4518, Wyandotte 112, and Ammonium citrate at 60 C dissolved all the precipitate (maximum U concentration tried was 7 gm/liter). However, Turco 4512 even at a 10% solution dissolved less than 1% of the precipitate. A carbonate-bicarbonate solution at pH 9.5 dissolved about 30% of the precipitate.

Cyclic Decontamination Tests. The CEP-4 Loop has completed the fifth decontamination cycle. Each cycle consisted of a chemical cleaning or decontamination with Turco 4502 and Wyandotte 1112 followed by normal operation at 300 C for one week. The corrosion rates of the Zircaloy and 304 stainless steel samples were all low. However, the carbon steel corrosion was rather high. For the mechanically coupled (carbon steel to stainless steel) samples, the carbon steel corrosion after four cycles was 0.79 mil.

There was no apparent corrosive attack on stainless steel whether it was coupled to carbon steel, Zircaloy-2, or uncoupled. The Zircaloy-2 appears to be corroded only by the water at 300 C and is unaffected by these chemicals. The Stellite alloys 6 and 12 and Haynes alloy 41 exhibited the characteristic pitting which occurs in the alkaline permanganate pretreatment.

Carbon steel samples in both the normalized and non-heat-treated forms have shown some pitting (galvanic with the stainless steel holder) and have a very roughened general surface appearance from the chemical corrosion. The welded samples non-heat-treated have shown indications of pitting in the heat-affected zone near the weld, but this pitting is not extremely deep. Undercutting of the weld is questionable at this time. However, the heat-treated samples (stress relieved at 1250 F for 2 hours, air atmosphere) have shown no gross pitting near the weld; but a knife-line or hair-line type of corrosion attack is quite noticeable adjacent to the weld on the carbon steel.

Quachrom Glucosate Inhibitor Tests. The substitution of quachrom glucosate for sodium dichromate as a corrosion inhibitor in reactor process water could potentially reduce the concentration of chromium discharged to the Columbia River. The results of screening corrosion tests after 1300 hours of exposure appear very favorable. Aluminum alloy X-8001 corrosion rates at 130 C in reactor process water (1.8 ppm  $\text{Na}_2\text{Cr}_2\text{O}_7$ ), 1.8 quachrom glucosate and 0.17 ppm quachrom glucosate are all 23 mils/year. The corrosion rates of aluminum alloy C-64 in all three solutions are slightly less. Since the radiation stability of quachrom glucosate is unknown, plans are being made for tests in a gamma pit and in-reactor.

#### Structural Materials Development

Burst Test of Irradiated KER Tube. Three sections of KER-1 irradiated Zircaloy-2 process tubing were burst-tested at room temperature. One sample was selected from the front and rear quarter points and one from the center of the reactor. The front quarter specimen burst at 16,500 psi corresponding to a hoop stress of 127,000 psi. Corresponding data for the rear quarter specimen were 17,000 and 128,000 psi. These data are comparable to those obtained in previous burst tests on a KER-2 irradiated tube. However, the center sample merely started leaking after an application of about 5000 psi internal pressure. Post-examination revealed a crack  $3/4$  the length of the tube, which is suspected to have been caused in handling subsequent to removal of the tube from KE Reactor. An active program is under way to trace the source of this crack, and the test will be repeated with adjacent samples from the tube.

Zircaloy Tube Replacement. Zircaloy-2 tubes needed for the overbore test at C Reactor are being ordered. Pilot lot production and delivery of the smaller size smooth bore tubes for C Reactor are essentially complete. Three vendors have demonstrated their ability to make this type of tube and at least one additional vendor is expected to do so prior to procurement of any large number of tubes.

NPR Process Tubes. The fluorescent penetrant, immersed ultrasonic, and vidigage tests were placed in operation on the NPR process tubes at Harvey Aluminum. After the usual technical and operating difficulties associated with startup of a new facility, the equipment performed well. Results of testing the first few tubes revealed that the quality of the tubing was excellent.

#### Nonmetallic Materials Development

Graphite Burnout Monitoring. Graphite burnout samples which were exposed to ambient DR Reactor atmosphere in process channel 2577-DR for four months (June through September 1960) exhibited satisfactory weight losses ranging from about 0.2 to 1.0%/1000 operating days. However, burnout data from the last three sets of samples exposed in process channel 1960-C have shown weight losses in excess of the allowable 2%/1000 operating days. In an effort to determine whether the high burnout is localized in channel 1960, two additional channels, 1889-C and 2780-C, were charged with monitoring samples on October 10, 1960.

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NPR Reflector Graphite Irradiation. The GEH-13-5 experiment containing NPR reflector graphite continues to operate satisfactorily in the N-5 corner position of the ETR. It has been in the reactor for one operating cycle and the temperatures of the four sample units are being controlled at 675 C, 700 C, and 725 C.

Hot Capsule Irradiations. Six hot capsules have been prepared for irradiation in the G-6 position of the ETR at 1000 C. The irradiation effects of coke particle size and additive variations will be compared in experimental graphites prepared by Speer Carbon Company using Great Lakes needle coke. Particle sizes included are 60% flour, 50% flour and standard mix in duplicant sets of samples from rotary and vertically calcined cokes. Standard mixes of vertically calcined coke, with and without iron oxide added, were used in samples which will be used to determine whether the additive is as effective in reducing contraction in needle coke graphite as previously observed in Texas Lockport and Sohio Lima coke graphites. Transverse and longitudinally cut samples of each variation, and CSF graphite standards, are included for the comparisons.

Hanford Irradiations. Three types of graphite irradiated at 30 C and annealed at 700 to 750 C were discharged after re-irradiation at 500 to 600 C to an exposure of 600 MWD/AT. A considerable amount of irradiation annealing occurred as indicated by the following length change measurements:

Graphite Type	Exposure at 30 C MWD/AT	% L* after 309 Irradiation	Amt. of Initial Growth Annealed Thermally at 700-750 C	Addl. Amount of Annealing by Irradiation at 500 C
TSFBB	868	+0.52	58%	42%
KC	1463	+1.11	57%	43%
CSF	3089	+2.2	32%	39%

\*Length change; plus signs indicate expansion.

The initial growth was fully annealed by thermal and high temperature irradiation in the lower exposure samples. Further irradiation annealing may be expected in the more highly damaged CSF samples. These results are in agreement with studies in which a thermal anneal at 375 C was followed by irradiation at temperatures ranging from 335 to 400 C.

The samples have been charged for additional irradiation at 550 C to determine what effect an initial low temperature irradiation may have on the long-term contraction rate at high temperature. This study will help establish the validity of employing contraction rates obtained on graphite samples irradiated only at high temperature in predicting the stack dimensional changes in the old Hanford reactors with their varied temperature histories at low exposures.

Stored Energy. Stored energy accumulates rapidly in samples exposed in-reactor at 30 C. After accumulating several hundred calories per gram, the rate accumulation slows and has tended toward saturation in the

vicinity of 650 cal/gm. Incremental exposures to demonstrate saturation have not been conclusive due to the slow rate of accumulation. However, the most recent value determined is  $647 \pm 2$  cal/gm for a CSF sample irradiated at 30 C for 10,500 MWD/AT, and it is now believed that this is close to a maximum value of stored energy for cold test hole irradiation of this material.

Graphite Drying Studies. Transpiration rates were observed from samples of NPR core and reflector materials. Solid cylinders, 2.0-inch long by 0.426-inch diameter were vacuum impregnated with water at room temperature. Linear weight loss rates of 142 mg/hr to 170 mg/hr were then observed (at room temperature) in air, for about two hours in each case, followed by exponentially decreasing loss rates to the original dry sample weights. This behavior is normal when compared with samples of CSF, CO, KC and SP-21 graphite.

Graphite Compatibility with He Containing 0.1 mm H<sub>2</sub>O Vapor. Tank He containing 0.1 mm H<sub>2</sub>O vapor partial pressure at atmospheric pressure was passed over a sample of NPR core graphite. The He was cleaned by passing through a trap of hot Cu turnings and then a trap of hot CuO turnings. H<sub>2</sub>O concentration was determined by means of a Beckman Electrolytic Hydro-meter. The graphite sample was a solid cylinder 0.43-inch diameter by two inches long, and its weight loss was followed by an Ainsworth semimicro-recording balance. The weight loss rates and conditions of the experiment are shown below:

<u>No. of Runs</u>	<u>Temp. (°C)</u>	<u>Gas Flow (Lfh)</u>	<u>Wt. Loss Rate (g/g Hr)</u>
4	730	0.5 - 1.0	$2.1 \times 10^{-5}$
2	771	0.5 - 1.0	$3.4 \times 10^{-5}$
2	830	0.5 - 1.0	$3.5 \times 10^{-5}$
1	625	There was no measurable weight loss during 3 hours of the experiment.	
1	730	2.0 - 3.0	$2.3 \times 10^{-5}$
1	771	2.0 - 3.0	$2.5 \times 10^{-5}$
1	830	2.0 - 3.0	$2.8 \times 10^{-5}$

Further experiments to show the effect of equilibrium mixtures of H<sub>2</sub>O, H<sub>2</sub>, and CO and the effect of gamma irradiation are in progress.

#### Thermal Hydraulic Studies

Experiments to Investigate the Effect of Eccentric Fuel Elements on Boiling Burnout. Fuel elements may be displaced from their normal position on the ribs of a process tube from a variety of causes. The resulting eccentric location of the fuel element will reduce the heat generation rate at which boiling burnout occurs. The high metal surface temperatures associated with boiling burnout may lead to fuel element ruptures. It is important, therefore, to know how severely an eccentric positioning of a fuel element will reduce the boiling burnout heat flux.

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As part of a program to determine the effect of eccentricity on boiling burnout, a test section was built which approximates two feet of the annular coolant passage of I&E fuel elements in a K process tube. The vertical position of the heater rod within the process tube of this test section can be adjusted. Three boiling burnout points were obtained this month with the top annular gap of 0.056 inch or 50% eccentric. The results are presented below, together with data obtained and reported previously with annular gaps of 0.113 and 0.028 inch, or 0 and 75% eccentricity.

Run	Flow gpm	Temp. °F	Q/A B.O. B/hr-ft <sup>2</sup>	Burnout Subcooling °F	Eccentricity %
1	22.3	196	1.0 x 10 <sup>6</sup>	24	0
2	22.3	196	1.6 x 10 <sup>6</sup>	0	0
3	22.6	196	0.47 x 10 <sup>6</sup>	71	75
4	23.1	233	0.47 x 10 <sup>6</sup>	35	75
5	23.0	191	0.83 x 10 <sup>6</sup>	56	50
6	23.5	191	0.81 x 10 <sup>6</sup>	57	50
7	22.8	223	0.74 x 10 <sup>6</sup>	29	50

These data show that an eccentric positioning of the fuel element will reduce the boiling burnout heat generation significantly. The depression of the boiling burnout heat flux is approximately directly proportional to the degree of eccentricity over the range of conditions studied. For comparison the normal present maximum heat flux from the annular surface of an I&E element in K Reactor is about 515,000 B/hr-sq ft.

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 burnout conditions. This is especially true in horizontal flow channels where the steam and water tend to stratify. The question is important since most experimental data regarding boiling burnout are obtained on test sections of lengths different from the fuel element under question.

This effect has been studied in the 189-D heat transfer laboratory by using two test sections, each a horizontal pipe 0.435 inch in diameter with coolant flow through the hole, but one 2-1/2 feet long and the other five feet long. The inlet coolant enthalpy, i.e., temperature or quality, to these test sections was so adjusted that boiling burnout data for the two test sections were obtained at nearly identical flows and outlet qualities. The data were obtained at flow rates between 500,000 and 2,000,000 lb/hr-sq ft, outlet steam qualities of 26 to 52% by weight, and at an outlet pressure of 100 psia. The heat flux at boiling burnout for these runs ranged between 350,000 and 2,000,000 B/hr sq ft.

Fourteen additional boiling burnout points were obtained during the month. These new data confirmed the conclusions previously reported that boiling burnout heat fluxes are dependent primarily upon the flow rates and outlet qualities, at least for the conditions studied. Two and a half feet is sufficient to establish the flow pattern and longer lengths would not

affect boiling burnout conditions. These results are important in that they indicate the validity of using inexpensive short test sections to investigate heat transfer conditions for long horizontal fuel elements.

Flow Orifices for Hanford Production Reactors. The solid fuel elements currently in the fringe zones of the present production reactors will soon be replaced with I&E (internally and externally cooled) fuel elements. Since I&E fuel elements have a lesser flow resistance, 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 elements in the fringe tubes requires a very high pressure drop across the orifices to establish the proper flow through the tubes. However, there is a limit as to how much pressure drop may be established across an orifice without attaining a condition of self-limiting or choking flow which is referred to as critical flow.

Normal operation in or near a condition of critical flow is avoided because to do so could result in the failure to obtain a Panellit trip in the event of a rupture of an inlet connector or loss of a nozzle cap. This is so because when critical flow occurs, the flow is independent of the pressure downstream of the orifice. This limits the increase in flow and associated change in Panellit pressure which would occur following a rupture of the inlet piping downstream of the orifice. The change in Panellit pressure may be insufficient to effect a trip and reactor power reduction. Furthermore, critical flow could cause damage to the inlet connector by cavitation and vibration.

An experimental program was therefore undertaken to establish orifice assemblies to meet the needs of the fringe tubes containing I&E fuel elements. The program consists of experimentally determining the critical flow constants for a number of orifices, using these new data together with orifice calibration curves already determined to design potential orifice assemblies. The orifice assembly best suited to reactor needs is chosen by reactor personnel. Vendor prototypes of the selected assembly are then tested in the laboratory to determine the final calibration and critical flow characteristics.

The program has been completed for the K Reactors. The new fringe zone flow rate, 34 gpm, is somewhat greater than was desired, but flows much less than this cannot be obtained without violating the criteria established by reactor personnel.

The orifice assembly for DR Reactor has been established. Final calibration is pending the delivery of production prototypes. The experimental determination of critical flow constants for C Reactor orifice assemblies is in progress.

#### Shielding Studies

Attenuation Measurements. The testing work to evaluate the shielding properties of iron-serpentine concrete as a function of density and baking temperature is complete. Concrete specimens with densities of

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210 and 265 lb/ft<sup>3</sup> were tested after baking at temperatures up to 320 C. At elevated temperatures it was found that the lower density material is the better neutron shield because of higher retained hydrogen content. The 265 lb/ft<sup>3</sup> concrete is superior as a pure gamma shield because of its higher density. The net result is that the two concretes are about equally effective on a total radiation dose basis. On an over-all basis, considering cost as well as shielding effectiveness, the lower density material appears to be superior and shows considerable promise for high temperature shielding applications. The first known large scale application of this concrete will be in the NPR front and rear biological shields.

Shielding Instruments. All three Perlow neutron chambers are now ready for calibration. The internal alpha source, which is used to check the instrument, was redesigned to eliminate the possibility of contaminating the inside of the chambers.

To test the neutron spectrometer under laboratory conditions, the Be<sup>9</sup> (d,n)B<sup>10</sup> reaction will be studied while the instrument is located at the positive ion accelerator laboratory.

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.

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C. REACTOR DEVELOPMENT - 4000 PROGRAM1. PLUTONIUM RECYCLE PROGRAMPlutonium Fuels Development

PRTR Fuel Fabrication. Fabrication of 19-rod cluster Pu-Al elements for the power loading of PRTR continued. Six of the assemblies are complete and components of the remaining 30 are in various stages of fabrication.

The billet casting rate was increased 25% by adding recycle scrap to the melting furnace, thus casting more billets per melting cycle. The recycle scrap consists of extrusion butts and cut pieces of cores which average 25 percent of the original billet weight.

Fabrication Development. Some very preliminary measurements were made to compare the gamma radiation from a fuel core containing 5% Pu-240 with a core containing 28.9% Pu-240. The radiation from the high Pu-240 core was from 8 to 10 times that of the low Pu-240 core at a distance of 2-1/2 inches. Use of 30-mil leaded gloves reduced gamma activity from the 28.9% material to twice that of the 5% material, also with 30-mil unleaded rubber gloves. Gamma activity from 5% Pu-240 material at 2-1/2 inches was the same as that of 28.9% material at 10 inches. Film studies to determine absolute dose rates are being conducted.

The development of swage fabrication methods for UO<sub>2</sub>-PuO<sub>2</sub> is continuing. Four rods were loaded with PuO<sub>2</sub> and fused UO<sub>2</sub>. The PuO<sub>2</sub> was added in two different forms: as high surface area powder and as a solid solution of 10 w/o PuO<sub>2</sub> in UO<sub>2</sub> from crushed high density pellets. Two rods were loaded to 0.5 w/o PuO<sub>2</sub> using each material, and two were loaded to 2.0 w/o with each mix. These were then reduced 42% in area by swaging. Gamma absorptometer scans showed the density to be over 90% theoretical over the full active length of the rods. The active length was reduced by one inch at either end by the addition of inert MgO end plugs. These rods are presently being machined to give three longitudinal samples apiece. The flat samples will be studied by microautoradiography to determine the distribution of Pu atoms.

A coextruded PRTR-size fuel rod with integral closures was produced using a contoured Al-Pu core and aluminum alloy can with a streamlined die of 60° entrance angle. Radiographs of this element show a uniform can wall thickness of 0.065". The reduction ratio was 20:1 as compared to the 11:1 reduction observed with 0.960" OD coextrusions performed on another program. The combination of the core configuration and 60° die produced a core with a two-inch end effect but no "dogbone". Modification of the configuration will be necessary to reduce the end effect.

The plutonium concentration of injection cast alloy (1.8 w/o Pu, 2 w/o Ni, Al) fuel cores was found to vary longitudinally and radially. Because of radial segregation and the method of cutting analytical samples, it appeared that the top section of the second casting contained 2 w/o Pu

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while the bottom section contained less than 1 w/o Pu. Two halves of the same wafer from a subsequent casting assayed: 1.76 w/o and 2.07 w/o Pu, respectively, indicating the possible extent of radial segregation and that half-wafer samples are not representative of cast cores.

The least amount of longitudinal segregation was found in a casting which was mechanically stirred in air at 800 C before injection: 1.65 to 1.94 w/o Pu (1/2 wafer samples). Since this run, four castings were made that were melted in vacuum and held at 800 C for times from one minute to fifteen minutes before casting. Data on Pu distribution in these castings is not yet available.

One aluminum alloy casting was made in which the core density was 97% of theoretical. This improvement was achieved by maintaining the temperature of the inlet end of the tube above 650 C during casting and by slowing the injection rate by a factor of three.

Fuel Evaluation. A prototypical 7-rod PRTR cluster with an over-all length of about 42 inches is undergoing thermal cycling in the ETR 3x3 loop. The element contains an Al - 2 Ni - 1.01 Pu alloy core in 35-mil wall Zircaloy-4 tubing with a diametral gap of four to six mils which duplicates as closely as possible the elements being fabricated for the PRTR power run. The element operated at steady state for three days before cycling commenced, and 26 thermal cycles were completed as of 10/22/60. Seventy-two cycles are scheduled. A thermal cycle consists of varying the coolant temperature between 180 and 480 F at the rate of 5 F/min. The core temperature consequently varies between 389 and 693 F. The loop is being operated at 1050 psig which is PRTR design pressure.

Examination of the UO<sub>2</sub> - 5.67 a/o PuO<sub>2</sub>, Zircaloy-clad capsule (GEH-14-89), which ruptured in the MTR at a heat flux a factor of ten above the designed value, has been initiated. Preliminary visual inspection of the specimen disclosed that the cladding had expanded 5-10% in diameter uniformly over the fuel core length. A view of the cladding surface on the side opposite the rupture site (0.4" x 0.6" long hole) showed the cladding to be relatively undisturbed except for the diameter increase.

Examination of an Al - 1.8 w/o Pu, PRTR prototype, 7-rod cluster with Zircaloy-2 cladding, stainless steel end fixtures, and quick-disconnect end caps is currently under way at the Radiometallurgy Laboratory. This cluster was irradiated (IP-226A, Supp.B) in the KER Loop 1 Facility in high pressure and temperature water. The cluster was easily disassembled by means of the special end caps. The cluster and the individual rods appear to be in very good condition. Initial dimensional measurements on the clad rods indicate length changes on the order of  $\pm 0.030$  inch. The measurement points are on the end caps and are 20.5 inches apart. Of the five rods measured to date, all but one lengthened.

A Zircaloy-clad 3-rod cluster containing an Al - 3 w/o Pu alloy fuel core has successfully completed 34 effective full power days in the GEH-4 loop. The element operated at a calculated surface heat flux of 576,000 Btu/hr-ft<sup>2</sup> with a maximum core temperature of 345 C. It was fabricated by simply

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slipping extruded cores into 0.030-inch thick Zircaloy cladding with a four to five-mil average diametral gap. Initially, the element generated an average of 66.5 kw/ft which dropped to 50 kw/ft at the end of the 34-day period; however, the power generation dipped to 47 kw/ft between 25 and 30 days. This unexplained minimum could be associated with the reactor flux pattern which will be examined.

The twelve Zircaloy-clad capsules (1/2" dia. x 5" long) for the Phoenix Reactivity Change Experiment have been fabricated and will now be autoclaved. All specimens contain an Al-Pu fuel core which will initially generate 30 kw/ft in a flux of  $2 \times 10^{14}$  nv. Three each contain plutonium which has 5.46, 13.13, 21.2, and 28.9 percent of the isotope Pu-240. The total plutonium concentration varies from 2.80 to 3.91 w/o Pu to give the same initial power generation of 30 kw/ft. Sample holders for irradiating the specimens and the Zircaloy lattice sub-assembly for making measurements in the Reactivity Measuring Facility are being fabricated.

Irradiation test proposals are being prepared for presentation to the MTR. The objectives of the tests are to conduct in-reactor sintering studies with plutonium and uranium oxides. An effort will be made to obtain a more thorough understanding of the kinetics of in-reactor sintering and to determine the effect of PuO<sub>2</sub> additions on the irradiation stability of UO<sub>2</sub>. Portions of the work will be performed in the VH-4 Hydraulic Rabbit Facility at the MTR. The capsules will contain both low and high density PuO<sub>2</sub>-UO<sub>2</sub>, and current plans are to vary the UO<sub>2</sub> content from 0 to 100%. The possibility of a joint irradiation experiment in the NRX Hydraulic Rabbit Facility at Chalk River was explored with J. L. Robertson on September 22-23, 1960, and is currently under consideration.

Facilities. The high pressure vertical autoclaves have been modified to obtain improved operability and safety. The two 100-inch horizontal autoclaves have been completed. One has been placed in operation and the other is awaiting testing.

Improvements in decontamination techniques have made it necessary to add hot drain facilities to the open front hoods in Room 113. The ultrasonic decontamination hood will be changed from static to full airflow for the same reason.

A monorail type hoist frame has been fabricated to allow handling of the 14" x 20" roll sets. Roll changing will be done by conveyor when the mill is hooded.

The 30 kw vacuum furnace hood has been activated. This is the first hood with an airlock using the Fisher-Governor self-sensing ventilation valves to be activated. Hood and airlock balance seem to be maintained satisfactorily with no apparent trouble as yet.

The hood inert gas system has been activated and found to be plagued with valve troubles. Modifications will be made to the system so that no dependence will be placed on the valves.

The criticality incident alarm has been installed but not tested. Arrangements will be made for routine testing of the system.

Ventilation operational tests using the various fan combinations have been made. The object of these tests is to obtain data for determining emergency operational procedures. Several unsafe building conditions were found to exist when certain fan combinations were run.

A power evaluation study is under way to determine present building power loads and to serve as a basis for future planning.

The BET hood is presently being installed. Glass line construction will begin the week of October 24. The sorptometer startup is awaiting fabrication of sample tubes and calibration cells. Calibration cells are needed to accurately measure the volumes of the injection valve tubes. These tubes provide a known volume of adsorbate gas for comparison with the unknown volumes desorbed from specimens.

#### UO<sub>2</sub> Fuel Development

Fabrication Development. Composite mixtures of electrodeposited UO<sub>2</sub> were prepared from material produced in 19 runs. Large crystal agglomerates were reduced to particle sizes less than 20 mesh to eliminate closed porosity. A mixture having a particle size distribution selected for favorable packing properties was compared with a mixture of unsized -20 mesh material on the MB C-50 shaker. Another similar mixture of unsized material was remotely fabricated, using the Genisco-Savage vibrator in the shielded facility in the 327 Building. Densities achieved were as follows:

	Density <u>% T.D.</u>	Compaction <u>Efficiency*</u>
Sized, C-50	86.4	88.3
Unsize, C-50	81.1	82.9
Unsize, G-S	79.3	81.1

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

Three hot-swaged, Zircaloy-4 clad, 19-rod cluster UO<sub>2</sub> fuel elements are being fabricated for the PRTR. Sixty 0.705" OD x 0.035" wall Zircaloy-4 tubes were filled with -65 mesh fused UO<sub>2</sub> and cold swaged to 0.625" OD. The final swage pass was made at 850 C. The densities of the rods after hot swaging are being determined.

A corrosion rate greater than anticipated was encountered on Zircaloy weld areas exposed to a 1100 psi 450 C autoclave test. This corrosion existed on samples welded in helium, air, and vacuum media. The depth of the unsatisfactory material was approximately 0.001 inch, determined by machining to various depths prior to the autoclave test. Microscopic examination revealed that copper contamination from the collet electrode which gripped

the tube caused the corrosion. The upset metal which was formed during the weld cannot be sheared but must be machined to a depth of 0.002 inch below the original surface to satisfactorily remove all the copper contamination.

Evaluation of the magnetic-force butt welding process for making closures on 0.005", 0.010", and 0.015" wall thickness stainless steel tubing was continued. A closure design which provides a directly aligned butting of the cap and the tube has produced satisfactory results with 0.015" thick tubing. The 0.010" wall thickness tubing resulted in accordion collapse of the tube adjacent to the weld and the 0.005" wall thickness tubing could not be satisfactorily aligned with the cap to provide the desired closure. Evaluation will continue with these thin wall configurations.

A preliminary evaluation was performed to determine the feasibility of welding beryllium fuel rod closures by the magnetic-force welding process. Tubing 1/2" dia. x 0.040" wall and rod 1/2" diameter commercially pure beryllium was obtained for the evaluation. The weld was performed in a vacuum with all fumes being exhausted through a filter. An initial pressure of 10,000 psi was applied to the weld joint prior to application of the welding current. Satisfactory closures were obtained with equivalent heating occurring in both the cap and the tube with a welding current of approximately 50,000 amperes for the 0.06 square inch weld area. A one cycle (1/60 sec) weld time was employed, with a weld current amplitude in the first 1/2 cycle equivalent to 95% of the weld current amplitude of the second 1/2 cycle.

The first remotely fabricated fuel element of electrolytically produced uranium dioxide was completed in the remote fabrication facility. The uranium dioxide, produced via "Fused Salt Cycle" electrolysis by the Chemical Development and Chemical Research Operation, was vibrationally compacted. The compaction efficiency\* was 79%. This first element was a 5/8-inch diameter Zircaloy-2 tube, 10.5 inches long, containing ungraded -20 mesh uranium dioxide.

Loading, compacting, and final closure by welding were all accomplished remotely proving the procedure for satisfactory assembly of irradiated material as soon as such material becomes available.

Hot swaged Zircaloy-4 cladding specimens were analyzed to determine the extent of hydrogen and oxygen diffusion into the cladding during hot swaging. Turnings from successive machine cuts were collected and analyzed spectrochemically for hydrogen and oxygen. Results are as follows:

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\*Defined as the ratio of the bulk density of the compacted fuel to the particle density of the powder employed times 100.

<u>Section of Wall</u>	<u>H<sub>2</sub> Conc.</u>	<u>O<sub>2</sub> Conc.</u>
OD - 0.002"	235 ppm	3900 ppm
0.002" - 0.006"	130	1450
0.006" - 0.011"	70	690
0.011" - 0.016"	70	765
0.023" - 0.027"	75	690
0.027" - 0.030"	80	700
0.030" - 0.033"	110	1525
0.033" - ID	185	4600

The high concentration of hydrogen, particularly on the internal surface, is cause for some concern. Tensile specimens were prepared to determine the tensile strength and ductility of hot-swaged Zircaloy-4. Testing of these samples is currently in progress. Corrosion samples were also prepared and will be corrosion tested.

#### Corrosion Studies

Effect of H<sub>2</sub> Pressure on Hydriding of Zircaloy. Work continued on the effect of H<sub>2</sub> pressure at constant water vapor partial pressure on the hydriding of Zircaloy-2 in H<sub>2</sub>-H<sub>2</sub>O mixtures. One segment of the experiment reported last month was repeated. Four vapor-blasted, vacuum-annealed samples were exposed at 400 C to 5 mm H<sub>2</sub> with 0.1 mm H<sub>2</sub>O added. The H<sub>2</sub> pickup data, together with that reported last month, are:

Time (HR)	<u>Hydrogen Pickup, ppm</u>						
	<u>6</u>	<u>24</u>	<u>48</u>	<u>96</u>	<u>120</u>	<u>144</u>	<u>234</u>
Experiment 1 (Reported last month)	335	535	345	645	585	655	
Experiment 2 (New data)		615		650		1030	770

Both experiments show the hydriding rate has been sharply inhibited after the first few hours of exposure. However, there is enough difference from sample to sample to hide a slow hydriding rate. Attempts to go to higher H<sub>2</sub> pressures failed because the samples were destroyed in the first hours of exposure before a protective film formed. Since higher pressure runs are necessary to determine the pressure dependence of the reaction, a new experiment has been started using etched samples. On this surface a protective oxide is rapidly formed by H<sub>2</sub>O vapor, and it is hoped the amount of H<sub>2</sub> picked up during the early portion of the experiment will be cut to a few ppm. Short-term runs up to 100 mm H<sub>2</sub> pressure have been completed without sample failure, but no data are available.

Corrosion Product Hydrogen Pickup in Static and Refreshed Autoclaves. The amount of corrosion product hydrogen pickup for Zircaloy-2 and Zircaloy-4 is different when exposed to 400 C steam in static and refreshed autoclave systems. The corrosion product hydrogen pickup was approximately a factor of two higher in the static autoclave for both Zircaloy-2 and Zircaloy-4.

The percent of theoretical hydrogen pickup for Zircaloy-2 was 31% in the static system as compared to 14% in the refreshed system. The hydrogen pickup for Zircaloy-4 was 20% in the static system as compared to 12% in the refreshed system. From the above results it appears that Zircaloy-2 is apparently more sensitive to hydrogen over-pressures.

A further comparison of Zircaloy-2 and Zircaloy-4 corrosion product hydrogen pickup has been made in 300 C, pH 10 water. In low oxygen content water (0.1 ppm O<sub>2</sub>) pickup was about 8% for Zircaloy-2; however, with three to four ppm oxygen, about 1%. For Zircaloy-4 the hydrogen pickup was 11% and 17%, respectively, though there is considerable spread in the Zircaloy-4 data.

The contradictory nature of the hydrogen pickup data emphasizes the need for data at other temperatures and water qualities.

Aluminum Alloy Development. A series of high purity base alloys with iron to nickel ratio 1.5:1, but varying total alloying additions, are being tested in 360 C deionized water. Alloys down to 0.25% Ni, 0.37% Fe show good corrosion characteristics in the short exposures obtained. An alloy

was observed on the control specimens and 7 to 12 mils on the artificially vibrated specimens. About two weeks prior to the last discharge, removal of an adjacent concrete structure with jackhammers was started. This increased vibration (8 hours/day) is believed the cause of the dramatically increased fretting attack on the control samples. However, apparently the magnets used to vibrate the one set of specimens also served to dampen vibrations set up by the jackhammers, with the result that the control specimens suffered more fretting than those equipped with the solenoid vibrator.

The test was terminated, but testing with larger contact areas and with different materials contacting the Zircaloy-2 will commence as soon as the filter removal work is completed. Also, the effects of environment (air, He, water) and temperature will be studied.

#### Structural Materials Development

PRTR Process Tube Monitoring. Bid invitations for the development and construction on a gamma radiation resistant TV camera have been sent out to interested vendors. Bids are scheduled to be returned the first week of December.

A Vidigage type ultrasonic wall thickness measuring unit and accessory equipment has been ordered with delivery scheduled for mid-November. This equipment will be used for prototypical testing of the transducer design and data-recording system. Two special transducer crystals, and various types of epoxy potting compounds used for mounting the transducer crystals have been received for determination of the effects of gamma irradiation. Fabrication of the instrument for measuring changes in the 1/4 inch gas gap between the Zircaloy-2 pressure and Al shroud tubes in the PRTR is about 95% complete. Bench tests of the instrument indicate an accuracy of about  $\pm 3$  mils.

The fabrication of 30 spare PRTR process tubes is on schedule with final delivery expected in January.

PRTR Sheath Tubes. A visit was made to Wolverine Tube Company on October 3, to discuss fabrication difficulties and late deliveries on a large Hanford order for Zircaloy-4 PRTR fuel jacket tubing.

Some progress has been made in overcoming fabrication problems. Fluorescent penetrant rejects at Hanford for the first 168 tubes fabricated by Wolverine's new techniques are 5 to 10%, and the vendor reports that his reject rate is approximately 10% versus a 50 to 60% reject rate for tubes fabricated by the former process. This is the lowest level of rejection experienced by either party on this order, indicating that the fabrication process is now under control and no further delays due to developmental efforts should occur. Wolverine has shipped 408 of the 0.495-inch ID tubes this month; 47% of these tubes meet the +0.002-inch to 0.0-inch ID tolerance.

Nondestructive Testing of Sheath Tubing. Sheath tubing is again being tested ultrasonically on a routine basis. The test equipment is standardized by setting it to reject on the signals received from 0.004-inch deep inside and outside surface scratches, and to accept the signals received from 0.002-inch deep inside and outside surface scratches. The magnitude of the signals received from the 0.004-inch inside and outside surface scratches are balanced so that defects on either the inside or outside surfaces may be detected.

This method of standardizing the equipment is being evaluated as the tubes are routinely tested. A group of 168, 0.495-inch ID tubes were inspected ultrasonically and the results compared with those obtained from the fluorescent penetrant test. These results are compared in the table below:

<u>Surface</u>	<u>Ultrasonic Indications</u>	<u>Confirmed by Fluorescent Penetrant</u>
Outside	3	3
Inside	1	1
Unconfirmed	1	0

Fluorescent penetrant indications were found in 20 tubes. In four of these, the ultrasonic signal tripped the reject alarm; in six tubes the ultrasonic signal was less than that from a 0.004-inch deep scratch; and in six tubes there was no ultrasonic indication of any kind. These results show a great improvement in correlation between the ultrasonic and fluorescent penetrant tests.

Twenty-one of the 168 tubes exhibited eddy-current indications. When radiographed, none of these tubes showed wall thinning or thickening. The tube with the largest eddy current indication was sectioned and examined. No defect could be found.

PRTR Process Tube Creep Rates. An annealed section of a PRTR process tube was subjected to a 96-hour test at 2250 psi and 650 F. The average permanent deformation was 0.0126-inch in diameter or about 0.3% deformation, compared to 0.17% after 48 hours. A second sample was tested at 1650 psi and 650 F. After 100 hours, this tube showed about 0.001 inch deformation. The test is continuing.

#### Radiometallurgy Laboratory Studies

Eight samples of high exposure UO<sub>2</sub> were prepared and delivered to Ceramic Fuels Development Operation. Samples represented exposures of 72,500 and 94,000 MWD/T (RM-609).

Metallography indicates that the flux peak of a defected, swaged UO<sub>2</sub> fuel element was near the downstream end. Three samples have been dissolved for burnup analysis to confirm flux differences through the length of the element (RM-611).

The four-rod Zr-2 also  $UO_2$  element which was irradiated to demonstrate enrichment simulation shows no detrimental effects of irradiation. Fission gas has been collected from the rods and metallography is now being done (RM-616).

No sintering was observed in a mixed plutonium-uranium oxide fuel element, the original shape of the pellets being still visible (RM-654).

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

#### Thermal Hydraulic Studies

##### Calculations Pertaining to the Hazards of a PRTR Gas Loop Process Tube Rupture.

One of the consequences of a PRTR gas loop rupture could be the injection of  $CO_2$  into the calandria. The presence of a large bubble of  $CO_2$  in the moderator in the calandria will reduce the reactor nuclear reactivity. However, the insertion of the bubble will temporarily raise the moderator level which will increase the reactivity. The net change in reactivity will be the sum of these two effects and may be either positive or negative. A knowledge of the leak rate of  $CO_2$  into the calandria is needed to determine the reactivity changes and potential hazards, if any, which will result. Approximate calculations were therefore performed to determine the maximum and minimum rates of injection of  $CO_2$  into the calandria which might be expected. The maximum rate of injection, which would result from a complete parting of the process tube, was found to be about 22 lb/sec. A volume of  $CO_2$  injected equal to one third of the calandria volume will occur in about 0.13 second. The minimum rate of injection, that rate of leak which will just pressurize the shroud tube sufficiently to cause its rupture, is about 6 lb/sec. This leak rate will require about 0.6 second to inject a volume of  $CO_2$  into the calandria equal to one-third of the calandria volume. These leak rates will be used in physics calculations to determine the nuclear reactivity transient and potential hazards.

##### Calculations Pertaining to the Hazards of Loss of Coolant to a Fuel Element in the PRTR Critical Facility.

If both power to the fuel handling system and fuel element coolant should be lost during movement of a fuel element in the PRTR Critical Facility, the fuel element will be left hanging in the facility without proper cooling. It may melt due to fission produced decay heating and release fission products to the Critical Facility atmosphere. One aspect of the potential hazards of such an incident is that of the necessity of containing the fission products within the cell. One possible loss of containment is the leakage of air from the cell which might occur due to the increase in cell pressure caused by the increase in air temperature following loss of coolant to the fuel element. Calculations were therefore made to determine the effectiveness of heat transfer through the cell walls to remove heat from the cell and thus suppress the increases in air temperature and pressure. The calculations show that if the fuel element is generating heat at a rate of about 6 kw or less, the heat transfer through the walls will remove enough heat to prevent the air pressure in the cell from exceeding two psig. The cell is designed to have an acceptably small

leak rate at a pressure of two psig. Qualitative transient heat transfer considerations indicate that if the fuel element were generating heat at a rate greater than about 6 kw, the times to reach air pressures greater than two psig will be long, in the order of several hours to a few days.

High Pressure Recirculating Pump Repairs. The recirculating pump used in the high pressure heat transfer apparatus was found to have developed interference between its rotating and stationary parts. The rotating parts of the pump are supported by a shaft through a bearing. The bearing housing is attached to a seal housing which, in turn, is attached to the pump case. The necessary alignment is accomplished with dowel pins through the bearing housing into the seal housing and with dowel pins through the seal housing into the pump case. Since the bearing housing is outside the seal housing, it has to be removed during a seal replacement. The present trouble was found to be due to damage to the dowel pin holes in the seal housing incurred during the reassembly of the bearing housing following a prior seal replacement. The dowel pin holes had become somewhat egg-shaped, which caused the bearing housing to be supported below its proper position and allowed the impeller to contact the pump volute case. The repairs to the pump consisted of honing smooth the rough spots caused by the rubbing of the impeller on the case and drilling new dowel pin holes in the seal housing. The repairs and realignment of the shaft bearings with the pump case were successfully accomplished on site with plant forces. Vibration measured at the bearing housings during operation is about 0.00025 inch.

#### PRTR Project Management and Design

PRTR Construction. The Phase III-A portion of the PRTR (remaining construction items not completed by the Phase III contractor or not included in his contract) being completed by the J. A. Jones Construction Company, CFFF contractor to the AEC, is estimated at about 20% completed. Construction work was delayed from about September 19 to October 3 because of a jurisdictional dispute involving pipefitters. Construction completion is being directed toward those systems required for the critical test program.

The reflector system has been flushed, cleaned, rinsed, and hydrostatically tested. A considerable amount of cloth-like material, believed to be from dessicant bags left in the pumps, was picked up on the strainer screen during the flushing operation. The rinsing operation was more extensive than anticipated because of the difficulty in removing the Turco cleaning solution. Resistivity of the final flush water was 20,000 ohms. The system is currently being dried prior to final helium leak testing and filling with heavy water.

The exterior portion of the moderator system was flushed with sanitary water. Minor amounts of sand, filings, rust particles, etc., were deposited on the strainer. During the flushing operation it was noticed that the impellers on two pumps dragged on the bowls. An out-of-alignment situation was noted, apparently due to improperly machined shafts. All three moderator pumps are currently being realigned. The interior moderator system piping is about 80% completed with all dump valves installed. Electrical and pneumatic tie-ins to the dump valves are being installed.

The helium piping required for the critical tests is estimated at 90% completed. The gas balance system valves are installed, and the temporary jumper piping for the helium system cleaning operation is installed.

The primary pumps are partially installed and some piping modifications on the H<sub>2</sub>O injection system associated with the primary system are complete. Some piping in the cleanup system has been flushed and cleaned. The RTD's which clamp on the jumper outlet piping are about 90% installed.

Work on the interconnections of the reactor flux monitoring and reactor control systems is nearing completion. An acceptance test procedure has been written covering wiring checkout and functional tests which will verify that all the proper connections are present and that no connections exist which do not show on the drawings. Upon completion of the acceptance tests, the system will be turned over to PRTR Operations for design tests.

Both the mechanical and electronic portions of the rupture detection system are currently behind schedule. The mechanical portion, being fabricated locally, is nearing completion, but will require additional manpower if it is to be completed and placed inside the containment vessel before the critical tests begin. The electronic portion has not yet been shipped because of the switching transient problem which still delays successful completion of the 24-hour acceptance test. The manufacturer reports that progress has been made but that the switching operation is still unsatisfactory. This is the same status report which the manufacturer has been making for the past three months.

The building radiation and air sampling systems have been completed and released on an extended basis to PRTR for design testing. Preliminary testing has revealed no major deficiencies in the systems.

Construction and acceptance testing were completed on the shim controls on October 22, and released for design testing. During acceptance testing it was found that seven of the position indicating meters had defective transformers and the power supply was improperly wired. The design test revealed several minor deficiencies; however, in general the shim control system performed as designed.

Minor modifications and repair to the fuel transfer system are in progress.

During final inspection of the loadout cask, it was determined that the end plate at the loading end was warped. Since this would result in a radiation leak when using the cask in the Radiometallurgy Building, Industrial Process Engineers was instructed to machine the end flat. Cask shipment is scheduled for late October.

The primary manipulator for the Fuel Element Examination Facility is being reassembled by the vendor in preparation for retesting. No firm delivery date can be determined until after the results of the tests are known.

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The Maintenance and Mockup Building construction contractor is estimated to be approximately 4% complete versus 4% scheduled as of October 31, 1960. A substantial part of the underground service line installation and relocation has been completed. Excavation is complete for the filter vault and 30-inch stack tie-in, and has been started for the Critical Facility.

Further analysis of cases requiring low pressure H<sub>2</sub>O injection into the primary system shows that the existing emergency well pump is adequate if connected to the "A" Cell injection line. The "B" Cell line will be connected to the boiler feed pumps for high pressure injection. Design work is complete except for rerouting of "B" Cell H<sub>2</sub>O injection piping to connect to the boiler feed pumps.

PRP Critical Facility (Project CAH-842). Over-all design of the project is approximately 95% complete versus 100% scheduled. The major remaining design item to be completed is the reactor control console.

Components of the prototype of the poison injection system triggering mechanism are on order.

The Henry Pratt Company submitted general layout drawings of the fuel transfer lock for approval. The drawings were returned "Approved as Noted." Since the drawings did not show the transfer mechanism in the lock, they were requested to re-submit the drawings of this item again for approval prior to starting construction.

A double-ended motor with two gear reducers has been ordered for use with the safety rods. This will permit the use of a potentiometer position indication system which will essentially be a duplicate of the system used for the PRTR shim rods.

A meeting was held with an engineering representative of Norden-Ketay (United Aircraft) concerning the synchro units for the control rod position indicators. As a result of this meeting, new bids have been issued and it is anticipated that satisfactory results will be obtained at a cost appreciably lower than the original bids. Alternate position indicator systems are being considered, involving pulse counters and analogue type encoders and resolvers.

A special "On-Mark" coupling has been ordered for prototype testing as the fuel element thimble tube closure.

Fuel Element Rupture Test Facility (Project CAH-867). A design contract was awarded to Cornell, Howland, Hayes, and Merryfield for design of the water filtration plant. The contract completion date is 12/30/60, at a contract cost of \$19,000. The General Electric portion of detail design is estimated at about 47% complete compared to 63% scheduled.

Orders are being placed for RLH-1 (immersion heaters), RLEX-1 (regenerative heat exchanger), and the coolant circulating pumps. Total cost of this material will be \$182,024 as compared to the project proposal estimate of about \$204,000.

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Bid due date for RLHX-2 (cooling heat exchanger) is 10/30/60. Specifications, drawings, and purchase requisitions are in process of approval for the storage tank, decontamination tank, vacuum deaerator, makeup system ion exchanger, cleanup system ion exchanger, and the chemical feed system.

Negotiations with Tube Reducing Corporation for Zircaloy-2 pressure tubes have been unsatisfactory to date. The detailed cost breakdown submitted to the AEC showed a per tube cost substantially in excess of their original quotation. Negotiations with an alternate vendor are in progress.

Drawings of Test Section "A" inlet assembly were completed and have been issued for comment. Specifications are being prepared for procuring certified materials for fabrication of components.

An order was placed for two Grayloc outlet connectors. Negotiations are continuing on the Aero Supply inlet valves to modify the design to meet ASTM Code requirements.

#### Design and Component Testing

PRTR Fueling Vehicle. Work instructions for completing all modifications to the fueling vehicle have been issued and no further reports will be issued.

PR-10 - Primary Loop Mockup. The PRTR primary process pump has operated 2710 hours with no indication of seal trouble. The leakage rate is less than 0.1 g/hr.

The prototype pump with the self-adjusting seal assembly has operated 3489 hours. The leakage rate has decreased to the range of 0.3 to 0.6 g/hr.

The Aldrich injection pump has now operated 2128 hours with R/M Vee-Flex packing rings with compression springs. This is more than twice the service obtained with this packing without springs. Two additional gland adjustments were required during the month to maintain the leakage rate per gland below 4000 ml/hr.

In Boiler Test No. 1, using simulated Yakima River water, the boiler has been sectioned for inspection of the tube-to-tube sheet joint. No excessive corrosion was observed although further sectioning and detailed examination is planned.

Process Tube No. 586-6063 was operated for 600 hours during the month for a total of 4725 hours at reactor conditions. Tungsten particles 0.060, 0.092, and 0.125 inch in diameter by 0.065, 0.100, and 0.112 inch in length, respectively, were placed in the in-let jumper to test the ability of the flow stream to flush ruptured fuel element particles from this location. It is assumed that the other particles passed by the fuel element, although this cannot be checked until the loop is shut down during November. Further tests with a greater range of particle sizes will be tried following replacement of the present pump strainer with one of fine mesh.

Process Tube Seal Experience. The new nozzle-to-process-tube gasket with the larger ID is now being evaluated in the Single Tube Prototype and in the flexure loop test pieces. Dimensions of this gasket are 3.415 to 3.430-inch ID, 3.787 to 3.807 OD, and 0.125 inch thick. The gasket on the Single Tube Prototype has been leaking only 1 to 2 ml/day. One of the flexure loop seals has been leaking at about 5 to 10 ml/day with the other leaking about 25 ml/day. The gasket with the high leakage rate is compressed a maximum of 0.025 inch, while the other gaskets are compressed from 0.030 to 0.035 inch. Conclusive results are not yet available; however, it does appear that average leakage with the narrower gasket will be somewhat larger than with the original gasket.

The special test piece for evaluating damage to the process tube from metal seizure at the nozzle to process tube joint has now operated through 1725 thermal and pressure cycles.

PR-40 - Shim Control Mockup. Operation of the Western Gear motor after exposure to  $1.4 \times 10^9$  R gamma has been completed with no observed change in electrical characteristics. The motor has been returned for further irradiation.

Installation of special shim rods of carbon steel, carbon steel with 0.4% boron and stainless steel with 1.2% boron, for use in the critical tests, are 50% complete. The new type drive motors are also being installed on these assemblies.

The final shim assembly has been shipped by GE-APED following the replacement of a faulty position potentiometer. A total of 28 Western Gear drive units have been shipped, leaving a balance of 22. These units were purchased as spares following the continual problems with the initial units.

PR-70 - Helium Compressor Test. The fourth high pressure compressor oil pump was operated with satisfactory output and piston leakage rates for 500 hours. Oil pump tests have now been concluded.

Four test check valves purchased from Specialty Engineering Company have been received. These valves will be evaluated during PRTR operability testing if the replacement valves, which use improved alloy materials, fail.

PRTR Special Reactor Tools. The process tube to nozzle alignment mandrel has been fabricated and successfully tested. This tool has been delivered to the PRTR Operation for use during gasket replacement.

The load-out cask wrench for operating the cask gate remotely under water has been completed and is being tested. Other tools for the load-out facility to open the relief valve, replace hangers, and handle the fuel are now partially fabricated.

The fuel element extractor has been tested using a lead filled 19-rod cluster. A stuck fuel element was simulated by loading the upper end of the fuel element. Further tests will be performed using the above method following severance of the wire wraps.

PRTR Unit Motion Study. Installation of the reference targets for the optical measuring system has been completed.

PRTR Process Instrumentation. A servo-manometer system for PRTR moderator level measurements has been assembled and tested in the laboratory. Preliminary testing indicates that the manometer system is capable of readily measuring differential levels to the nearest 0.001 inch under laboratory conditions. This equipment will be used in precise reactivity measurements (as related to moderator levels) during the PRTR Critical Tests.

An autoclaved section of Zircaloy plate has been sent to the vendor to permit calibration of the Fuel Exam Facility temperature probes prior to shipment.

The instruments to measure PRTR moderator dump rates have been assembled in shim tubes and are ready for installation in the reactor. The rate of fall over the first 30 inches from moderator heights above 75 inches will be measured with the short probe, and the longer instrument will be used to follow changes over the entire moderator level range. These measurements will be part of the design testing of the moderator system.

#### Design Analysis

PRTR Process Specifications. All Process Specifications required for the initial startup and critical testing of the PRTR have been approved by the Startup Council. Approval of two additional specifications will be required prior to power testing.

Safeguards Analyses. The Uniform Accident Report Form covering PRTR Safeguards Analyses which was submitted to the General Electric Reactor Safeguards Council was revised to clarify the assumptions and basis for the information reported. Copies of the revised report were forwarded to the Reactor Safeguards Council.

Analyses of the consequences of primary coolant system leaks under various primary coolant conditions and for the full range of possible leak sizes are virtually complete. A report of these analyses, which is now being written, will be the basis for the last process specification. The analyses show that the light water injection system, as modified by approved Phase III-A construction items, is capable of preventing fuel element melting for any possible primary coolant leak.

PRTR Critical Tests. Nearly all of the remaining detailed procedures for Critical Tests have been written and reviewed in conjunction with the Critical Test Sub-Council. Fabrication of the foil-containing fuel elements and cadmium covers for lutetium foils have been completed for use in Critical Test 21. Two reactor physics orientation lectures have been presented as part of the PRTR Critical Test training program. A computer program has been written to analyze the period data from Critical Tests. The code performs a least squares fit to the data points, followed by solution of the in-hour equation for the reactivity.

Detailed procedures for approximately 75 percent of the Critical Tests were reviewed for conformance with safety restrictions and specifications. A supplement to the hazards and restrictions section of the Critical Test Document has been prepared and has received the approval of the PRTR Startup Council. This supplement was required because of (a) tests added following recommendations of the IPD Audit Team, (b) completion of additional Startup Process Specifications, and (c) plans to begin testing before construction of all reactor systems has been completed.

Other Startup Preparations. Preparation and review of power test descriptions is continuing in conjunction with the Power Test Sub-Council. Power Test 18 (Photonutron Flux) has been amended to conform with review comments, and Power Test 6 (Shielding Adequacy) has been approved by the Startup Council. Safeguards review of Power Test descriptions and Operating Procedures continued as these have been written and scheduled for Startup Council approval. Approximately 50% of the PRTR Operating Standards have been reviewed for conformance with Process Specifications.

Critical Facility Calculations. The FLUX-WEIGHT reactor code has been modified to carry out calculations which employ the use of refined statistical weight distributions and their integrals. The perturbation method used observes the 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. Compilation and debugging of the code is completed, and calculations have been performed for several expected loading configurations in the Critical Facility. These were two-zone loadings of Mark I UO<sub>2</sub> and Pu-Al fuel elements with a D<sub>2</sub>O moderator and reflector.

The properties of individual reactor cells (surrounded by the appropriate environment) or whole reactors constructed as a one dimensional, multi-region model are determined by this calculation. Data for each problem consists of a geometric description and the parameters which make up the operators J and K in the wave equation  $K\phi = J\phi$  for each region of the system.

Quantities calculated for each case include the following:

1. Three-group flux distributions and fission density distribution normalized to unit power operation.
2. Effective multiplication of the system.
3. Three-group adjoint flux distribution.
4. Statistical weight distribution for each parameter in the operators J and K.
5. Homogenized or effective average value in the system of each parameter in J and K.
6. Prompt neutron lifetime in the system.
7. Effective slowing down and diffusion area of the system.
8. Effective buckling value for each energy group in the system.
9. Variational coefficients of the parameters in J and K for each region. From these coefficients, for example, it may be known that an increase of 1% in the thermal absorption cross-section

in a  $UO_2$  loaded region of the PRCF will result in a decrease in multiplication of the system of 4.8 mk. Again, for example, an increase of one percent in the fast-to-epithermal scattering cross section in this same region will result in a decrease of 0.03 mk in the system multiplication, due to causing a slightly increased loss of neutrons by resonance absorption.

### PRTR Operations Planning

Preparation of PRTR Operating Standards continued. Sixty-eight standards pertaining to the reactor have been issued for review and approval. Of the 68 standards, 32 were approved at month's end.

Review and approval of the PRTR Operating Procedures by the Startup Council continued. Seventy-two procedures have been approved. The remaining 20 are under review.

River Pump No. 1 operated for 135 hours during October. Pump No. 2 operated for 46 hours. Both pumps were shut down from October 10 to October 28 because of excavations in the vicinity of the 2400 V feeders and the Manhole No. 3.

A Work Request was issued to authorize installation of 0-5 GPM rotometers in the cooling water lines to the air compressors to allow fine control of the operating temperatures.

Considerable effort was devoted to reviewing the status of the moderator and reflector systems in preparation for receipt of heavy water. Punch lists were compiled for both systems and the status of instrumentation systems was reviewed to insure minimum delay in preparing both systems for operation.

Seventy-six drums of  $D_2O$  were moved to the Reactor Hall in preparation for deuterizing ion exchangers and filling the reflector system. An additional 56 drums were sampled and readied for movement to the PRTR for use in the moderator system. An accountability system was established for heavy water samples.

The procedures for flushing and cleaning the helium system were reviewed a weekly Design Test Exceptions List has been issued to assist the contractor in correcting the problems. Also, to assist the contractor, a System Status Summary for each system was prepared and kept current.

A partial shipment of spare parts for the Hofer helium compressors was received during October. The rest of the spares ordered will be shipped in December. Half-hard steel stock to be used for compressor diaphragms will be received in November. It has been necessary to obtain the assistance of liaison personnel because of the difficulty encountered in obtaining a commitment from the Hofer Company in Germany.

The process water pump alignment and vibration problems reported last month have been corrected. A number of control circuits on one water chiller have been rewired and the water temperature controller was re-located to a wall location to correct the control problems. Unmarked wires were traced and properly identified.

All necessary equipment has been installed in the Temporary shop in the basement of the PRTR Service Building. The Fuels Preparation Department maintenance organization now are using the shop facilities. A jib crane is being installed for use in lowering supplies to the shop floor level.

A preventive maintenance program, for installed equipment in the PRTR, is being implemented as the individual components are released to PRTR.

All PRTR Technologists and Technicians completed the oral examinations. With minor exceptions, all personnel demonstrated a training status adequate for participation in the initial startup operations. Additional training in these areas will be accomplished with the individuals involved. Training continued with emphasis on Critical Test Procedures, Building Radiation Procedures and review of Operating Standards.

Preliminary planning for the training program to familiarize PRTR personnel with the gas loop operating techniques was completed during the month. A tentative training program outline was established. Responsibilities for various phases and a schedule was prepared. The objective is to qualify all Technologists and Technicians to operate the loop one month before the loop is ready to start up.

Performance of Design Tests continued as systems became available for testing. The exhaustion and regeneration of water softeners under Design Test No. 12 (Secondary System - Miscellaneous) is being repeated due to the large amount of difficulty experienced with the automatic cyler and valves during the first test of the softeners. All other sections of this test have been completed. With one exception, the water softeners do not meet the vendor's specifications. It is planned to seek assistance of the vendor to correct the problems.

Design Tests No. 15 (Heating and Ventilating System - Startup) and No. 22 (Effluent System) were completed. Ten of the Building Radiation Monitoring Chambers were tested per Design Test No. 29. The instruments were found to drift 10 to 50% in a 24-hour period, rather than 1/2 percent as specified in the procurement specifications. The drift test was re-run for a 72-hour period drifts ranged 10 to 30%.

Thirty of the 36 shim rods were tested per Design Test No. 30, and Addendum No. 1. The rods remained stationary in the up, or inserted, position. Several minor problems were discovered during the course of testing. One serious problem developed in the position indicators. Calibration of the indicators requires adjustment of the zero point downwards thereby preventing checking the meters for drift during operation. A design revision to correct this deficiency is being processed.

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Testing of the Fog Spray System under a portion of Design Test No. 53 (Fog Spray System) was completed. The equipment for activating the system from the reactor control room was found to operate satisfactorily. The portion of the test covering activation of the system from the 384 Building will be completed later.

Portions of Design Test No. 20 (Motor Control Circuits) were completed in conjunction with the other design tests.

Preparation of the detailed Power Test descriptions and procedures continued. Sixteen of the 33 test descriptions have been approved by the PRTR Startup Council. All test descriptions will be completed by the end of November.

Critical Tests. Formal training sessions were held for all persons directly connected with the Critical Tests. The subjects discussed included organizational planning, responsibilities, general test descriptions, PRTR physics, procedural restrictions, process specifications, test instrumentation, and detailed test descriptions. Informal training of the shift crews to familiarize the personnel with detailed procedures is now in progress.

All equipment needed for Critical Tests will be available by November 4. Approximately 3 days will be required to install and check the test equipment. Installation and testing will be done concurrently with Design Testing of the systems required for the Critical Test Program.

## 2. PLUTONIUM CERAMICS RESEARCH

Experiments have continued on the structural stability of  $\text{PuO}_2$  in various atmospheres. Plutonium oxalate was calcined at 150 C increments from 150 to 1050 C in air to give  $\text{PuO}_2$ . Crystallite sizes have been determined by studying the broadening of the (111) reflecting plane with  $\text{CuK}$  radiation. Pellets of these powders were heated to 1100 C and 1500 C in hydrogen containing various amounts of water vapor, helium, and vacuum. In many cases the pellets cracked and chipped so that precise density determinations could not be made. In hydrogen, however, the sintered density appears to increase slightly with the dryer gas at both 1100 and 1500 C.

X-ray data were obtained directly from the surface of the as-sintered pellets. The surfaces of some specimens were rough to the extent of giving broadened lines and reduced intensities; however, in no case was the surface so bad as to give a repetition of the same reflection at two different Bragg angles. The patterns from the pellets sintered at 1100 C for one hour showed, for every sintering treatment and calcination temperature, only a single cubic structure corresponding to  $\text{PuO}_2$ . These pieces were heated in oxygen to 750 C and the weight gain measured to get an as-sintered oxygen/plutonium ratio. The O/Pu ratio for helium, vacuum, wet and tank hydrogen sintering, were all near 1.99, regardless of calcination treatment. The O/Pu ratio for very dry hydrogen, varies almost linearly with calcining temperature, reaching a low of 1.96 for a 1050 C calcine.

The  $\text{PuO}_2$  powders sintered in all atmospheres for one hour at 1500 C showed a partial reduction of  $\text{PuO}_2$  to both alpha and beta  $\text{Pu}_2\text{O}_3$ . Lines of cubic  $\text{Pu}_2\text{O}_3$  were indexed according to the interplaner spacing data reported by Mooney and Zachariasen; however, in some cases intensity differences were seen. Hexagonal  $\text{Pu}_2\text{O}_3$  has not been frequently observed and plane spacing data is unavailable. The compound is isomorphous with  $\text{La}_2\text{O}_3$  and interplaner spacings were calculated from lattice parameters given by Templeton and Dauben. Based on the  $\text{La}_2\text{O}_3$  isomorphism, intensities of observed reflections agreed well with those expected. A number of lines on many patterns were unindexed and it is speculated that these may be the result of  $\text{Pu}_2\text{O}_3$  -  $\text{PuO}_2$  solid solutions, or conceivably a  $\text{Pu}_4\text{O}_7$  phase. High angle lattice parameters of the  $\text{PuO}_2$  phase varied from 5.396 to 5.406 A indicating in some cases an oxygen deficient structure. Oxidation of the pellets heated in tank hydrogen at 1500 C gave an oxygen/plutonium ratio of about 1.81 for most of the pieces with a high of 1.90 for the powder calcined at 150 C.

Duplicate samples of those just referred to were subjected to diffraction analyses and also gave alpha and beta  $\text{Pu}_2\text{O}_3$  and  $\text{PuO}_2$  phases. The surfaces were then ground and the resulting patterns showed only a  $\text{PuO}_2$  phase. This would indicate that the reduction of  $\text{PuO}_2$  is a surface effect and would explain why a  $\text{Pu}_2\text{O}_3$  phase has almost never been observed before at Hanford, i.e., samples had always been prepared by mounting in a cold setting plastic and grinding until smooth.

Several 1/2" dia x 1/2" long PuO<sub>2</sub> pellets and UO<sub>2</sub> pellets containing 0, 20, 40, 60, and 80 w/o PuO<sub>2</sub> were heated to about 1750 C for 75 hours in very dry hydrogen. A very, very striking change occurred. The PuO<sub>2</sub> pellets, a total of eight, completely vanished. All that remains is a black coating on the molybdenum boat and traces of a white residue. The UO<sub>2</sub> and UO<sub>2</sub>-20 and 40 PuO<sub>2</sub> appeared to have flowed plastically and the bottom of the initial 1/2" dia pellets conforms to the contour of the 1 1/2" dia boat.

The UO<sub>2</sub>-60 and 80 PuO<sub>2</sub> still remain as cylinders; however, they possess a very charred coating. Detailed examination of these pieces and of the flow phenomenon is presently in progress.

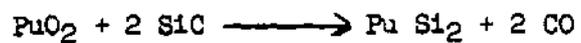
A sample of PuO<sub>2</sub> and carbon heated to 2000 C for one hour at  $1 \times 10^{-14}$  mm Hg was found to have completely vanished. Conceivably, Pu<sub>2</sub>C<sub>3</sub> had formed on passing the peritectic and then vaporized. That pure Pu<sub>2</sub>C<sub>3</sub> has a high rate of vaporization was observed visually by heating pure Pu<sub>2</sub>C<sub>3</sub> to 2000 C in both a vacuum and in one atmosphere of helium. The heating was accomplished in an inverted Mendenhall type tungsten wedge. A sample of pure PuC was heated in a wedge in helium and decompositions were observed at 1645 C and 1970 C.

Pure PuC, as determined only by diffraction, has been formed regularly by heating PuH<sub>3</sub> with carbon at temperatures between 1100 C and 1450 C. The PuC has a variable lattice parameter depending on whether the defect NaCl mixture is carbon rich or carbon deficient. Lattice parameters varying between 4.970 and 4.961 A have been noted.

Attempts have been made to form UC-PuC solid solutions by reacting ball milled arc melted UC with PuH<sub>3</sub> and carbon in vacuo. This has been done at 1450 and 1600 C using "batch"-type samples. UC, PuH<sub>3</sub> and C were weighed out to give PuC - 35, 50, and 65 w/o UC solid solutions. In every case a single phase resulted; however, no correlation could be made with Vegard's Law since slight errors in the carbon addition have such a pronounced effect on the resultant lattice parameter. Thus it will be necessary to form one large lot of PuC from several small batches and thoroughly homogenize this to give a stock of working material.

Twenty-one pellets containing PuO<sub>2</sub> - ZrO<sub>2</sub> are being sintered in helium at approximately 1400 C for 20 hours, for use in determination of the phase diagram of this system. Compositions include the entire range with particular emphasis on the lower concentrations of PuO<sub>2</sub>. Pellets having excellent integrity will then be thermally cycled to further verify the stabilization effect of PuO<sub>2</sub> additions. X-ray diffraction data correlated with photomicrographs should clarify or reconfirm the room temperature equilibria previously reported. Experiments have also been planned using stabilized zirconia containing small amounts of calcia or magnesia.

An attempt to produce PuSi<sub>2</sub> was made by heating a mixture of PuO<sub>2</sub> and beta-SiC in a stoichiometric ratio according to the following equation:



The mixture was heated in vacuum for two hours at 1400 C. X-ray diffraction data indicate that beta-PuSi<sub>2</sub> was formed. Trace amounts of SiC were also presented in the reacted product.

### 3. URANIUM DIOXIDE FUELS RESEARCH

#### Fuel Evaluation

Swaged  $UO_2$  capsules have attained estimated exposures of approximately 19,500 MWD/T in ETR-MTR.

A 7-rod swaged cluster, purposely defected with four 0.006 inch holes completed 17.8 days of irradiation at a maximum surface heat flux of approximately 475,000 BTU/hr-ft<sup>2</sup>. The irradiation included four reactor start-ups and approximately ten scrams. The coolant temperature was raised to 515 F during the last 28 hours of the irradiation. No large increase in the gamma activity of the water was observed during the increase in the coolant water temperature. No decontamination of the loop was required after the irradiation.

A Hanford production reactor is now being used to irradiate a purposely defected fuel element. During the first two weeks of irradiation (the period covered by this report), essentially no activity was detected in the effluent coolant.

The irradiation of defected elements in the Hanford reactors will provide long-term irradiation data to augment the short-term data obtained from MTR and ETR defect tests. A number of elements, covering a wide range of power generations and a variety of fabrication techniques, eventually will be irradiated. The element now under irradiation contains sintered pellets of  $UO_2$ .

The test elements are 4-rod clusters, 12" long, with each rod 0.565 inch in diameter. Two rods of each cluster are clad in Zircaloy-2, and two are clad in Zircaloy-4. One each of the Zircaloy-2 and Zircaloy-4 rods contains a 0.006" diameter hole through the cladding.

A vibrationally compacted, purposely defected fuel rod was successfully irradiated in the GEH-4 facility in the MTR. The behavior of this fuel element during irradiation was, in general, quite similar to the irradiation behavior of four swaged, deliberately defected fuel elements previously tested.

The fuel element was 24" long and 0.565" in diameter. The cladding consisted of twelve inches of Zircaloy-2 tube, and twelve inches of Zircaloy-4 tube butt-welded together. The 0.006 inch diameter defect was drilled through the weld. The fuel core was (-6 + 150) mesh  $UO_2$  (homogeneously enriched to 3.2 w/o  $U^{235}O_2$ ) vibrationally compacted to 80.6% T.D. This was the first defect test employing an element with vibrationally compacted fuel core. This was also the first test in which defected Zircaloy-2 and Zircaloy-4 were irradiated under identical conditions. Post-irradiation examinations will provide an excellent comparison of these two cladding materials with respect to hydriding.

The fuel rod was irradiated for a total of 86 minutes, 29 of which were at full power. The reactor was power cycled twice during the irradiation. During the first cycle, the reactor power level decreased from 40 MW to 0.4 MW in 30 seconds. In the second power cycle, the same decrease was accomplished in about seven minutes. No differences in behavior were observed as a result of the difference in cycling time. During every change in reactor power level, bursts of activity were released to the coolant. The largest bursts were released during decreases in reactor power; however, these bursts decayed to a constant activity level more rapidly than the bursts which occurred during increases in reactor power. This activity pattern is essentially the same as the pattern observed during irradiation of the four defected swaged UO<sub>2</sub> fuel elements.

The reactor was shut down and the test was terminated after 86 minutes of the scheduled 90 minutes of operation. The shutdown was caused by the high inlet pressure in the GEH-4 facility. The inlet pressure increased from 105 psia (normal operating pressure) to ~250 psia. Simultaneously, the outlet pressure decreased from 80 psia to ~35 psia and the flow decreased from 7 gpm to ~5 gpm. The exact cause of these changes in coolant conditions has not yet been determined because the fuel element has not cooled sufficiently to allow examination.

#### Basic Studies

The JEM electron microscope has been installed, aligned, and tested in operation. Resolution of better than 10 Angstroms has been demonstrated. Accessory equipment is being tested; performance of reflection microscopy, high temperature transmission microscopy, and diffraction (to 1100 C), and high resolution diffraction accessories has been very satisfactory.

Discussions of methods for thermal conductivity measurements on single crystals of non-irradiated UO<sub>2</sub> have been conducted with personnel of BMI. The first crystal to be investigated probably will be about one inch long and one-fourth inch square in cross-section. The research proposal is currently being considered in relation to other thermal conductivity programs in progress.

Facilities for measurement of electrical conductivity of irradiated UO<sub>2</sub> are being assembled at BMI. Specimens to be measured are among those already prepared by Ceramic Fuels for measurement of thermal conductivity at BMI. Electrical measurements will be made on samples not previously heated, at temperatures corresponding to significant points on thermal conductivity curves already obtained from similar irradiated specimens.

Fabrication and installation of additional equipment for high temperature microscopic examination of irradiated materials has been completed. The glove box containing the resistance furnace is equipped with glass ports through which specimens can be examined from either the top or the side of the "V" shaped tungsten filament of the furnace. A third port facilitates measurement of specimen temperatures with an optical pyrometer.

Examination of irradiated  $UO_2$  with burnups of 72,500 and 97,000 MWD/T has been initiated. Several samples of each lot of material will be examined under the microscope at temperatures to the melting point.

Ultra-High Density  $UO_2$ . Fused-200 mesh  $UO_2$  and sintered -200 mesh  $UO_2$  were compacted in the Dynapak machine at 1200 C to bulk densities of 99.5 and 99.0% T.D., respectively. The compacting pressure used was greater than 500,000 psi, and was obtained with the aid of modified Bridgman anvil die inserts.

Electron micrographs of  $UO_2$  compacted by the Dynapak process indicate that specimens heated to 1100 C or higher contain numerous small closed pores. It is probable that these pores are caused by gases evolved from the  $UO_2$ . Since the specimens are vacuum outgassed at 600 C before the stainless steel capsules are sealed, it is difficult to see how large amounts of adsorbed gases could be present.

A more logical source of gas is the oxygen contained in the  $UO_2$  in excess of the stoichiometric requirement. Micronized  $UO_2$  has an O/U ratio of 2.05-2.09. The excess oxygen contained in a typical 85 gram  $UO_2$  specimen is equivalent to 200 ml of  $O_2$  gas at room temperature and atmospheric pressure.

Samples of micronized  $UO_2$  compacted in the Dynapak at various temperatures from 900 C to 1200 C were analyzed for O/U ratio by coulometric analysis. O/U ratios decreased with increasing temperature, indicating that excess oxygen is indeed evolved. O/U ratios and densities obtained at the various temperatures are tabulated in Table I. The lower  $UO_2$  density above 1100 C may be due to the presence of gas and/or to the decrease in the plasticity of  $UO_2$  with decreasing O/U ratio.

Table I

O/U Ratio of Micronized  $UO_2$  Heated to Various Temperatures  
and Compacted by High Energy Impact

<u>Temperature, C</u>	<u>O/U Ratio</u>	<u>%T.D.</u>
900	2.0615	88.8
950	2.0579	86.3
1000	2.0541	91.1
1050	2.0429	91.8
1100*	2.0369	94.6
1150*	2.0090	92.2
1200*	2.0094	88.9
1200*	2.0133	91.9

\*Stainless steel capsule reacted with  $UO_2$  or with  $O_2$  gas.

Experimental evidence has been obtained which indicates that the decrease in compacted density above 1100 C is due to lack of plasticity in near-stoichiometric  $UO_2$ . Micronized  $UO_2$  was made stoichiometric by reduction with hydrogen, loaded in a stainless steel capsule, sealed in vacuum, heated to 1200 C, and compacted by high energy impact. Impact pressure was the same as that which had previously resulted in a density of 99.4% T.D. for nonstoichiometric  $UO_2$  after heating first to 1200 C, then cooling to 800 C or lower. A density of 95.3% T.D. was obtained. No reaction layer at the  $UO_2$ -cladding interface was found, which indicates that the reaction products previously formed were caused by an  $O_2$  - stainless steel reaction. Electron micrographs of the compacted  $UO_2$  show that pores of the type found in nonstoichiometric  $UO_2$  compacted at 1200 C are not present.

It was concluded that some excess oxygen is necessary for high compacted densities, the amount depending upon compacting pressure, temperature, and powder particle size and past treatment.

#### 4. BASIC SWELLING STUDIES

Irradiation Program. General swelling capsule No. 5 containing one 3 per cent enriched and two natural uranium spheres was discharged from the reactor. It had operated at a control temperature of 525 C. One thermocouple failed quite early in the test supposedly due to thermal shock. The heater and the other three thermocouples retained their integrity until discharge. When the reactor was operating, there was a large temperature gradient along the capsule due to the difference in specific rate of heat generation because of the two levels of specimen enrichment employed. In future capsules of this configuration, it is planned to insert only specimens with the same U-235 content.

General swelling capsule No. 4 containing four natural uranium spheres was also discharged. All of the components of this capsule retained the original integrity. The specimens of both capsule No. 4 and 5 will be examined in Radiometallurgy as soon as the radioactivity has decayed enough to permit handling. This will probably require another sixty days. Metallography and density measurements will be performed and, depending on the results, other physical measurements may be made.

The assembly of capsule No. 6 was completed, successfully bench tested and the capsule was charged into a reactor. This capsule contains one-half inch diameter, 30 mil wall, split, hollow cylinders, two of which are as-extruded and a third that was oil quenched from 730 C after a holding time of fifteen minutes in vacuum. Radiographs were taken of the completed capsule showing the internal components including the NaK level. The radiographs were taken both vertically and horizontally at room temperature, 400 C and 500 C. Under each of these conditions shots were taken 90° apart to view all of the internal parts. Interestingly enough the level of NaK in the expansion chamber was observed to decrease as the capsule was heated in spite of the fact that NaK has a much higher coefficient of expansion than the capsule tube. Concurrent with this the NaK meniscus was observed to change from a convex shape to a concave shape indicating an initial non-wetting and a subsequent wetting action. As there are numerous crevices in this capsule, it is postulated that the lowering of the NaK level is brought about by the wetting of the internal surfaces of the capsule and the attendant flow of NaK into cracks and crevices. It is important, therefore, either that the capsule be hot when it is filled with NaK or that the initial heating after filling be done horizontally so that the flexible bellows arrangement in the NaK expansion chamber can perform as designed and allow NaK rather than helium to be drawn back into the specimen chamber.

Pore Size and Distribution. Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. Such information is needed for understanding how gas atoms migrate, coalesce, and grow into large pores. Statistical analysis of pore density and size relationships which exist in irradiated uranium

subjected to post-irradiation, unrestrained annealing treatments is continuing. The specimens are being analyzed with respect to the following parameters: (1) burnup level (0.29 a/o vs. 0.41 a/o), (2) temperature of irradiation (550 C, vs. 350 C), (3) temperature of annealing (25, 600, 650, 700, and 880 C), and (4) time at temperature (1 hour vs. 100 hrs). The numbers of pores of a given size, as well as the volume of these pores per unit volume of uranium have been determined for the various conditions listed above, and are being plotted graphically. Such curves are being subtracted from each other to yield distribution difference curves, and these in turn will be analyzed to establish the relative importance on swelling of the parameters under consideration. Such an analysis should contribute to the understanding of the kinetics and mechanisms of the swelling which has occurred in the specimens being studied.

Specimens of uranium irradiated to 0.29 a/o and 0.41 a/o burnup have been annealed for one hour at 880 C, and will be processed for metallography. The respective densities of the two specimens after the anneal were found to be 18.66 and 14.67 g/cc. The high burnup specimen was severely cracked and exhibited very little coherency. The density of the 0.29 a/o specimen is being rechecked, since this value is not consistent with values obtained after annealing at lower temperatures. Four additional specimens from each of the 0.29 a/o and 0.41 a/o burnup material have been deacid and are being annealed at temperatures of 400 and 500 C, respectively. Two annealing times, 1 hour and 100 hours, consistent with previous, higher temperature anneals are being used.

In support of the radiometallurgy processing of specimens irradiated under conditions of minimum temperature gradients and constant temperatures, unirradiated control specimens have been processed for metallography and density. Satisfactory results have not yet been obtained by radiometallurgy techniques. The specimens are hollow cylinders of uranium, split longitudinally, weighing approximately 2 grams. Because of their small size, they are difficult to handle and test remotely.

Fission Product Mobility. Several approaches are currently being pursued in order to learn more about the mobility of fission products, particularly the inert gases, xenon and krypton. Gases are being introduced into a uranium surface by glow discharge and fission products are being introduced into one half of a diffusion couple by irradiating enriched uranium bonded to depleted uranium. The glow discharge-mass spectrometer system is still in a state of evolution, but preliminary measurements are under way. The mass spectrometer has been operated extensively and has been calibrated for helium using several standard leaks, a calibrated leak and Veeco leak detector. It has also been calibrated for krypton and found to be more sensitive to this gas than to helium. The lower limit of helium detection is about  $10^{11}$  atoms per sec. of helium while that for krypton is about  $10^{10}$  atoms per sec. A uranium disk is currently being "glowed" in krypton in a glass cell instead of the uranium one previously employed. After "glowing" the system will be evacuated, the specimen heated in place, and the exhaust gases monitored with the mass spectrometer.

The diffusion couple will consist of a shell of enriched uranium co-extruded with a core of depleted uranium. Extrusion is being used to produce a well bonded interface with a minimum of interdiffusion of U-235 atoms. The uranium has been melted and cast and is now being prepared for extrusion. The extrusion will be performed in a copper jacket. After extrusion the copper will be removed, the uranium rod inserted in an aluminum can using the standard Al-Si process, and the capsule will be irradiated cold in the basket facility at the MTR or ETR. This should produce the sharpest possible interface to study the diffusion of fission products during various annealing treatments after irradiation.

Restrained Irradiations. In reactor swelling experiments on Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposures are being conducted employing NaK filled, temperature monitored capsules. Four swelling capsules GEH-14-98, 14-99, 14-104, and 14-105 are presently being irradiated in the MTR with goal exposures in the range 0.25-0.31% B.U. Exposures and average center uranium temperatures for the fuel rods in these capsules through MTR Cycle 144 are respectively 0.28, 0.12, 0.3, 0.38 a/o B.U. and 500, 290, 600, and 335 C. GEH-14-101 was discharged at the end of MTR Cycle 144 at 0.3 a/o B.U. Its average center uranium temperature was 450 C. One capsule of similar design to those in the MTR is now being irradiated in the ETR at a central uranium temperature of 425 C. The exposure is 0.03 a/o B.U. Three 1.6% enriched uranium rods co-extrusion clad in Zircaloy-2 and irradiated in NaK filled aluminum capsules at Hanford are awaiting examination at the Radiometallurgy Operation. Exposure on these elements is approximately 0.14 a/o B.U.

##### 5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements. The creep measurements of a Zircaloy-2 specimen in a reactor are continuing in the prototype capsule. The capsule appears to have operated satisfactorily but the external instrumentation has not. The difficulties are associated with reactor modification work for the new capsule instrument facility. Holes were drilled through the concrete floor with an air hammer near the instruments. Apparently the vibration caused the instruments to malfunction. The creep monitors have been removed, recalibrated and adjusted, and reinstalled for another attempt. However, since construction in the immediate area is continuing, there is no assurance that operation will not be disrupted again.

Capsule and Instrument Development. The first of the second generation capsules has arrived on-site and is being thoroughly bench tested before installation in the reactor. No shipping damage has been found. Resistance and continuity measurements are completed, the nozzle cap is installed and the capsule is now ready for insertion. A final set of radiographs remain to be taken.

Pre-Irradiation Material Characterization. Activation energies for creep of Zircaloy-2 at 332 C have been determined. The activation energies were

obtained from Zircaloy-2 in the 25 per cent and 45 per cent cold rolled condition. Creep rates just before and just after an abrupt temperature change from 325 C to 340 C were used to calculate the activation energy.

Values found were 62,000 cal/gm-atm. for 25 per cent cold rolled Zircaloy-2 and 64,700 cal/gm-atm. for 45 per cent cold rolled material. Transient creep conditions were observed upon changing specimen temperature. The transient is the result of either strain aging or the establishment of a new array of dislocations appropriate for the new creep rate.

As part of a program to evaluate the metallurgical character of materials to be used for in-reactor testing, texture studies on Zircaloy-2 scheduled for in-reactor creep testing are being conducted. Cold rolled (20 per cent and 40 per cent) Zircaloy-2 rods were found to have a texture similar to cold rolled Zircaloy-2 sheet. Textures of these cold rolled rods do not have cylindrical symmetry. The (0001) planes are inclined 60° to the assumed direction of rolling pressure with  $[10\bar{1}0]$  direction parallel to the rod axis.

## 6. GAS GRAPHITE STUDIES

Oxidation of EGCR Graphite. Oxidation rates of EGCR graphite in oxygen are currently being studied to assist in evaluating the hazard of runaway oxidation in the event of a coolant line rupture. This graphite oxidizes approximately 2.45 times as rapidly as CSF under identical conditions. For EGCR graphite:

$$\text{Oxidation rate (hr}^{-1}\text{)} = 1.0 \times 10^{11} \frac{-25,000}{e^{\frac{0}{K}}}$$

EGCR graphite pits quite badly on oxidation indicating a relatively high concentration of metallic impurities.

Graphite Oxidation by Oxygen. An experiment to test the effect on oxidation rates of variation in flow and surface-to-volume ratio and prior irradiation was recently completed. No influence from these factors was discernible within the ranges studied. The range of variables covered irradiations at 500 C of 0 and  $4 \times 10^{19}$  nvt ( $\lambda > 1$  mev), flows of 0.2 and 2.0 cfh, and surface to volume ratios of 10 and 20 in<sup>-1</sup>. The experiment was a 1/2 replicate of a  $4 \times 2^3$  factorial in which two levels of each variable were tested at four temperature levels.

Microwave Activation of Nitrogen Gas. Use of a recording balance has shown that the apparent decrease in reaction rate with time that was reported last month for the  $N_2 + C$  (graphite) reaction in a microwave field was due to an initial outgassing of the sample when the glow is first turned on. Preliminary studies of the effect of pressure on the reaction rate at about 200 C are shown:

<u>Approximate Pressure Microns Hg</u>	<u>Specific Weight Loss Rate g/g/hr</u>
625	$4.6 \times 10^{-5}$
600	$5.1 \times 10^{-5}$
225	$21.3 \times 10^{-5}$
190	$13.2 \times 10^{-5}$

In-Reactor Nitrogen--Graphite Reactions Studies. Graphite at about 500 C under an initial capsule pressure of 37.8 psi  $N_2$  was exposed to 2000 MWD/AT in C Reactor, with the following results: (1) there was 0.01% weight loss of graphite sample (negligible), (2) the number of moles of gas in the capsule increase 19% due to diffusion of He from the pile atmosphere into the capsule (this transfer of He has been observed for every capsule opened so far), and (3) the gas composition as analyzed by mass spectrometer showed no compounds of carbon and nitrogen.

Oxidation of SiC Coated Graphite. The second group of SiC coated graphite rods from the Carborundum Company that had been in reactor and received approximately 3,000 MWD/AT at 500 C were tested for integrity. All five coatings were on Speer 901 S base graphite and ran in air at 1,000 C for 493 hours with no indication of failure. A slight weight gain of a few tenths of a milligram was noted for each sample.

EGCR Graphite Irradiation. The H-3 capsule containing EGCR prototype graphite was removed from the GETR on October 4 after exposure for four GETR cycles. All 24 samples were in excellent condition, and preliminary results from the irradiation show the EGCR-type, needle-coke graphite to be consistently more stable in the transverse direction than CSF graphite. A significantly higher contraction was observed in the parallel direction than in the transverse direction ( $3/1 = \text{EGCR parallel/EGCR transverse}$ ), the EGCR-type parallel contraction equaling CSF parallel contraction. The contraction rate as a function of temperature and exposure will be reported as flux traverse information become available.

The new capsule, H-3-2, contains 15 samples recharged from H-3-1 to accumulate higher exposure and 9 new samples. Five of the new samples are from a broken EGCR graphite bar and four are of CSF graphite for control purposes. The samples in the first capsule were from a prototypical 16 in. x 16 in. square electrode. The H-3-2 capsule will be inserted in the GETR during the cycle No. 18 shutdown for a planned four-cycle irradiation.

Gas Loop Project Management and Design (Project CAH-822). The ex-reactor package by Struthers-Wells (Phase A) has been completed except for operational testing after installation. The last of the four ex-reactor package sub-assemblies was shipped on October 25. The first two sub-assemblies arrived in damaged condition. A claim will be filed against the carriers for repair costs, currently estimated at \$4,000.

Construction installation of the gas loop physically started on October 17. Minor Construction awarded a sub-contract to J. P. Head Mechanical for the installation of services and auxiliary equipment.

Gas Loop Component Testing. Mockup testing of the in-reactor test section has been delayed due to excessive pressure drop at design conditions in the shroud coolant (heat) exchangers. Substitute heat exchangers are being fabricated and testing will be resumed early in November.

Fabrication of a 50 KW heater, for testing of the in-reactor section, was completed and tested at rated capacity in air.

The Arrowhead pin joint was operated for 290 hours while being cycled 275 times between 900 and 1500 F at 450 psi before a small leak developed. This unit was specified for 500 cycles at the above conditions and will, therefore, be returned to the vendor as unacceptable.

Several temperature detectors are being evaluated to develop a protective device for the Gas Loop and are intended to monitor continuously for significant in-reactor movement of the high pressure tube relative to the calandria shroud tube. Irradiation testing of four Fenwal line detectors has been completed. One unit accumulated over  $10^{20}$  nvt before its response drifted beyond acceptable limits. Failure of the other three units has been ascribed to mechanical defects caused prior to testing rather than to radiation damage.

Four additional detectors, differing slightly in composition from the original units, have been received for irradiation testing.

#### 7. GRAPHITE HIGH TEMPERATURE IRRADIATION DAMAGE STUDIES

Hanford Irradiations. Graphites, carbons, and cokes in the initial shipment of materials to be studied under contract with National Carbon Company were charged in-reactor for a series of short irradiations.

X-Ray Diffraction Calculations. No change in the X-ray parameters of irradiated CSF samples (exposed to 1000 to 4000 MWD/AT) resulted from the final annealing treatment of 3 hours at 2800 C after prior annealing at 2000 C. Thus, it appears that annealing at the crystallite level is substantially complete after annealing at 2000 C.

Electron Microscopy. Sodium chloride faces were decorated with evaporated gold. Crystals of gold which nucleate at lattice edges or steps are smaller than those nucleating on crystal faces. This technique will next be tried on graphite.

An ultra-thin slice of resin-impregnated CSF graphite was mounted on plastic and ground thinner on the Syntrol vibratory polisher. An area of interest

was cut free and floated onto a grid for examination. Direct transmission was possible only in a few areas near edges. An attempt will be made to grind the sample even thinner.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals, namely, copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. Three zirconium specimens have been isothermally annealed for five minutes at 300, 475, and 550 C. Significant microhardness recovery occurred in all cases. Isochronal annealing of copper has been extended to 500 C. Microhardness has shown nearly complete recovery in both irradiated specimens ( $0.9 \times 10^{19}$  and  $1.5 \times 10^{20}$  nvt) but electrical resistance in both specimens has decreased only slightly from the post-irradiation values. This is thought to be an effect of the relatively large amount of transmutation products present.

E. CUSTOMER WORK

Radiometallurgy Service

Three samples of irradiated KER Zircaloy-2 process tubing were burst at room temperature. Details are reported elsewhere in this report under Structural Materials Development (RM-330).

Bumps as high as 30 mils were observed on the interior and exterior of a self-supported fuel element from IPD. Metallography of the longitudinal section revealed a large grain size, which contributed to the bumping (RM-408).

Metallography Laboratories

A cracked Type 316 stainless steel ferrule removed from a front face connector (Type 304 SS) of KER Loop 3 was examined to determine the cause of failure. Metallographic examination showed that the failure was caused by stress-corrosion cracking. Initiation of the cracks appeared to be from the outside surface. Examination of the connector, microscopically and by Zygo dye penetrant treatment, failed to reveal any cracks in the area from which the ferrule was removed.

The annealing of samples has been completed for the study of time and temperature effects on the structure of the AlSi braze. A total of 194 samples were heat treated over a temperature range of 250 C to 550 C from periods as short as 15 minutes to 100 days' duration. Slightly more than half the samples have yet to be prepared for microstructural examination.

Electron Microscopy. Work during the month included the examination of replicas from irradiated UO<sub>2</sub> fractured and polished surfaces before and after annealing as well as fracture surfaces from micronized and sintered UO<sub>2</sub> which had been Dynapak extruded at 1200 C.

Replicas from an irradiated Zircaloy-2 clad tubular fuel element were examined for cracks in or near the bond zone. No cracks were found in the two replicas examined.

Techniques for making clean, carbon substrates are being tried. Particulate matter from air samples then collected on millipore filter paper will be examined and counted by means of electron microscopy by placing the millipore filter on the substrate, dissolving the filter and leaving the particles on the carbon substrate. Identification of the particles can also be accomplished by means of electron diffraction.

A NaCl single crystal was strained and cleared immediately prior to insertion in the evaporator. Gold and carbon were then evaporated normal to the cleaned surface. The film was floated from the NaCl surface and examined in the electron microscope. It has been shown that there is a tendency for the gold to deposit in particles of more than one size depending on the salt substructure. An attempt will be made to adapt this technique to the examination of graphite structure.

A modification of the evaporator was completed during the month which will allow evaporation of three materials on a surface or replica instead of just one material.

Samples Processed During the Month:

Total samples	623
Carbon replicas	35
	<u>658</u>

Photographs

Micrographs	354
Macrographs	169
Electron Micrographs	62
	<u>585</u>

Special Fabrications

A total of 1,440 co-extruded fuel elements was fabricated and shipped as scheduled. The over-all yield for the fabrication effort was 75 per cent. This value is based on the assumption that the 25 pieces currently in process are all rejected. The yields at the various process steps were as follows:

<u>STEP</u>	<u>YIELD, (%)</u>
Casting	92
Clean, Assemble, Extrude, and Straighten	90
Rod Machining	99
Bond Testing	93
Inspection	98

An evaluation program was initiated to study the effect of various extrusion temperatures on the "dogbone" problem in these solid rod co-extrusions. Three pairs of billets were assembled according to standard loading procedures but the nose projection on the billet can was removed from one billet in each pair. The billets were located in the central section of the furnace, adjacent to the thermocouple, for outgassing to give reliable temperature control. Extrusion temperatures for the three pairs were 590 C, 550 C, 525 C. Container temperature was maintained at 525 C for all runs. Radiographs have been taken of the elements and measurements of the can wall are now being made.

A technique for coating low surface area arc melted normal UO<sub>2</sub> with electroless nickel has been developed. Particle sizes in a range of 100 to 250 microns were coated with a uniform coating of nickel of 7.5 micron thickness. This thickness gives total alpha radiation shielding. A sample of arc melted and crushed PuO<sub>2</sub> will now be coated using the same technique and the alpha emission checked before and after coating. Samples of coated PuO<sub>2</sub> will be briquetted with polystyrene into discs to check for gas evolution, if any, resulting from radiation damage of the plastic.

#### NPR Charging Machine

Fabrication of a full-size charging machine is presently favored over the reduced size model initially proposed. This approach will permit a more thorough development program and will provide the early availability of a charging machine for operational training and initial reactor testing.

A work review was issued and approved for assignment to plant forces. Fabrication and procurement have been delayed pending resolution of the following items:

1. Receipt of new work order.
2. Selection of frame material (carbon steel or aluminum).
3. Range of machine vertical travel.
4. Method of supporting charging forces.
5. Drawing approvals.

Limited activity was continued in testing the positioning cylinder, which operated satisfactorily.

Drawings of the nozzle adapter using a low pressure integral relief are 60 per cent complete.

NPR magazine tubing was received during the month.

Shielding Analysis

Calculations were made of dose rates from high exposure Pu product solutions in product removal cans of the present design for the Non-Production Fuels Facility design group (CPD). The gamma dose rate was calculated to be 3.1 mr/hr at one foot from the can and is due predominately to residual fission products. At the same location, the neutron dose rate due to spontaneous fission was estimated to be 3.5 mrem/hr.



Manager, Reactor and Fuels Research  
and Development

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATIONMONTHLY REPORTOCTOBER 1960FISSIONABLE MATERIALS - 2000 PROGRAMREACTORExponential Measurements for N-Reactor

The final buckling for the wet mockup lattice is  $116 \times 10^{-6} \text{ cm}^{-2}$  with the graphite control rod plugs in the pile. The buckling measured with the graphite control rod plugs removed and 1 inch diameter Lucite rods in the control rod channels is  $120 \times 10^{-6} \text{ cm}^{-2}$ .

PCTR Measurements for N Reactora. Measurements of Lattice Parameters

Measurements of lattice parameters for N-Reactor have been made in the PCTR. Analysis is proceeding and preliminary results obtained are listed below:

	<u>Wet</u>	<u>Mockup</u>		<u>Condensed Lattice</u>	
			<u>Dry</u>	<u>Wet</u>	<u>Dry</u>
$k_{\infty}$	1.075		1.015	1.069	1.005
$\rho$	0.879		0.941	0.886	0.950
$\epsilon$				1.059	1.073

The listed values of  $\epsilon$  were obtained from the method used at WAPD and BNL, comparing the fission activities of bare enriched (0.938%) and depleted U foils. A value of  $P = 1.125$  was used to correct measured fission product gamma activities to corresponding fission rates. The Hanford method of comparing cadmium ratios of enriched foils and U-235-Al alloy foils would yield values for  $\epsilon$  of 1.036 and 1.040 for the wet and dry cases. The cadmium ratio method is considered invalid because the large cadmium box covering the sector foils drastically reduces the fission neutron production inside the box. The cadmium ratio could be used more successfully with pins instead of foils, although a small depression would still occur.

b. N-Reactor Fuel Temperature Coefficient

The three-element resistance thermometer system, described in August, has been completed and is being calibrated over its useful range. Preliminary data look quite satisfactory.

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Digital Computer Codes for Reactor Analysis

A large part of the programming necessary to couple C-5, an ANP slowing down spectrum code, to the 100 point data tape has been completed. It will be possible to test the success of this coupling arrangement independent of the remainder of the C-5 program. The input to C-5 is being designed in such a way that only those quantities which are to be changed need be entered for succeeding cases. Although many quantities used by the program are normally obtained from the nuclear data tape, any of these quantities may be read in along with the normal problem input.

Debugging of HFN, the Hanford version of the multigroup neutron diffusion theory code FN, is continuing. HFN allows neutrons to be scattered between any two groups, making it more flexible than other FORTRAN language multigroup codes in use at Hanford.

Attempts were continued to resolve the differences between FN and HFN results for an infinite medium thermal spectrum calculation. In addition to being different from each other, neither the FN nor the HFN results are self-consistent. It has been supposed that the differences are caused by round-off error, while the inconsistencies appear to be caused by errors in the iterative techniques used. These latter errors do not affect calculations on models including epithermal groups.

As was mentioned last month (HW-66960B), the multigroup diffusion equations become, in an infinite homogeneous medium, a set of simultaneous, linear, algebraic equations. The results of solving this set of equations, mentioned last month, were in error because of improper application of an existing program. In order to get an independent solution to the problem, and to facilitate study of iterative methods of solving sets of equations, a short experimental program, QUAD-5, was written. QUAD-5 solves, by iteration, a homogeneous set of simultaneous, linear, algebraic equations. The first version used an iterative technique similar to that used in HFN, and gave almost identical results, complete with the inconsistencies mentioned. This indicates that the formulae in HFN which allow for spatial flux variation introduce relatively little round-off error. Successive experiments with QUAD-5 led to two iterative methods which yielded identical, self-consistent results. These results, with the FN results, bracketed those from HFN, and were much closer to the latter. HFN is now being modified to use the faster of the two techniques. Attempts to duplicate FN results have failed. A letter describing progress to date, with a request for a copy of the latest FN symbolic program deck, has been sent to the original author of FN.

Correction and checkout of C-3 proved to be much more difficult than anticipated. This was due to the fact that the error was not a logical one but involved a limitation of FORTRAN which is not mentioned in the FORTRAN Reference Manual. It turned out that the FORTRAN compiler set aside two locations for a subscript. In different parts of the program the machine used these different locations, one of which contained the correct value and the other one a zero. This error was rectified.

Test cases run using F-3 and AIM-5 codes showed certain characteristics of the different codes:

F-3AIM-5

Easy input.

Input more involved.

Very few options.

Many options, very versatile.

Calculates flux for the input given.

Does repeated flux calculations, varying specified parameters and searching for best value.

Presently limited to 3 groups and 10 regions.

12 groups and 20 regions possible.

Fast ( $\sim .01$  hr per case).

Not so fast ( $\sim .04$  hr per case).

Easy interpretation of output.

Some parameters of output need interpretation ( $\lambda$ ).

### Computational Programming Services

VFOCL, the monitor version of the production code for exponential pile data reduction, is conditionally checked out and is processing production data under close observation. COFIT-2, the cosine-fitting companion code, is undergoing conversion, expansion, and refinement of error-detection techniques. The principal additions to this code are the inclusion of fast source theory harmonic corrections and calculation of  $A_{\text{thermal}}$  by the cadmium ratio method. Both require a significant amount of revision. COFIT-2 is about 25% complete. A routine which accomplishes matrix inversion by cofactors (INVRTL) is ready for use. Its value as a general-purpose routine is seriously reduced by the restrictions imposed by its subroutine DETERM, which requires that there be no zeros on the diagonal.

### Instrumentation and Systems

Cooperative effort continues with Instrumentation Design, CEoUO, and Instrument Development, IPD, concerning the hybrid NPR Fuel Failure Monitor. The slow-scan portion circuit specifications are being prepared for complete transistorization to assure the best possible reliability and to reduce instrumentation volume, which is, now, an extreme problem. The evolved Slow-Scan system will use two detectors 180 degrees apart on each scanning wheel, each viewing a process-line sample can. The opposite sample cans will be for adjacent reactor process tubes. Transistorized switches and annunciators will indicate the appropriate process line activity increase. Complete system checking will be accomplished using two standard radioactive sources.

Effort was restarted on the original (proposed) development scintillation Fast-Scan system and slip-rings are ready for installation. The use of the new slip-rings, a distinct change from the original method, will permit removal of the amplifier and high voltage supply from the scanning wheel. In addition, by this method, both averaged signals and pulse information can be obtained directly if desired. Several new circuitry ideas will be incorporated as planned.

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A meeting was held with members of Instrumentation Design, CEOJO, and Radiological Engineering, IPD, to resolve differences concerning the prototype NPR Dual-Probe Scintillation Building Area Monitor. The building monitor prototype performance exceeds the specifications as originally desired; however, there are definitely several 105-N locations where use of our developed unit would be incorrect due to the extreme variation of gamma field levels, depending upon the reactor condition. For these particular locations, a modification of our original prototype or else a completely different detector-instrument approach to the problem will be necessary. Our in-development, servo-system multi-decade logarithmic monitor may well fit the needs. Further problem discussion will be necessary before it can be resolved. From the discussions to date, it appears that our prototype system (Dual-Probe Linear) will be satisfactory, without modification, for about 85 of the 106 locations in 105-N. For the remainder, our system will have to be modified to de-energize the more sensitive probe during up-reactor time or else incorporate the servo log system.

All fabrication is complete on the prototype NPR Beta-Gamma Scintillation Air Monitor except for a cart to mount the unit on. All circuitry tested correctly and the new detector head is complete and being tested. This unit seems satisfactory to all parties concerned.

Some of the 100-D reactor operating data collected last month for the automatic control study were plotted on a common time base to determine whether useful information on reactor dynamics could be obtained. It appears that some useful qualitative information on flux distribution and thermal time delays may be obtained in this manner, but modifications to the present instrumentation will be necessary to obtain quantitative information of sufficient accuracy to check theoretical studies.

The reactor kinetics test problem was run on the Goodyear computer again after making changes in scaling methods. A considerable improvement in accuracy and repeatability was obtained as compared to the previous tests. It is planned to study coupled-reactor kinetics next, using the analog computer, to determine the effects of changes in coupling coefficients and other reactor parameters on various types of automatic control devices.

A paper has been issued on the principal results of the reactor kinetics equation study. An additional paper on an apparently novel mathematical technique has been issued, and a second is being typed. These evolved as a by-product of the reactor study. Additional reports and papers on the work to date are in preparation.

The simulation of the NPR primary loop is on the EASE computer. The program is presently being revised to make more economical use of the computer.

Plans are being made to simulate the entire NPR system for use by operators and supervisors as a training aid. This is a long range program and is scheduled for completion by November of 1961. The general method of attack is outlined below.

- A. Make preliminary investigations of reactor using a detailed simulation.
- B. Make a study using a simplified model.

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- C. Compare response of A and B.
- D. Revise the simplified model as necessary so that it has the same response as the more refined model.
- E. Determine what equipment is necessary to construct the complete model.
- F. Revise and improve simulation as necessary.

Work was begun on the NPR pressurizer analysis. The problem is being scaled, and will go on the GEDA computer this month.

Simulation of the latest study on speed of control was completed and the results given to the IPD Reactor Physics Operation.

#### SEPARATIONS

##### a. Critical Mass Laboratory Program Meeting

The Hanford Operations Office of the Atomic Energy Commission arranged a meeting at Richland on October 25 and 26 to review the program presently planned for the Hanford Plutonium Critical Mass Laboratory, and to modify it, if necessary, to meet the over-all needs of the Atomic Energy Commission.

Personnel in attendance from off site were:

- E. F. Miller - AEC, HQ Division of Production - Germantown, Md.
- A. F. Perge - AEC, HQ Division of Production - Germantown, Md.
- M. C. Gaske - AEC, HQ Division of Licensing and Regulation - Germantown, Md.
- P. Hogroian - AEC, HQ Division of Licensing and Regulation - Germantown, Md.
- G. H. Daly - AEC, SROO
- D. C. Davis, Jr. - AEC, OROO
- J. W. Pollock - AEC, IDOO
- H. K. Clark - duPont Savannah River Laboratory
- T. J. Cloven - duPont Savannah River Laboratory
- R. L. Menegus - duPont Savannah River Laboratory
- J. P. Nichols - Oak Ridge National Laboratory
- J. T. Thomas - Oak Ridge National Laboratory

Some of the principal items of discussion from the agenda were the following:

- a) Proposed General Program of Studies for Hanford Plutonium Critical Mass Laboratory
- b) Initial Experiments for the Laboratory
- c) Time Sequence for Accomplishing the Experimental Program
- d) Stage II of Hanford Plutonium Critical Mass Laboratory
- e) Discussion of Types of Experiments and Criticality Data of Special Interest to Other Sites
- f) Manner of Scheduling Experiments and Integration of Program.

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Minutes of this meeting have been prepared covering the complete agenda, HW-67240 RD, "Minutes of Critical Mass Laboratory Program Meeting," by E. D. Clayton.

b. Progress Toward Startup of Plutonium Critical Mass Laboratories

Familiarization and checkout of the instrumentation in the facility is continuing.

Fabrication of the neutron source drive assembly and cask was completed during the month by the technical shops; the source drive mechanism will be used to remotely position the neutron source during the approaches to criticality.

Nuclear Safety Meeting - Idaho Falls

A meeting of AEC and contractor personnel was attended by C. L. Brown, Critical Mass Physics, in Idaho Falls, on October 27 and 28, 1960. The purpose of this meeting was to discuss nuclear safety in the transport of fissile materials.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

a. Analysis of the P-11 Burst

As a check on the reliability of the burst analyses, which were made for the "Hazards Summary Report for the Plutonium Critical Mass Laboratory," HW-66266, similar calculations were made to reproduce the nuclear excursion which occurred at Hanford at the "P-11" facility in November of 1951. The results of this analysis are given below, together with corresponding data reported for the excursion in Document HW-24327 by B. R. Leonard.

SUMMARY OF TRANSIENT STUDY FOR THE P-11 ACCIDENT

	<u>Calculated</u>	<u>HW-24327</u>
Peak Power (Megawatts)	56.06	50.0
Total Energy (Megawatts-sec)	1.21	3.0
Total Fissions	$3.75 \times 10^{16}$	$9.3 \times 10^{16}$
Maximum Reactivity (Dollars)	1.72	-
Minimum Period (Milli-sec)	5.0	10.0

The above results are considered satisfactory for the purpose intended, in view of the inherent difficulties in making calculations of this type.

b. Lattice Parameter Code - IDIOT

The present IDIOT code is being modified to improve the general over-all capabilities of this code. The following improvements are being made in the code:

- a) Speedup of the P-3 subroutine,
- b) Improved Westcott parameters,
- c) A more flexible input,

- d) Improved technique for calculating fast fission interaction between fuel assemblies, and
- e) Improved calculation of the resonance capture, i.e., calculation of the resonance shielding effect of adjacent fuel rods.

R. J. Shields of the Irradiation Processing Department has revised the P-3 subroutine previously coded by D. D. Matsumoto with the following improvements:

- a) The time requirement was decreased by a factor of 20,
- b) The memory requirement was reduced by a factor of four, and
- c) The working tape was eliminated.

The revised P-3 subroutine has been completely debugged and placed into operation in the present IDIOT code.

The latest Westcott parameters have been transferred to a card library suitable as input to the curve fitting POLLI code. The curve fitting process is approximately 80% complete.

There has been some difficulty in fitting the Westcott "s" parameters for the fissionable isotopes over the temperature range of 20°C to 1280°C with a single function.

The input formats to the IDIOT code have been rewritten (but as yet not compiled) so that a new case may be processed utilizing only those cards for which changes from the preceding case are denoted. This will permit survey type calculations with a minimum of input data.

c. Application of 9-Zoom Multigroup Diffusion Code to Plutonium Solution Experiments

Further work was done on the correlation of theory with the early plutonium solution critical experiments. Using a revised data tape with the 9-Zoom multiple group diffusion code, it was possible to calculate k effective within 2% for reflected cylinders with H/Pu ratios in the range of 200-600. It was possible to calculate k effective for bare spheres to 1% for H/Pu ratios in the range of 700-1200; however, calculated results for reflected spheres are not satisfactory.

Data Correlation - Enriched Uranium Rods in Light Water

The correlation of theory with experimental data for uranium rod lattices in water at 1%, 2%, and 3% U-235 was continued. The endeavor this month was toward establishing accurate cladding corrections for the BNL data with 1.03% enriched uranium. The uranium rods at this enrichment were clad in 28 mils of aluminum.

A previous conservative estimate for the effect of the aluminum cladding on the buckling was 250  $\mu$ B. The results of the recent calculations which have been made using the 709 IDIOT code are shown in the following table:

CALCULATED BUCKLING CORRECTIONS FOR 28 MILS ALUMINUM  
CLADDING - 1.03% ENRICHED URANIUM RODS IN WATER

Rod Diameter (inches)	$\frac{V_w}{V_i}$	Experimental (Clad)	Bucklings ( $10^{-6} \text{cm}^{-2}$ )		Difference
			Calculated (Clad)	Calculated (Bare)	
0.387	2.3	2970	2800	2970	170
	2.9	3170	3080	3260	160
	3.6	2860	2830	3060	230
0.60	2.0	3610	3450	3572	62
	2.4	3690	3670	3760	90
	3.0	3320	3410	3490	80
0.75	1.7	3620	3460	3570	110
	2.1	3790	3820	3850	30
	2.6	3500	3620	3680	60

Interaction of Subcritical Systems

An examination of the interaction between subcritical fissile units has been undertaken in order to provide information facilitating the safe storage and handling of such systems. The two computational methods which have been considered both rely on a variational method to obtain a stationary expression for a parameter such as k-infinity or k-effective. A multigroup method based on the Selengut multigroup equations reported in HW-59126 may be used to get such a stationary expression. In an application of the multigroup method the stationary expression for k-effective was formulated using only two energy groups. Several systems, consisting of both isolated fuel regions and pairs of interacting fuel regions, were considered in evaluating k-effective. In all cases the resulting k-effectives were 20 to 30% below the experimental values. Thus, to the degree of approximation used, the method is not only inaccurate but highly non-conservative. It is not clear at this time why the method gives such poor results.

The second method, reported by Stuart in Vol. 28, pt. 1, of the Journal of Applied Physics, considers the thermal diffusion equation with a source depending on an infinite medium slowing down kernel. This equation leads to a stationary expression for the parameter of interest which is different from that obtained by the multigroup method. In actual calculations Stuart uses an empirical kernel to represent the infinite kernel. Again, as in the multigroup method, a two-group approximation was effected by replacing Stuart's kernel by the appropriate two-group kernel. The value of k-effective for an infinite cylinder, water reflected, was calculated using both the Stuart method and the two-group approximation to this method. The results show agreement within 5% between the two methods; however, both are slightly below the experimental value and thus non-conservative. The Stuart method gives k-effective within 2% of experiment, while the two-group approximation is 7% below the experimental value. The Stuart method and the two-group approximation agreed to within 3% when the interaction

between two infinite slabs was considered. In this case both calculated values of  $k$ -effective were above the experimental value, the Stuart  $k$ -effective by 4% and the two-group  $k$ -effective by 1%, and thus both are conservative. The results reported here are tentative due both to the uncertainty in experimental data and to the limited number of cases considered.

If the corresponding two-group approximation to the Stuart method and to the multigroup method have the same degree of validity then it is apparent that the Stuart method is considerably more accurate than the multigroup method. The reason for the poor results of the multigroup method is being sought.

#### Criticality Studies in Support of Processing Power Reactor Fuels

##### Measurement of $k_{\infty}$ in the PCTR for Three Percent Enriched Uranyl Nitrate

Further work was done on the measurement of criticality parameters for evaluating nuclear safety in connection with the reprocessing of power reactor fuels. Measurements were completed of  $k_{\infty}$  in the PCTR for a three percent enriched uranyl-nitrate mixture with a nominal H/U atomic ratio of 13. A preliminary value for  $k_{\infty}$  is 1.13; a final value of  $k_{\infty}$  will be given when the results of various analyses which are being made on the uranyl nitrate are received.

##### Pulsed Neutron Source Studies Applicable to Nuclear Safety

On October 20, a meeting was held at the Critical Mass Facility to discuss the feasibility of using pulsed neutron source techniques (pulsed neutron source and time analyzer) in pre-criticality instrumentation for assuring nuclear safety in the separations plants. Representatives from ELO - PIRDO and CFD-RoE and FEO were in attendance; the meeting was called by M. T. Slind of FEO.

A theoretical investigation of the feasibility of using a pulsed neutron source as a device for measuring  $k_{\text{eff}}$  of subcritical assemblies has been undertaken at the request of the Chemical Processing Department.

The investigation is expected to yield information on the applicability of such a device to problems of measurement within the Critical Mass Program as well.

##### Criticality Models for Nuclear Safety Display

The plutonium criticality models, which are being prepared as an aid for nuclear safety education and training of plant personnel, are about 50% complete. This display will consist of models of spheres, cylinders, and slabs, both bare and reflected, for plutonium metal and solution of the actual critical sizes.

##### Mass Spectrometry

The mass spectrometer for this program operated very satisfactorily during the month. The ion source vacuum interlock operated without difficulty. The source region of the spectrometer was given a prolonged heating and outgassing, and since that time the spectrometer has operated without the electrical breakdowns that have been so troublesome in the past. The spectrometer was shut down once because of the failure of a drive belt on a mechanical vacuum pump. Isotopic analyses were performed on two customer samples.

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The primary effort during the month was the start of an investigation of the effect of pretreatment of sample filaments on the efficiency and lifetime of uranium metal ion emission. The pretreatment under investigation is based on experiments by M. H. Studier at ANL which showed that the presence of carbon on a rhenium filament greatly increased the reduction of uranium oxides. Our studies are based on the relative uranium ion-uranium oxide emissions and lifetimes of one microgram natural uranium samples loaded in a standard filament geometry. The samples which have been investigated at this time have been heated to different temperatures in a propane atmosphere prior to loading. Excellent results have been obtained with some samples which indicate the desirability of a more complete systematic study of this type of pretreatment.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Scattering Cross Sections

The series of high resolution measurements of the quasi-elastic scattering of 0.1 ev neutrons from room temperature water was completed. Some progress was made on the analysis of these data and that previously obtained for the scattering of 0.25 ev neutrons.

The results obtained on the quasi-elastic scattering of 0.147 ev neutrons from water were reviewed and prepared for publication in the Nuclear Physics Research Quarterly Report.

Approximately two weeks of spectrometer operation were lost because of Reactor Operations procedures. A thermocouple installation necessitated disassembly of the spectrometer. Following this, severe instrument damage was incurred from water dripping on the spectrometer from an overhead duct on the X-2 level. The repair of damaged instruments and circuitry has not been completed as yet.

Subthreshold Fission

Although no new measurements were made on this program, the results which have been obtained on the entire program were reviewed, reanalyzed and some new results obtained from existing measurements. Previously unreported results were prepared for publication in the Nuclear Physics Research Quarterly Report and an abstract for a talk at an American Physical Society Meeting.

Previously unreported results of this measurements program include 1) an upper limit to the fission in the 20.4 ev resonance in  $\text{Pu}^{240}$ , 2) an upper limit to the peak resonance fission cross section of the 2.65 ev resonance in  $\text{Pu}^{242}$ , and 3) new estimates of the thermal fission cross sections of  $\text{Pu}^{242}$ ,  $\text{U}^{234}$ ,  $\text{U}^{236}$ , and  $\text{U}^{238}$  based on the resonance fission results.

The upper limit to the peak resonance fission cross section of the 20.4 ev resonance in  $\text{Pu}^{240}$  was established to be 535 barns from a reanalysis of previously obtained data. This result is consistent with the fission width expected from the value obtained for the 1.06 ev resonance fission.

The results of fission cross section measurements previously obtained on two

peak resonance fission cross section was 41 barns. The value implies a characteristic energy of the fission barrier,  $\bar{E}_0$ , less than 0.45 Mev, consistent with the expectations based on most other nuclides studied.

The resonance fission cross sections which have been measured were used to calculate the resonance contribution to the thermal fission cross sections. On the assumption that the measured resonance fission width is representative of the average value the best estimates obtained for the 2200 m/s fission cross sections were: Pu<sup>242</sup>, less than 0.02 barns; U<sup>234</sup>, less than 0.06 barns; U<sup>236</sup>, less than 0.0002 barns; and U<sup>238</sup>, less than 0.00002 barns. These upper limits are all at least an order of magnitude lower than has been attained in direct measurements by others where the correction for sample fissile contaminants severely limit the precision of direct measurement. In the case of U<sup>236</sup> no value has previously been reported for the thermal fission cross section.

#### Fast Neutron Spectra

The new beam-locating system designed for the Van de Graaff accelerator has been installed and used to align and focus beams of positive ions. The limit on precision of alignment of the beam is now set by the smallest change in position which can be obtained from the remotely operated positioners on the accelerator. The focus and alignment achieved with this new system has been entirely satisfactory as has been the energy control stability achieved by using the molecular-ion beam for this purpose in the new system. One difficulty has been encountered in binding of the bearings of the pickup electrode assemblies caused by thermal expansion when the beam is on. A modification of the bearing design is under test and has seemed successful in operation to date. A Nuclear Physics Research Quarterly Report article describing the new system in detail has been prepared.

#### REACTOR DEVELOPMENT - 4000 PROGRAM

##### PLUTONIUM RECYCLE

##### Low Exposure Plutonium Lattices

The scheduled irradiations in the 8-3/8-inch graphite lattice with 1.8 w/o Pu-Al, 19-rod clusters were completed on October 14. The foil data have been processed on AFDAC-1. The results of these and previous irradiations are being analyzed to complete the  $k_{\infty}$  measurements in the 8-3/8 and 10-1/2-inch lattices.

##### High Exposure Plutonium

The ETR irradiations have been halted. Larger quantities of the desired material will be available at an earlier date from other sources.

##### PRTR Startup

A revised Critical Test schedule was developed to conform to the current target dates for achievement of criticality, initial power operation, and full power operation. Some modifications in Critical Test procedures are required with the revised schedule.

Drafts of the Detailed Procedures for Critical Tests 13, 18, and 22 have been written. Equipment which will be used for conducting the experiments was fabricated.

Foils which are to be irradiated during the PRTR Critical Tests were analyzed with the 256 channel analyzer. Tests were run to determine the purity of the foils and the best procedure to be used when the foils are counted.

#### Single Rod Experiments

A report on the feasibility of single rod experiments in the PCTR was prepared for Nuclear Physics Research Quarterly Report July, August, September, 1960.

#### Neutron Spectrum Studies

#### Neutron Rethermalization

##### a. Graphite Experiments

The initial analysis of the graphite experiments has been completed. The results appear reasonable in the sense that there is good agreement between the experimental and theoretical curves of the spatial dependence of thermal activity of a  $1/v$  detector. Further, the temperature dependence of the rethermalization cross sections appears reasonable and is smoothly varying.

The degree of confidence which can be expressed in these results is dependent upon many factors, including the uncertainties in approximately twenty-five diffusion parameters, and the validity of the neutron spectrum model. Work is in progress to evaluate this question of confidence.

##### b. Water Experiments

The analysis of the experiments has been started. The rethermalization cross sections of water are being determined by the same methods used to find the rethermalization cross sections of graphite. The initial values of the rethermalization cross section of graphite obtained in the analysis of the graphite experiments are being used in this analysis as known quantities. The initial results seem to be in reasonable agreement with the preliminary values presented in the ANS summary for December, 1960. However, the question of confidences is far more acute in these experiments for the same reasons as in the graphite experiments and because of the additional dependence upon the graphite rethermalization cross section. Work is in progress on further analysis of these experiments and on the problem of confidence.

#### Cycle Analysis

#### Code Development - LOLA

The basic formulation of a portion of the LOLA code, concerned with matrix inversion, was revised in order that more dimensions may be handled. The revision was recoded and debugged. The code is now lacking only a provision for final optimum estimation. This final provision is nearly completed. A paper describing the LOLA code is being prepared for presentation at the winter meeting of the American Nuclear Society.

Code Development: Cross Sections

Work continues on the edit routine which is designed to produce a FORTRAN tape for the MKW spectrum code from the RBU cumulative tape. The spectrum code has been completely coded, compiled, but not debugged.

Code Development: GPR

The cross section treatment in the generalized Plutonium Recycle code has been brought into conformity with that used in the MELEAGER burnup code. The main effect appears in the spectrum-hardening contribution of the recycled plutonium in the steady-state case, which tends to make this case appear even less attractive than it was in early studies. Little change in once-through cycle performance appears to have resulted from these modifications.

Code Development: RBU

The final set of modifications to the RBU code were completed at the end of the month. These consisted mainly of improvements in the output listing, improvements to on-line messages, revisions of the code to simplify operating procedure, and correction of a few minor errors in the input code. Two simple sample problems have been run through the code on the 7090 computer, but machine difficulties have prevented completion of a more complex problem. It has also not been possible as yet to carry out the "punch squeeze" or cleanup operation on the Monitor Code, due apparently to defects in the SOS system. As soon as these obstacles are overcome, the code will be released for distribution through the SHARE organization. All material for the final report was assembled, and a first draft copy is currently in preparation. A preliminary 7090 time estimate on more or less typical problems can be quoted with some basis in experience; fifteen minutes per Monte Carlo system for the first time step, ten minutes or less for subsequent time steps, fifteen minutes for the input code. These time estimates are strongly dependent upon the nature of the problem being run and the desired precision of the results. Diffusion and burnup speeds on the 7090 have not been determined, but should not be more time consuming than the Monte Carlo unless a large number of diffusion and burnup steps are carried out between Monte Carlo calculations. All portions of RBU except for the Monte Carlo are limited by tape speed, and the improvement over 709 running time is little better than a factor of two even with high-density tapes. The Monte Carlo appears to be running five to six times as fast in the new machine.

Elimination of the cumulative tape in the Input Code may result in improved running time, since on the 7090 the group cross sections can be recomputed in less time than it takes to read them from this tape. This modification has, however, been postponed in order to make the RBU system available for general use at the earliest possible date.

Instrumentation and Systems

Investigative work continued regarding the "last ditch" safety circuit system for the Plutonium Recycle Critical Facility. New calculations show that the system will energize (alarm) in less than 0.75 seconds for a 50-millisecond reactor period. Commercial parts necessary for the experimental device have been ordered and fissile material is being obtained. Experimental tests will be conducted in the 305-B Building.

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All instruments required for the special detectors to be used in the PRTR critical tests have been fabricated or borrowed. Each detector and its associated electronics has been calibrated in a Reactor Lattice Physics standard pile. The equipment has been assembled and sent to the PRTR. Testing of the installation there will begin as soon as the cabling from the reactor vessel to the control room has been completed. Four training sessions were held to acquaint the operating personnel with the equipment.

All development work on the PRTR Gas Gap Measurement Instrument has been completed and all but one of the required modifications to the Magnaflux Corporation FW-400 have been installed and satisfactorily tested. The modification remaining to be incorporated is a phase-sensitive circuit for providing a signal which will indicate the quadrant in which the gas gap spacing is minimum. This circuit has been developed and is being fabricated. The probe assembly has been fabricated, assembled, and satisfactorily tested. Work remaining on this project includes an extensive calibration of the instrument as a complete system, using Zircaloy-2 tube samples of various wall thicknesses and an eccentrically bored tube to simulate various combinations of wall thickness; 150°F water testing of the probe; testing of the system in the full size tube-in-tube mockup located in 314 Building; and final checkout making the initial condition inspections of the actual reactor tubes in the PRTR. It will also be necessary to write an instruction book containing operating procedures and a guide to aid in the interpretation of recorder traces obtained during process tube inspections.

Because of cable failures in the first Mark I PRTR process tube inside diameter probe, a second model was fabricated to accommodate more easily the television camera cables. The new probe, along with a pair of new amplifier-indicator units, will be used for future PRTR measurements.

Arrangements were made to test the equipment and techniques to be used in measuring the PRTR mean neutron lifetime at the PCTR. The test was actually made on the TTR because PCTR was shut down for modifications. To date the neutron flux data have been recorded on magnetic tape and are ready for analysis in the laboratory. The motor and brake assemblies ordered for the Ampex tape handling mechanism were received during the month. It is expected that they will be mounted in the recorder cabinet and tested by November 15.

The evaluation of the PRTR controller period control mode has been tentatively dropped. It was determined that the evaluation was impractical using portable Donner analog equipment due to a basic lack of stability in the electronic multipliers.

#### Specific Fuel Cycle Analysis

A presentation of physics contributions to the Plutonium Fuel Value program was made at the semi-annual meeting of the Evaluation and Planning Branch, Division of Reactor Development, USAEC, on October 19. Primary emphasis at this meeting was on economics evaluation.

Assistance was given to personnel of IPD in the application of the MELEAGER code to analysis of fuel cycles in a Russian graphite-moderated power reactor. The MELEAGER results have been aligned with Russian data.

The "base case" in the AFWR study for the Plutonium value program was re-analyzed with a revised thermal utilization. Reductions in Step 1 exposure of about 500 MWD/T and in Step 2 exposure of about 850 MWD/T resulted. The effect on the economic analysis is believed to be small.

A study concerning a fission monitor fuel has been carried out, with satisfactory results thus far. Further areas of investigation will be undertaken by the customer.

#### NONDESTRUCTIVE TESTING RESEARCH

The six-section, a-c coupled, orthonormal filter for use in application of orthogonalized exponentials to the analysis of the broadband eddy current test signals was completed. The output of the broadband eddy current test system was applied directly without time reversal to this filter and observations were made of the various filter output signals. By observing the filter output at a time about 10 microseconds from the start of the driving pulse, appreciable changes in the filter output could be observed as test specimen parameters were changed. This is a possible method of use of the filter as contrasted to the application of a time reversal operation to the signal prior to its application to the filter. For the type of signal with which we are dealing, such a time reversal results in the filter giving more accurate coefficients for the chosen orthogonal exponential components representing the signal. However, it is believed that suitable results can be obtained without the time reversal operation of the coil output signal. Pending the outcome of the present tests, measurements are being made without time reversal of the test coil output signal, although it is planned to investigate means for providing the time reversal.

The attempt to utilize a test coil driving function composed of growing exponentials to eliminate the need for the time reversal operation directly ahead of the filter is continuing. Several waveforms containing growing exponential components have been used but a better generator scheme is being sought. It is observed that a great gap exists in the electronic literature concerning signals of this type and means to generate them.

Measurements of the orthonormal exponential filter outputs are being made as a function of test specimen parameters in order to determine the general design of a transformation network which will transform these outputs into the desired parameter readout signals.

A six-section pulsed diode sampling circuit was designed based upon a single-section prototype and placed in the electronic shop for fabrication. This sampler will be used to sample the outputs of the six-section orthonormal filter and will drive the aforementioned transformation network.

The work under a proposed research contract with Johns Hopkins University was discussed with Dr. W. H. Huggins and a doctoral candidate, Mr. L. G. Wolsey, who will perform the work under the direction of Dr. Huggins. At month's end, the University agreed to accept the proposed contract with a starting date of January 1, 1961.

A modified infrared radiometer for use in the heat transfer testing equipment being fabricated at HAPO is partially complete. The main features incorporated in this instrument are an increase in detector-test piece spacing to reduce spurious

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signals due to strong fields of the induction heating coil, and the use of a single 13-inch-diameter elliptical mirror and an arsenic trisulfide relay lens near the test piece. The relay lens facilitates placing the chopper and limiting aperture two inches from the target to overcome space limitations at both the detector and target. Bench tests of the optical system were made to insure that the design would be adequate prior to actual fabrication of the instrument.

Experiments with flattened multi-turn induction coils have continued in an attempt to utilize an induction heater available for part-time use. A 3-1/2-turn coil one-quarter inch long having 1-9/16-inch I.D. was fabricated from 0.005-inch copper foil. Approximately two kilowatts were induced in a 1-1/2-inch O.D. aluminum load cylinder using this coil in conjunction with a 7-1/2-KW induction heater. This is approximately three times the power induced with previously designed coils. However, an increase in coil-load spacing will be necessary, and the resulting broadening of the heated zone will reduce the power density below the present level. Tests with these coils are continuing.

A bid on the general purpose infrared radiometer has been accepted. Delivery time is approximately five weeks. This instrument should be useful in a broad range of HAPO temperature measurement problems.

Two inductive (eddy current) thermometers of the latest design are nearing completion in the shop. These will be used first in a heat transfer test in an attempt to measure the quality of weldments of the lugs on self-supported fuel elements.

#### NEUTRON FLUX MONITORS

Several plutonium alloy combinations were "tested," via computer use, for burn-out under typical production reactor conditions. The IBM 709 computer was utilized with specific burnout codes as applicable. Results indicate that burnout of the fissile neutron detection materials can be held to  $\pm 10$  percent limits over a four- to twelve-month period at normal reactor flux levels.

#### BIOLOGY AND MEDICINE - 6000 PROGRAM

##### ENVIRONMENTAL SCIENCES

##### Atmospheric Physics

Results of the reanalysis of the 1959 atmospheric diffusion field test data indicated that, with a knowledge of the wind speed and atmospheric stability under the conditions of these experiments, one can estimate the area enclosed within a given dosage isopleth from a source near ground level to within 50 percent in the distance range of 1 to 16 miles from the source. A regression analysis of the area enclosed vs. normalized dosage showed that a power function fits the data very well, both for very stable and moderately stable atmospheric conditions when the stability is determined from the bulk Richardson's Number.

Calculations were started of the flux of zinc sulfide tracer material through vertical surfaces defined by the vertical and horizontal sampling grids. Based on the analysis of one experiment, results indicated that the mass flux decreased exponentially between 200 meters and 3200 meters' distance downwind from the source. The loss of material is attributed to deposition on the ground surface

and vegetation. Analysis of data from additional experiments was in progress at month end.

Field activities in the current series of atmospheric dispersion studies included two additional successful experiments and one failure, bringing the total number of successful trials to 16. Additional samplers were added to the grid to provide data on the magnitude of the error in dosage estimates caused by aerodynamic impaction of the tracer material on the membrane filters at the higher wind speeds. Several supplemental experiments were conducted using oil fog tracer photography to qualitatively study the effect of ground contour change on dosage determinations. Results of these studies supported our concept of plume behavior that gave rise to anomalous crosswind variance estimates at 8 miles' distance from the source obtained from the 1959 field test data.

In our preliminary work on precipitation scavenging processes, investigations continued on field methods of collecting rain samples and feasibility of using artificial rain for pilot studies. A sampler for collecting individual raindrops was designed and fabrication started.

#### DOSIMETRY

An improved ability to measure  $\text{Na}^{24}$  reported last month has led to its detection in a large number of people. All these people work in the reactor areas. The amounts of  $\text{Na}^{24}$  have been in the range 1 to 10  $\mu\text{c}$ . A sample of drinking water from one of the reactor areas was counted and  $\text{Na}^{24}$ ,  $\text{Np}^{239}$ ,  $\text{Mn}^{54}$ , and  $\text{Cr}^{51}$  were detected. Since the  $\text{Na}^{24}$  has been found in people these other isotopes should also be present. Efficient detection of these isotopes requires improvement of the low energy response of the multichannel analyzer. Three methods were designed to achieve this improvement. One method involved summing the pulses from two amplifiers, one of which was diode limited. This method was tested by Chemical Research and Development Operation. A second method involving a diode switch in a voltage divider was tested by us. These first two methods were fairly satisfactory but resulted in a small transition region in the analyzer in which the results were non-linear. Calibration of either of these systems would have been very complex. A third method is under development which involves manipulation of digital information inside the analyzer. Both objections to the first two methods should be removed in this method.

An arrangement was completed which permits simultaneous operation of both the old and the new large scintillation counters. A  $\text{K}^{42}$  calibration experiment was carried out for the scanning counter arrangement using the two counters separately and then together. The results were better than obtained with a subject in the chair position but were not as good as had been hoped for. Other experiments are in progress.

$\text{Cr}^{51}$ ,  $\text{Zn}^{65}$ , and  $\text{Np}^{239}$  were found in the coveralls at the whole body counter by counting a large stack of them. The amount in each coverall is small but should be removed to eliminate uncertainties in the low energy range when the apparatus described above is in operation.

It was made possible to mount the new large scintillation counter in the place of the present whole body counter. A cross-calibration between the two was carried out.

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Consultation was given in planning a new whole body counter facility. A calculation was made of the proper thickness of iron shielding between adjacent iron rooms. An integrated instrument system was designed that would incorporate both the new and the old counters without requiring duplication of all the recording equipment that we now have. This system will require development of a transfer circuit that will permit transfer of information between multichannel analyzers.

The installation of a new analyzing chamber and a new positioning device on the positive ion accelerator were completed. While not yet in full use these additions appear to have essentially eliminated the long-standing problem of accelerator alignment.

Measurements were completed of the energy degradation of the neutrons from two more PuBe sources. These sources were borrowed from the National Bureau of Standards and from Vallecitos.

An Sb-Be source being prepared for counter standardization was lost when it was ejected from the reactor after being activated.

Analysis of the accumulated data on precision long counters showed that the position of the effective center of the counter shifted linearly with the energy of the neutrons being counted. It was also shown that the fraction of room-scattered neutrons that were counted was independent of energy. This last relation may be peculiar to our laboratory. These two relations, plus our previous calibrations, have permitted substitution of our precision long counter for our previous long counter in neutron flux standardization in our laboratory. Further machining was done on a second precision long counter made here at Hanford in an attempt to make its response more nearly like that of the other counters. No improvement was obtained.

The performance of the helium ion source being developed was improved by using a stronger magnetic field, thus permitting operation at a more nearly optimum gas pressure. The limitation on the output of the source appears to be sputtering of metal from the exit of the source.

The beam sweep for producing uniform electron exposures with the electron Van de Graaff was installed and is now being tested. It should be possible to irradiate uniformly an area about one inch square, although the area to be irradiated may be reduced as desired.

A simple and accurate method was developed for correcting for the nonlinearity of thermistors used in calorimetry. The value of this technique is that it permits correlation of experiments performed under different conditions. The method was applied in measuring the stopping power of aluminum with a transmission type calorimeter. The result was within 0.7% of the accepted value. The standard deviation among different readings was only 0.1%. However, systematic errors, especially multiple scattering in the foil increased the total uncertainty to 1.2%.

INSTRUMENTATION

Experimental prototype (first model) fabrication was complete on the GM tube miniature detector approximate dose-rate integrating personnel monitor. The unit has performed satisfactorily; however, redesign and repackaging must be considered since the unit exceeds 1.5 pounds in weight and occupies 32 cubic inches. A reduction of 50 percent of present size and weight will be necessary.

Modifications were complete for the Dog Monitor at Biology to permit counting of  $Ce^{144}$  in rats. Since the unit was originally designed for large animals, a probe was removed and reinstalled in the shield to permit rat counting. Operation is satisfactory.

The coincidence-type alpha air monitor was modified to increase air flow to 19 CFM. Perfect balance has been achieved through a 7000 d/m radon-thoron buildup. In other words, the stated buildup, which is about as high as we have ever experienced, produced no false meter indication on the  $Pu^{239}$  meter. With the stated flow rate, the calculated sensitivity to alarm for a continuous level of airborne  $Pu^{239}$  of  $2 \times 10^{-10}$   $\mu\text{c/cc}$  (100 MPC) is about four minutes or less. This alarm level, if it can be maintained, is quite satisfactory. It appears that the major problems have been solved for this development project. Only an improved transistorized count-rate meter remains as a problem.

Fabrication continued, with design modifications incorporating a complementary transistor flip-flop, on the second type of selectable-alarm-level personnel dosimeter incorporating a pencil dosimeter, CdS cell, and transistor circuitry. The modified circuit materially reduces battery drain for the alarm portion.

Investigations were started, using the 200-channel analyzer, for a new type of zinc sulfide particle counting system for use in Atmospheric Physics programs. The approach will be to use two different ZnS pigments deposited on the same filter to see if they can be distinguished via their inherent characteristic differences.

An apparatus was completed for experimental fabrication of the miniature  $CaF_2:Mn$  thermoluminescent dosimeters. The readout system for the dosimeters was modified to improve the readout accuracy and reliability.

The lead-shielding-modified, transistorized alpha-beta-gamma experimental prototype scintillation hand and shoe counter was moved to 100-F Area for tests. Operation, to date, has indicated a need for an additional binary circuitry in the beta-gamma hand and shoe channels due to the much higher background conditions than were experienced in the long-term 300 Area tests.

The two completed prototype "wand" alpha monitors using silicon surface barrier diode detectors and all transistorized circuitry are still performing quite satisfactorily. Unit size is one inch diameter by eleven inches long. One unit is being used, experimentally, at 234-5 Building with good results to date. The units have essentially zero background counts, greater than 20 percent geometry for  $Pu^{239}$ , and have no gamma interference problems in 5 r/hr fields.

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Tests and experiments were concluded on the logarithmic voltage quantizer circuit incorporating tunnel diodes as a voltage comparator. The unit was used with the 200-channel analyzer to obtain a logarithmic horizontal scale. Tests were conducted with Na<sup>22</sup> (1.28 and 0.51 Mev), Cs<sup>137</sup> (0.66 Mev) and Am<sup>241</sup> (0.06 Mev). Results were displayed on the analyzer with errors of about  $\pm 10$  percent from a true logarithmic characteristic.

Development work continued on the servo-system logarithmic area monitor with phototube interchangeability tests completed. No phototube selection will be necessary. Circuit experiments are underway to develop a voltage regulator controller to eliminate the servo motor. The regulator, if successful, senses the anode current to change the high voltage to keep the anode current constant.

Two good resolution Pu<sup>239</sup> alpha sources were obtained for use in evaluating the alpha energy resolution characteristics of the silicon diode surface barrier detectors. Several commercial diodes were ordered to compare with those of our manufacture. Processing was started on another group of ten experimental diodes of various sizes using 400 ohm-cm silicon. Various finishing techniques will be tried to attempt to reduce the reverse current (leakage).

Installation of all equipment was completed for the electron beam deflection system for the Van de Graaff negative accelerator. Tests indicate the thyatron circuits will probably have to be modified to operate from a pulse source rather than dc for stability. The commercial deflection plates do not perform as indicated by the manufacturer. This problem remains to be solved before tests can be completed with our portion of the equipment.

An experimental circuit was proposed concerning a thermistor-controlled oscillator for use in a temperature readout system.

Fabrication continues on the three prototype experimental scintillation transistorized beta-gamma dose-rate meters of a portable type. Portions of the work completed and tested to date have proved to be satisfactory.

#### WASHINGTON DESIGNATED PROGRAM

##### Isotopic Analysis

As a measurements criterion for this program we have established a numerical standard for the number of program and standard samples for which high quality isotopic analyses are obtained each month. This goal is based on 100 percent operating efficiency for 75 percent of the available time, allocating 25 percent of the time for mass spectrometry research and development in support of the program. This goal has been consistently exceeded during the past six months because 1) research and development activities have been confined to the other mass spectrometer which has offered some new challenges in the form of operating difficulties, and 2) the mass spectrometer for this program has been operating in a remarkably reliable fashion, and a near negligible amount of time has been lost due to operational difficulty and maintenance, and 3) operating procedures and utilization of manpower have been extremely effective. During the past six months we have achieved in excess of 150 percent of the established goal for analyses performed culminated during October by the achievement of 200 percent.

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As part of the continuing effort to study and improve the accuracy and reliability of isotopic abundance measurements attainable with the mass spectrometer for this program, a series of analyses have been started on uranium samples provided by the National Bureau of Standards. These samples vary in  $U^{235}$  isotopic content from depleted to highly enriched. It is the intent of this study to determine whether or not an over-all mass discrimination effect exists. All samples run to date have agreed with the NBS analysis within established precision measures.

The improved ion count control circuit for the ion counting detection system of the mass spectrometer has been completed.

An improved filament vacuum bake-out system was designed and is being fabricated. The new system will provide three independently accessible vacuum chambers, any of which can be opened to the atmosphere without shutting down the vacuum system.

#### TEST REACTOR OPERATIONS

Increased flexibility will be provided for the present PCTR by boring additional fuel holes in the inner edge of the reflector. The work was started October 24. Excellent alignment with the existing holes in the back reflector has been obtained. Approximately three weeks' outage will be required to drill 100 holes.

Operation of the PCTR continued routinely during the month until the scheduled reactor improvement outage starting October 24, 1960. There were no unscheduled shutdowns during the month.

The IPD mockup lattice measurements of  $k_{\infty}$ ,  $f$ ,  $p$ ,  $\epsilon$ , wet and dry were completed during the month.

The first part of the experiment to determine nuclear safe concentrations of enriched uranyl nitrate polyethylene mixtures was completed.

The maintenance outage to drill 100 holes for additional driver positions was started October 24, 1960.

A new source drive mechanism was prepared during the month to accommodate the larger physical size of the Pu-Be source scheduled to replace the present Po-Be source.

The TTR was used to test an automatic period timer and a method of measuring neutron lifetimes for Nucleonic Instrumentation Operation.

Two irradiations of calibrating foils were made, one for PRTR experiments and one for NPR experiments.

#### CUSTOMER WORK

##### Weather Forecasting and Meteorology Service

Meteorological services, viz., weather forecasts, observatories, and climatological services, were provided for plant operations and management personnel on a routine basis.

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<u>Type of Forecast</u>	<u>Number Made</u>	<u>% Reliability</u>
8-Hour Production	93	87.1
24-Hour General	62	82.8
Special	150	90.7

October was the second consecutive month of warmer and drier than normal weather. The only highlight was a high wind with gusts to 53 mph on the 23rd.

#### Instrumentation and Systems Studies

Evaluation of the designed Pu<sup>239</sup> (17 Kev) Wound Probe for Records and Standards Operation was completed. A small probe with a two-inch-diameter one-millimeter-thick NaI crystal was found to be capable of detecting about 2000 d/m of Pu<sup>239</sup> through one-eighth-inch-of-flesh-simulating lucite in a 10 minute count. This is the best that can be done using hand-selected phototubes. The detection level is about four times better than indicated (originally) as required for field use. A letter was written to the interested personnel concerning final delivery of the small probe. The large four-inch-diameter NaI crystal was returned to the manufacturer for repackaging after a hole was discovered in the thin aluminum back plate.

Advice and consultation was rendered to Redox instrument maintenance personnel regarding the adjustment and operation of the Redox Stack Effluent Monitor.

A design proposal was completed and sent to Chemical Research and Development concerning an alpha and beta-gamma stack monitor system for the 325 Building. The alpha portion was designed to alarm if  $5 \times 10^{-6}$  curies of Pu<sup>239</sup> are emitted or if  $10^{-4}$  curies of mixed fission products are emitted. The beta-gamma portion will be a modification of our previously developed and tested High-Level Air Monitor, and the alpha portion will use our developed and tested Medium-Level Alpha Monitor. Mechanical time constants will be incorporated in the alpha portion to improve sensitivity and reliability.

A design proposal was submitted to 327 Building personnel concerning a mixed fission product air monitor using our developed and tested High-Level Air Monitor circuitry and a moving-tape mechanism.

A request was received from Radiation Protection Operation to provide engineering services to improve the reliability of the Whole Body Monitor multichannel analyzer and its peripheral equipment.

Two X-ray diffraction peak integrators for FPD have been ordered from the Perkin-Elmer Corporation. The customer increased the requirements on this item to include an automatic printing feature.

The nickel plating process for FPD Process Engineering has been set up on the GEDA computer. The solution should be complete in about a week. Results should include optimum controller settings and location of the pH measuring element.

Work is continuing on the reference system to be used in calibrating the DRS-100 system. The DRS-100 is intended for future use in making in-reactor creep measurements by the Physical Metallurgy Group. A furnace and controller are being modified to provide for individual control of ten specially installed heater wind-

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ings to insure that the required "flat" temperature gradient is obtained throughout the entire length of the furnace. An even temperature distribution within the furnace will be a necessary condition while the DRS-100 is being calibrated at elevated temperatures.

### Optics

#### Length Measurement Periscope

A periscope is being designed for 105-C Fuel Examination Facilities. The periscope will permit measurement of the length of fuel elements under twelve feet of water from the same station at which internal diameter measurements will be made. Preliminary sketches have been prepared which are being used as a basis for further tests and calculations. A work order has been issued to drafting to prepare detailed drawings.

#### Radiation Ratio Pyrometers

The HLO metallograph pyrometer is ready for installation. Installation is scheduled for October 31.

The FPD extrusion press pyrometer is fully assembled and has been tested extensively using the Barnes radiation standard as a source. During the first two-and-one-half hours of operation after starting up cold there is a 50°C drift in indication, after which no drift can be detected for periods of at least eight hours. The drift seems to be in the detector cell itself. Tests are now being made to determine if the drift can be eliminated by using an auxiliary slow chopper which cuts off radiation to the cell periodically.

### Shop Work

A total of 548 manhours work was performed during the five-week period (September 25 to October 30) included in this report. Of this, 11% was for IPD, 17% for CPD, 51% for HLO, 4% for Code 1525, 6% for Code 9710, and 11% for Code 0710. The work included:

1. Fabrication of 20 glass bearings.
2. Fabrication of PRTR gas gap probe.
3. Repair of two cathetometers.
4. Repair of two periscopes for 105-F.
5. Fabrication of four light pipes.
6. Fabrication of pyrometer lenses and filters.

### Analog Computer Facility Operations

The major problems on the analog computers this month were Reactor Speed of Control and the NPR Confiner.

An open house in the Analog Computer Facility was held October 11 and 12. This consisted of demonstrations of two computers and short explanatory talks. The purpose of the open house was to acquaint personnel of the various engineering and production groups on plant with the analog facility and the work being performed by its use. The demonstration used with the EASE computer consisted of the simulation of the PRTR reactor. The simulation was connected to an external

electronic controller and to a manual control panel arranged to make possible a choice between manual and automatic control. This demonstration was designed to point out the use of the analog computer for system simulations, operator training, and hardware evaluation. The demonstration with the Litton DDA consisted of solution of a spring-mass problem showing the interchange of energy between two masses. The solution of a damped, second order differential equation and the solution of Van der Pol's equation were also demonstrated. This demonstration was designed to illustrate the use of analog computers for equation solving.

The amplifier test unit for the analog computer has been completed. The operational amplifiers, previously reported inoperative, have all been repaired with the aid of the test unit. Routine maintenance procedures on the computers have been started. Spare equipment has been ordered for use in the maintenance program but it has not been received. It was discovered that the EASE 1148 amplifier input tubes had been wired in two different ways. Some amplifiers had been wired for low voltage filament operation and some for the full rated volts. On this basis the 69 bad tubes removed from the computer were tested with six volts on the filament. About nine percent of the 12AX7's and 45 percent of the 12AU7's appeared to have exceptionally low transconductance at this low filament voltage.

The two Ampex tape transport lag simulators have been checked out against the specifications. The specifications were met or exceeded in every case. The static amplitude accuracy was five to ten times better than specified. A memorandum will be issued on this checkout.

#### Computer Operation

GEDA	132 hours up	EASE	140 hours up
	20 hours idle		0 hours idle
	4 hours unscheduled downtime		16 hours unscheduled downtime
	12 hours scheduled downtime		12 hours scheduled downtime
	<u>168 hours total</u>		<u>168 hours total</u>

#### Instrument Evaluation

1. Acceptance tests were completed on 20 T-P dose rate portable instruments.
2. Evaluation temperature tests were completed on T-P type probes (plastic wall ionization chambers) from +75 F to +175 F. At +125 F, the readings were 10% down from reading to 75 F; and at +175 F, the readings were in error by -35%.
3. All tests were completed for testing RCA 6655-A multiplier phototube interchangeability for use in the servoed logarithmic area monitor. One chart (calibration) was found to be sufficient for all tubes (no selection necessary) over the range from one mr/hr to 10 r/hr.
4. Advice and assistance were rendered to PRTR personnel concerning calibration of their Victoreen Remote Area Monitors. Zero drift was found to be excessive and calibration results were correct to within only  $\pm 15\%$ . The internal calibration source was not in reading agreement with the plant-standard sources.

5. The Model II Scintran was moved to Redox for further field tests after a successful two-week test at 108-F (Biology). The plastic-cast alpha probe was found to be slightly contaminated from use at Biology and was recovered.
6. Personnel from the 300 Area Portable Instrument Repair Shop were instructed as to the correct method of applying zinc sulfide to Air Filter Monitor alpha probes and as to proper light-covering application methods. One probe was properly assembled for the demonstration and the tests showed it to have an average geometry over the 4-inch-by-4-inch face of about 29%.

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATIONRESEARCH AND ENGINEERINGFISSIONABLE MATERIALS - 2000 PROGRAMIRRADIATION PROCESSESUranium Oxidation and Fission Product Volatilization Studies

With studies on the effect of uranium irradiation levels on release of fission products in an air atmosphere about 75 percent complete, several conclusions can be drawn. Over irradiation levels of  $10^{14}$  to  $10^{18}$  nvt there is no significant change in the oxidation rate of the uranium. Also for consideration on reactor incidents the release of noble gases from the fuel will be 100 percent. Apparently, the measured low release of noble gases at trace irradiation levels resulted from the adsorption of about 30 percent of the gases by the uranium oxide itself.

Work commenced on the determination of size and size distribution of particulate material formed during the oxidation of unirradiated uranium specimens. Experiments were made at temperatures of 1200, 1000 and 800 C and air flow rates of 1000, 2300 and 3500 cc/min. Observations of the particulate material by optical microscopy indicated that the temperature at which oxidation occurs has a marked effect on the size of particulate generated. Also, increased air flow rates increased the amounts of larger particles collected which is probably due to increased entrainment and higher settling velocities.

NPR Effluents

Laboratory studies of possible treatment methods for phosphoric acid decontamination wastes were directed toward precipitation and scavenging processes to conform with the process found most suitable for other decontamination wastes. The work included methods of removing phosphate as well as radioisotopes from the waste. More than 99 percent of the phosphate is precipitated from the neutralized waste upon the addition of calcium salts. However, this process results in the formation of very large volumes of sludge. After settling for a month or more the sludge volume is roughly equal to the volume of 10 percent phosphoric acid decontamination solution used before dilution with rinse water. Caustic neutralization after addition of calcium salt minimized the sludge volume. The phosphate precipitation scavenged radioactive barium, zinc, and cobalt tracers from solution with decontamination factors of about  $10^3$ .

It was found that scavenging decontamination factors of  $10^3$  for radiozinc and radio-cobalt in phosphoric acid waste were obtained by precipitates resulting from treatments with  $KMnO_4$  (0.012M) or  $FeSO_4$  (0.06M) prior to caustic neutralization. The sludge volumes in these cases were less than half those obtained from calcium precipitation of the phosphate.

Reactor Effluent Treatment

Preliminary analyses of reactor effluent water samples from the two half-reactor tests in which higher flocculant feed rates are being used indicate that removal

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efficiencies of arsenic and phosphorus expected by comparison with laboratory tests were not achieved. Repeated laboratory tests using the same chemicals as in the half-reactor test showed that high removal efficiency could not be obtained unless Separan was added to the filter. Best results were obtained with 20 ppm aluminum nitrate flocculant and 0.02 ppm Separan to the filter. Further laboratory tests show that this treatment efficiently removes arsenic when present as either the arsenate or arsenite ion. These conditions were recommended for trial in the half-reactor test.

Work was initiated to seek minerals suitable for large-scale decontamination of reactor effluent. Batch experiments were performed with pyrite, gypsum, erionite, calcite, apatite, clinoptilolite, anorthite, albite, labradorite, microcline, sodalite, scapolite, and vermiculite to determine the ability to adsorb Zn-65 from 80 C tap water. All except pyrite adsorbed zinc significantly. Most of the remaining minerals adsorbed 50-75 percent of the zinc after one-hour contact. Sodalite, scapolite, and vermiculite removed 89, 91, and 96 percent of the zinc, respectively, and were superior in this regard to all other minerals studied. Future studies will concentrate on mineral bed removal of phosphorus and arsenic.

The reactor effluent pilot scale test facility using an aluminum bed was operated at a water rate of six feet per minute, about 50 percent greater than that of the initial tests. Significant trends were noted during the period. Radiation measured at the wall of the bed structure essentially trebled to 1.5 r/hr., requiring re-locating the radiation zone boundary. The concentration of dissolved aluminum was appreciably higher during six feet per minute flow than during the 3.8 feet per minute flow tests. Pressure drop across the bed increased, but the drop was less than that anticipated. Since bed life will be influenced by the rate of dissolution of the aluminum and the pressure drop reaching a limiting value, the increase in aluminum concentration may be viewed with some concern for the higher flow rates. Lower pressure drop will permit greater economy in the full scale design and construction.

#### Air Monitor

The efficiency of an Anton 234-B air monitor modified according to the earlier recommendation was calibrated. A gain of about 50 percent in efficiency was achieved over the original design.

#### Observation Wells

There were no significant changes in ground water contamination patterns in the vicinity of the 200 Areas during the past month. Ground water samples from a well monitoring the Purex A-6 steam condensate crib have sporadically shown low concentrations of strontium-90 for the past several months. This would be premature breakthrough of strontium-90 into the ground water based on laboratory soil column test results. Samples have contained gross quantities of decayed animal matter, probably rat or rabbit, and there is a possibility that the source of the Sr-90 is related to the decay material. Further efforts to define the source are underway with assistance from the Radioecology Operation. A replacement crib, necessitated by the decreased percolation capacity of the existing crib, is scheduled for completion in about five weeks.

A study to evaluate current and past analytical data relative to nitrate and nitrite ion concentrations in the ground water and Columbia River, and to interpret these

results in terms of Hanford waste disposal practices was accelerated. A quite preliminary evaluation indicated that information relative to waste movement in ground water may significantly supplement knowledge gained from the routine well sampling and water analysis program.

## SEPARATION PROCESSES

### Redox Studies

During the past year the Redox Plant has occasionally experienced a loss of partition in the LB column. Such instances apparently increased with adoption of the first cycle acid flowsheet. Since such a flowsheet is more conducive to solvent degradation, samples of the plant solvent were examined.

Infrared and ultraviolet absorption studies of the solvent indicated a relatively high concentration of an unidentified nitro compound. Precipitation of this material as the sodium salt confirmed the optical analyses and showed an impurity level of 0.2 to 0.5 mole percent. Laboratory experiments showed that only incomplete separation of the impurity from hexone was achieved by steam distillation. After distillation of 65 percent of the sample, about 17 percent of the impurity was found in the distillate. Complete distillation of the hexone, as is done in the plant, would of course result in a greater carry-over of the impurity.

Treatment with 0.5 M  $H_2SO_4$  prior to steam distillation was relatively ineffectual in reducing the nitro-impurity.

Tests of the effect of the nitro impurity on the partitioning agent were also carried out. Ferrous ion was rapidly oxidized when a large excess was contacted with a plant hexone sample. However, no change in the absorbance due to the nitro compound was observed. Similarly, no change was observed in the absorbance due to diketone impurity which is also identified in the process solvent. Oxidation of the reducing agent is thus not due directly to the nitro impurity identified spectrophotometrically.

Laboratory tests showed that a five-minute wash with eight percent sodium hydroxide solution removed 98 percent of the nitro impurity content. Application of this procedure in the plant was much less effective, due undoubtedly to less efficient contacting.

### Solvent Evaluation Studies

Batch contact solvent extraction tests on chemically degraded Ashland Oil and Refining Company candidate diluents were completed for the series of 16 samples (R-1 through R-16) so far received at HAPO. The diluents were first nitrated by contact with 8 M  $HNO_3$ -0.05 M  $NaNO_2$  (initial concentration) for 24 hours at 80 C. The nitrated diluents, made 30 volume percent in TBP, were used in batch contact experiments simulating extraction, scrubbing and stripping in the first Purex cycle. Simulated Purex feeds used in these contacts were spiked to 0.2 percent full level activity with plant dissolver solution. The degraded Ashland Oil samples were nearly uniform in their tendency to extract gamma activity and to retain it through scrubbing and stripping. Compared to similarly degraded Shell E-2342, the Ashland Oils extracted about one-fourth as much gamma activity and retained about one-third as much through scrubbing. However, gamma  $E_a^0$  values during stripping were higher for degraded Shell E-2342 than for the Ashland Oils with the net result that the final stripped aqueous phase contained less gamma activity with degraded Shell E-2342 diluent than with degraded Ashland Oil diluent. This phenomenon will be investigated further.

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Reclamation Facility Continuous Dissolver

A system capable of continuously dissolving simulated solid feed materials from the Reclamation Facility has been installed in the 321 Building. The dissolver is a five-inch inside diameter, 10 foot long tube. Solid feed is introduced through an air lock at the top of the dissolver. An equilibrium heel of solids will build up in the dissolver. Dissolvent, introduced at either the top or bottom, will make one pass through the heel and overflow as product.

Materials of construction are 309 SCb stainless steel for the dissolver, product overflow line and reflux line. Stainless steel (304 L and/or 347) are used for the remaining tanks and lines subject to corrosion. Miscellaneous fittings and valves on many of the low pressure lines and vessels are Penton or Teflon plastic.

Process variables to be investigated are solid and liquid feed rates, liquid feed concentrations, liquid feed point, reflux return, product take off point, and solids bed height.

Simulated slag and crucibles were dissolved this month in both the pilot plant continuous dissolver and in the laboratory. Laboratory studies of cerium reduction (as stand-in for plutonium) and synthetic slag and crucibles showed essentially instantaneous dissolution of all material except the crucible fragments, which dissolved within two hours. These observations were verified in the pilot plant.

Screen analysis of cerium reduction slag and crucibles showed no regular particle size distribution. The sand agglomerated into large chunks which disintegrated immediately on contact with water, and gradually on contact with moist air.

WASTE TREATMENTRadiation Stability of Calcined Solids

A series of calcined waste solids have been irradiated in the Van de Graaff accelerator and the evolved gases measured and analyzed. The results show that either sulfate- or phosphate-matrix solids are quite stable and could be stored in sealed containers without significant pressure build-up. Nitrate salts, as expected, undergo complete decomposition with production of a very large volume of gas (mostly oxygen). Carbonate containing wastes (from spray calcination of neutralized Purex waste) gave intermediate results and will require additional work to determine whether venting would be required.

Pot Calcination with Phosphoric Acid

Two runs were made in a three-inch stainless steel pot to test with synthetic Purex LWV a Brookhaven scheme for converting to phosphate glasses. The pot was partially filled with phosphoric acid, brought to temperature, and the waste slowly introduced while the calcination proceeded. The first run was with a formaldehyde-killed, low-sulfate composition. This evaporated very smoothly. The second run was with an acidic, high-sulfate LWV. This, too, evaporated smoothly during the early stages, but produced several inches of foam when the temperature rose to 140-170 C. Analysis of the pot residue indicated that sulfate removal was not complete during the drying stages and that additional sulfate elimination would occur during calcination.

### Semiworks Batch Calciner

A pilot plant test (P-2) reported last month confirmed the foaming problems that seems to exist when solutions with a high salt content are batch calcined with a liquid phase in the pot. Additional study of problem was carried out by another test (P-4) under identical conditions as P-2 except the feed rate was halved to 3.7 liters/hr. allowing a low liquid depth. Foaming was greatly alleviated but the solution splashed and spattered to the extent that the entire pot interior was coated with calcined waste. Entrainment to the condensate was 0.15 percent despite the baffle covering the off-gas line outlet. In both runs the calcine melted at about 850 C and the thermal conductivities of the solids were about 0.4 BTU/hr.-sq.ft.-F/ft.

Additional studies of simulated underground waste acidified with sulfuric acid have been carried out in a series of four experiments in a small scale (3 inch diameter by 7 inch high) calciner. These studies have indicated that if a melt is to be formed at 900 C or less, the acidified wastes must have a sulfate to salt nitrate ratio of greater than 1 and a sodium to iron plus aluminum ratio between the limits of about 1.5 minimum and 8.5 maximum.

### Fluid Bed Waste Calciner Prototype

Waste calcination studies in the fluid bed calciner were continued using a feed of simulated high-acid Purex waste.<sup>(1)</sup>

Tests were made in which the "bubble-cap" distributor plate was replaced with one consisting of a double thickness layer of heavy quartz cloth. Fluidizing air distribution with the latter distributor is notably better than with the "bubble-cap" type, even with reduced pressure drop through the cloth distributor. In addition, attrition of calcine particles is less with the cloth distributor as manifested by the reduced quantity of fines entrained with the calciner off-gas (about five percent of the total calcine compared to eight percent under conditions otherwise comparable), and by the reduced quantity of attrited smaller particles in the calcined product.

A short test was made in which an aqueous sugar solution was injected into the feed stream to a final sugar concentration of 130 grams/liter of original feed. In comparison with other tests, the "sugar" tests showed the following results:

1. The calcine has a lower bulk specific gravity (1.3 vs. 1.4+). Further reduction in specific gravity would be expected under equilibrium conditions reached during extended operation.
2. The calcine is more frangible. This is in part due to the higher porosity of the "sugar" calcine.
3. The amount of fines entrained into the calciner off-gas stream is increased (to about 11 percent of the product calcine rate). This effect, however, is partly caused by the increased gas rates in the system.
4. The agglomerate formation rate and the nozzle lump formation tendency are decreased somewhat.

(1) Nominal Composition: H 6.0M, Al 0.10M, Fe 0.25M, Na 1.0M, Cr 0.008M, Ni 0.005M, SO<sub>4</sub> 0.51M, PO<sub>4</sub> 0.016M, NO<sub>3</sub> 7.0M.

- Heat requirements are decreased about 30 percent due to the exothermic reactions between the sugar and the nitrates.

The removal of solids from the wet calciner off-gas stream during the condensation step improves when the relative amount of condensables in the gas stream is increased. Under typical conditions tested, the condenser removed 62, 75 and 98 percent of the solids in the wet gas feed stream to the condenser when the calciner was operated with air as both atomizing and fluidizing gas, with steam as either atomizing or fluidizing gas, and with steam as both atomizing and fluidizing gas, respectively.

Additional data show that the solids de-entrainment factor of the non-condensable gas stream in the packed scrubber (packed with eight feet of one-inch Raschig rings and surmounted by a Yorkmesh demister section) is greater than 100. The overall solids de-entrainment factor from the calciner through the roughing cyclone, the condenser and the scrubber is greater than 10,000. (The actual number is not known because of the limit of analytical accuracy, but is expected to be an order of magnitude higher.)

#### TRANSURANIC AND FISSION PRODUCT RECOVERY

##### Strontium Recovery Program

Strontium Purification - Installation of the larger columns and accessory equipment in A-Cell for production-scale strontium purification was virtually complete at month end. One or more cold shake-down runs will be made in November with the first production run scheduled for early December.

Supporting laboratory studies were made on concentration of strontium by nitric acid elution from the last column, the complexing of high concentrations of iron in the crude Purex feed, and on sequential elution processes. Room temperature elution of strontium from the last column in the EDTA process with 6 M  $\text{HNO}_3$  rather than with buffered EDTA gave a peak concentration of 125 grams of strontium per liter, and 98 percent of the strontium was eluted at an average concentration of 52 grams per liter. The absorption break-through curve was very sharp. A similar elution at 51 C recovered 99 percent of the strontium at an average concentration of 56 grams per liter.

The concentration of iron and lead in the Purex strontium concentrate has been found to be much higher than expected and will saturate the ion-exchange resin, thus significantly decreasing the capacity of the in-cell equipment for strontium purification. Ways to overcome this difficulty are accordingly being sought. On the basis of preliminary results from a column run currently in progress, addition to the feed of a quantity of EDTA just sufficient to complex the iron and lead appears to allow these elements to pass through the column without interfering with alkaline earth loading. Major drawback is the need for an accurate analysis of each batch of feed.

Laboratory Solvent Extraction Studies - Experiments were continued to develop flowsheets for solvent extraction recovery of strontium from Purex Plant "crude cut" solution. Mini-mixer-settler runs were made with both acetate and citrate buffered concentrated feeds to determine operability and decontamination with various proposed flowsheets. Emulsion formation and poor phase disengagement led to severe flooding with acetate buffered feeds at pH 4 and with the solvent (D2EHPA) initially all in

the sodium form. Satisfactory mini operation occurred when citrate buffered feeds at pH 4 were used with all or partly sodium form solvent. Also, excellent mini operability was obtained with feeds at pH two or three buffered with either acetate or citrate when the solvent was all initially in the acid form. Feeds used in these runs were spiked with appropriate tracers to permit determination of decontamination from various crude cut constituents. Analytical data on the runs are not yet available. Batch contact data to define distribution coefficients of crude cut constituents versus pH for different buffers and solvent loading are being accumulated. It is of interest that iron extraction is much less from citrate than from acetate buffered feeds. Operation of the first extraction cycle at pH 4 without extraction of iron appears feasible. Batch contact data also indicate that, with concentrated feeds, the organic to aqueous flow ratio must be greater than one to obtain strontium distribution coefficients greater than one at any pH up to five.

Pilot Plant Solvent Extraction Studies - Investigations of the pulsed column solvent extraction behavior of strontium in D2EHFA and simulated Purex LWV crude cut have continued using a concentrated feed, i.e., 2 g/l strontium. Results indicate that:

1. Strontium extraction (pH 4) HTU's were in the range of 1.7 to 2.0 feet at 430 gal/hr-sq.ft. throughput.
2. The partition column (pH 2) dispersion characteristics and degree of stability were not significantly different for acetate or citrate buffered feeds.
3. The use of a complexing agent (trisodium - N - hydroxyethylethylene-diaminetriacetate, i.e.,  $\text{Na}_3\text{HEDTA}$ ) decreased the extractability of zirconium, iron, and lead by a factor greater than 10.
4. The problem of preferential wetting of the column internals by the organic phase (reported last month) has been considerably alleviated by either (1) more stable column operating conditions, or (2) pointing the nozzle plates toward the top interface.
5. The stripping of strontium, calcium, and lead from organic produced in extraction and partition runs is nearly quantitative with 0.1 M  $\text{HNO}_3$ .

Filtration of Strontium Product Precipitate - Strontium sulfate precipitated from strontium nitrate solution (6 g Sr/l) by adding sodium sulfate solution and digesting one hour at 80 C was ca. 100 percent retained on a 10-15 micron porosity filter (Medium Dow Corning fritted glass) but essentially all passed a 40-50 micron porosity filter (coarse fritted glass). When the precipitation was made at pH 7 by addition of ammonia solution, the solid was ca. 100 percent retained on the coarse filter.

Variations in reagents used and digestion conditions were tried in an effort to increase particle size of precipitated strontium carbonate. Solids formed under all conditions tried were ca. 100 percent retained on a medium filter but zero percent retained on a coarse filter unless a filter aid was used.

Storage of precipitated strontium sulfate and strontium carbonate with Selite filter aid for one week at 400 C had no observable effect on the ease of suspending the solids in water

In the pilot plant filtration characteristics of strontium oxalate, carbonate and sulfate are being studied to develop a shipping and storage concept. In the first

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of a series of tests, slurries of these compounds were (1) filtered on a stainless steel cloth, (2) heated to 650 F to simulate potential conditions during shipment or storage, and (3) backflushed with a volume of filtrate equal to that removed by the filtration. Current results of these studies are summarized as follows:

1. The strontium sulfate required no filter aid. About 99 percent of the cake was removed by backflush.
2. The strontium carbonate required a filter aid. About 88 percent of the cake deposited without filter aid was removed by the backflush.
3. The strontium oxalate required filter aid. No backflush tests were made.

Strontium Precipitate Stability - A study reported last month of the radiation stability of shippable solid strontium compounds was continued with irradiation of strontium carbonate samples to higher total dosages than were initially used, and with re-irradiation of samples to determine whether gas-producing impurities would "burn out." The results were summarized in an informal report, HW-67189 by F.M. Smith and G.B. Barton. Although the rate of gas production did decrease with increased dose, CO<sub>2</sub> and CO were still produced in significant amounts.

Corrosivity of Strontium Storage Solutions - Weldment coupons of 309 SCb in the as-welded condition are being exposed to boiling solutions simulating Purex Plant crude cut solutions which will be stored for subsequent Sr-90 recovery. To date corrosion rates have been less than 0.1 mil/mo.

Instrumentation - A survey was made of the condition of the old style gamma monitor cells at the Hot Semiworks. An order for 12 molded fluorothene and polyethylene cells has been placed.

Two pH flow cells will be installed in A-Cell samplers. Two gamma ion chambers will be installed alongside the cooling water effluent lines. One will monitor gamma activity in the effluent line to the crib and the other will monitor effluent to the pond.

Purex Plant Flowsheet Studies - Laboratory studies with tracer-level synthetic solutions were continued in an effort to improve strontium yield and purity in the current Purex plant head-end strontium recovery campaign. No supporting B-Cell runs were made during the month due to inability to obtain LWV feed from Purex. Highlights of the laboratory findings follow:

1. Good strontium recovery can be obtained in the sulfate precipitation step over quite a wide range of conditions (pH, sulfate, lead, and tartrate concentrations). It is particularly significant that 97 percent strontium recovery can be achieved with 0.02 M Pb at a sulfate concentration of only 0.66 molar, thus eliminating the need for added sulfate, with its accompanying dilution and complication of waste disposal.
2. Metathesis with a mixture of caustic and carbonate (2 to 5 M NaOH plus 0.5 to 1 M Na<sub>2</sub>CO<sub>3</sub>), vice carbonate or caustic alone, removed about 70 percent of the lead with a loss of one percent (or less) of the strontium.
3. In-centrifuge oxalate leaching shows promise for separation of strontium from lead and rare earths without the necessity for a second centrifugation. Direct sequential leaching of the sulfate cake did not work well, but similar

## 3. (continued)

treatment of the carbonate cake gave excellent strontium recovery at pH 0.3. Alternately, a single leach at pH 3 removed iron and the fission products other than strontium.

4. Washing a sulfate cake with disodium citrate dissolved all of the rare earths but only about ten percent of the strontium.
5. A laboratory strontium recovery run was made simulating the heels, jet dilutions, etc., involved in plant operation. Conditions were those of plant run #7. Simulation of the heels appeared to have little effect on strontium recovery or decontamination, as compared to earlier laboratory results. Overall strontium recovery was 86 percent.
6. In the course of the above work, a large discrepancy was observed in measuring the pH of some of the process solution - depending on temperature of measurement. Observed pH increased by as much as one pH unit over the temperature range 20 to 80 C. Thus, for processes in which pH control is critical, measurement of pH at different temperatures in laboratory and plant could have serious and puzzling consequences.

Strontium Concentrate Composition - A complete analysis has been made of a sample of the strontium concentrate from the #4 Purex plant production run, and a partial analysis has been completed on a sample of the pooled concentrate stored in the 244-CR vault, the latter representing material from production runs 1, 2, 3 and 4. Results are shown in the accompanying table. The barium concentration is gratifyingly low (below detection limits), and the calcium to strontium ratio is also quite favorable. However, the strontium concentration itself is lower than desired, and the high iron (and lead) would seriously reduce the capacity of planned solvent extraction and ion-exchange purification processes.

Isotopic analysis of the strontium from the #4 concentrate indicated a very high quality product with negligible natural strontium contamination. Analysis indicated 57.33 percent strontium-90, 41.86 percent strontium-88, 0.33 percent strontium-87, and 0.48 percent strontium-86. Theoretical strontium-90 content for pure fission product strontium is about 61.5 percent.

COMPOSITION OF PUREX-PRODUCED STRONTIUM CRUDE

<u>Constituent</u>	<u>Run #4 Concentrate</u>	<u>244-CR Vault Sample (Runs 1, 2, 3 and 4)</u>
Fe	0.33 g/l	1.25 g/l
Pb	0.15 g/l	0.24 g/l
Na	3.2 g/l	2.0 g/l
Ca	0.023 g/l	N.A.
Ba	<0.002 g/l	N.A.
Sr	0.050 g/l	N.A.
Sr-90	$1.28 \times 10^{13}$ d/m/ml	N.A.
Sr-89 and 90	$4.43 \times 10^{13}$ d/m/ml	$4.75 \times 10^{13}$ d/m/ml
Ce-Pr	$5.63 \times 10^{12}$ $\gamma$ /m/ml	$2.0 \times 10^{13}$ $\gamma$ /m/ml
Ru	$6.10 \times 10^{11}$ $\gamma$ /m/ml	Not detectable
Zr-Nb-95	$1.06 \times 10^{13}$ $\gamma$ /m/ml	$2.2 \times 10^{13}$ $\gamma$ /m/ml

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### Fission Product Packaging

Strontium Nitrate Calcination - Exploratory studies on the direct denitration of strontium nitrate included two approaches with the agitated gas-fired pot: (1) batch calcination of  $\text{Sr}(\text{NO}_3)_2$  crystals, and (2) continuous calcination of a water solution of  $\text{Sr}(\text{NO}_3)_2$ .

The charge of crystals calcined uneventfully at 600 to 700 C. Considerable corrosion of the stainless steel pot took place. The residue contained 88 percent  $\text{SrO}$  and eight percent insoluble matter assumed to be corrosion products. The water solution (400 grams  $\text{Sr}(\text{NO}_3)_2$  per liter) was fed at about 10 ml/min to the pot, maintained at 500 to 700 C. Dusting was severe, calcination was incomplete, and the incompletely calcined material adhered to cooler portions of the pot.

Further tests are planned to determine the best method, operating conditions, and materials of construction for the calcination of  $\text{Sr}(\text{NO}_3)_2$ .

Salt Drying and Crushing - Further tests were made on the "king sized hotplate" in batch conversions of brine ( $\text{NaCl}$  - as a stand-in for  $\text{CsCl}$ ) to a dry salt. In spite of relatively severe corrosion of stainless steel surfaces used in the feasibility studies, the resultant slab of salt continued to be easy to remove after the equipment cooled to room temperature. The successful cleavage between the slab and the container is believed to be caused by differential thermal contraction. Salt cake removal and crushing has been successfully accomplished with (1) a plate-type rotary crusher, (2) a roller chain crusher-remover, and (3) a conventional cube remover from an ice tray. The latter produced cubes readily transferable to a crusher.

### EQUIPMENT AND MATERIALS

#### Magnetic Pulser

A magnetic pulser with two solenoids driving a 1.55-inch diameter piston was operated successfully pulsing water in a 1-inch glass column. Pulse frequencies and amplitudes up to 100 cyc/min and 2 inches were attained. Previous problems with severe burning of electrical contacts were corrected with diodes. A study of magnetic pulser parameters will follow this initial operation.

#### Corrosion in Heat Exchanger Tubes

Non-uniform corrosion attack observed in process heat exchangers prompted an investigation of several chemical and concentration cells which might be responsible. The cells were established between 304-L stainless steel electrodes of equivalent area. Cell currents were measured under conditions of zero external resistance; cell potentials were measured with a pH meter. Corrosion rates measured indicate the chemical and concentration cells studied would have little effect on the overall corrosion rates except at very adverse surface area ratios. A specimen of 304-L scaled by heat treatment showed a high corrosion rate as the anode in boiling 65 w/o  $\text{HNO}_3$ . The scale was only partially covering and the corrosive attack was primarily through local action.

#### Effect of Fluoride on Corrosion by Purex LWV

Attempts to obtain meaningful data on the effects of added fluoride on the corrosion of 304-L stainless steel by synthetic Purex LWV have not been successful

ue to oxidation of chromium in the laboratory equipment used. In tests in boiling 6 M  $\text{HNO}_3$  - 0.01 M HF, aluminum to fluoride ratios of four and six are required to reduce corrosion rates for 304-L to 0.5 and 0.2 mil/mo., respectively. Tests in 8 M  $\text{HNO}_3$  - 0.01M HF are in progress.

#### Ceramics Evaluation for 234-5

A second 99.9 percent Yttria crucible was tested in a barium-potassium-sodium chloride solution. After 32 hours some of the solution was still in the crucible but some had percolated through. After 96 hours the salt had all percolated through the crucible.

A Li-Al Silicate crucible has been tested for two 100-hour periods at 750-800 C with the same solution as above. During this test hydrogen is bubbled continuously through the solution. There has been no detectable percolation of the salt through the crucible. At present the crucible is being subjected to a third 100-hour test.

#### Non-Metallic Materials Evaluation

Three samples of Durachor 4000, a product of the Ceilcote Company, were tested for use in the presence of 35 percent nitric, 3.5 percent hydrofluoric acid. After 10 days at room temperature and 10 days at 35 C, there was no detectable damage to the resin. There was damage to the glass roving reinforcing of one sample.

#### PROCESS CONTROL DEVELOPMENT

##### C-Column Test Facility and Studies

The C-Column Test Facility was operated to test the operability of the instrumentation of the unit and to examine the reproducibility of the data obtained.

The Data Reduction code was modified to include the calculation of (1) the standard deviations of several controlled variables, (2) the density of the two phases at any sampled port, and (3) the LCF uranium concentration from the LCF photometer reading.

Data from ten runs were processed using the modified code. The average values of the standard deviations for the controlled column variables which were obtained during this series of runs are tabulated as follows:

<u>Variables</u>	<u>Nominal Value</u>	<u>Average Standard Deviation</u>
LCX Acid	0.7 g/l	0.04 g/l
LCF Uranium	90 g/l	1.10 g/l
LCX Flow	1000 ml/min	14 ml/min
LCF Flow	1000 ml/min	14 ml/min
LCX Temperature	--	0.8 deg C
LCF Temperature	--	2.1 deg C
Typical mid-column Temperature	--	0.7 deg C

In addition, one run was made where the mid-column photometer was left in one sampling port for three hours. This particular port was located at the point in

the column which had the largest concentration gradient with respect to column position, thus it would be expected to have the largest random variation in concentration. The standard deviation of the readings obtained during this period was 0.84 gram/liter, at an average concentration of about 30 g/l. It is expected that this would be the maximum deviation over the concentration range 1-100 grams/liter.

The temperature indicating elements in the column were found to be sensitive to the ambient temperature in the canyon. This has been improved and the eight thermohms now agree within 2 C at a nominal operating temperature of 50 C.

#### Bubble Counter Study

Satisfactory operation of the bubble counter instrument system for mid-point samples of the column in the above facility was obtained using input signals from the internal calibration system. It is now possible to count bubbles on the twenty channel analyzer. However, the problem of drawing a representative sample from the column will require additional study.

With the two probe sizes now being used, bubbles of varying lengths can be drawn from the column. It appears that the bubbles may be breaking up upon entering the probe.

#### Calciner Furnace Control System

The remote automatic set point programmer has arrived and is being evaluated for use with the K-Cell furnace shell temperature controller. Since a mechanical cam-driven slide wire is used in the set point programmer, synchronization of the finish section shell temperature with the feed section shell temperatures will be insured by cutting a cam to precisely match the existing finish section shell temperature versus time curve.

#### Redox Column Control System

A list of control components required for the Redox 1B, 2A and 2B automatic column control system is being prepared. Most of the components will be pneumatic, with a 3 to 15 psi range to match the existing Foxboro Dynalog Model 40 type controllers and recorders. Transient column frequency response tests will be run as soon as the 1BP plutonium neutron monitor is installed. The transient tests will aid in determining controller settings to obtain a stable control system.

#### Electrolytic Conductivity Cell

A prototype conductivity flow cell has been fabricated from 1/4-inch stainless steel pipe which incorporates the seal - insulator described last month. Tests with the prototype indicate that the cell constant can be varied from 1 to 100. Under normal flow conditions, the cell requires about 1 minute to sense the change from 0.9 M nitric acid to 2.0 M nitric acid. Tests and evaluations are continuing.

#### ANALYTICAL AND INSTRUMENTAL CHEMISTRY

##### Simultaneous Determinations of Lead, Strontium, and Zirconium by X-Ray Emission

Increased analytical needs for strontium recovery studies led to the development of a new method for the simultaneous determinations of lead, strontium, and

zirconium. Important aspects of the method were the use of an X-ray tube with a tungsten target and the use of rubidium instead of mercury as an internal standard. The L beta 1 and 2 lines of lead; the K alpha lines of strontium, rubidium, and zirconium; and a background near each of the analytical lines were measured using a sodium chloride diffraction crystal and a scintillation detector. The use of a single internal standard for determining three elements reduced sample preparation and counting time, as compared to the use of separate preparations of a sample with a different internal standard for each unknown. Precision of the strontium and lead determinations was  $\pm 5$  percent and the detection limit, 10 ppm. The precision and detection limit for zirconium were  $\pm 10$  percent and about 100 ppm. Poorer zirconium performance resulted from both a considerable difference in wave lengths of the zirconium K alpha line and the rubidium K alpha line, and an uncertainty in correcting for the influence of the strontium K beta lines at the zirconium K alpha line.

#### Direct Determination of Iron in Organic Samples

A method for directly determining ferric iron in organic samples was adapted to support strontium recovery studies. Sample, diluted with colorless Purex solvent, was contacted with 50 percent potassium thiocyanate. The resultant red ferric thiocyanate complex was completely retained by the organic phase. Its light absorption at 480 m $\mu$  indicated original iron concentration. Results were comparable to those obtained by the wet ashing - orthophenanthroline method.

#### Coulometric Determination of Plutonium in the Presence of Fluoride Ion

Fluoride ion interfered with the coulometric determination of plutonium by shifting the half-wave potential of plutonium to more or less negative values, depending upon the fluoride ion concentration. Beside not being able to select the correct potential for plutonium, one found the shift in potential was in the direction of the half-wave potential of iron to the extent that iron became a significant interference in the plutonium titration. The shift in potential resulted from a complex formation by fluoride and plutonium ions. Adding aluminum, to subdue the fluoride ion, reduced the shift in the plutonium potential. The shift was essentially eliminated with at least eight times as much aluminum as fluorine. Thus, plutonium was successfully measured in hydrofluoric-nitric acid dissolutions of PuF<sub>4</sub> and PuO<sub>2</sub>.

### NON-PRODUCTION FUELS REPROCESSING

#### Materials of Construction

Laboratory-scale dissolvers fabricated from BMI experimental alloys HAPC-4, -11, -20 and -21 were exposed to failure in boiling 1 M HNO<sub>3</sub> - 2 M HF. All of the dissolvers except one of two fabricated from HAPC-20 failed after less than one month exposure due to preferential weld metal attack. The welding done on these dissolvers was not top quality; penetration was poor in many places. Attempts to rectify the initial poor welding by laying down a heavy bead on top of the original seam were not wholly successful. Carbon content of the alloys will be checked since some attack occurred in heat sensitized zones indicating high carbon.

#### Criticality Feed Materials Preparation

Feed material for the third FCTR experiment to determine K<sup>∞</sup> vs. H/U atomic ratio for three percent U-235 enriched homogeneous uranyl nitrate-water systems were

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prepared and delivered. The shipment consisted of approximately 275 pounds of boron carbide-poisoned, crystalline uranyl nitrate trihydrate with sufficient polyethylene pellets to bring the H/U atomic ratio to 13.

## REACTOR DEVELOPMENT - 4000 PROGRAM

### PLUTONIUM RECYCLE PROGRAM

#### Processing PRTR Fuels

Ruptured PRTR fuels will be transported to the Redox plant in sealed aluminum alloy cans. The alloy currently proposed for fabrication of the cans is 6061 which contains from 0.4 to 0.8 weight percent silicon. Under some circumstances (badly ruptured fuel elements) it may be desirable to dissolve these cans in  $\text{HNO}_3\text{-Hg}(\text{NO}_3)_2$  and process the solutions in the Redox plant. A simulated Redox process feed solution was prepared by dissolving 6061 alloy in  $\text{HNO}_3\text{-Hg}(\text{NO}_3)_2$ , butting the solution with UNH and concentrating it to 1.0 M  $\text{Al}(\text{NO}_3)_3\text{-1.25 M UWH}$ . Following simulated plutonium oxidation, standard dispersion disengaging time tests were made using plant hexone. Thick emulsions were formed in both phases. A solution prepared by dissolving X8001 aluminum (0.35 w/o Si max.) was used to dilute the 6061 solution in preparation of simulated Redox feeds. At dilutions of four or more parts X8001 solution to one part 6061 solution, dispersion and disengaging behavior was comparable to "normal" Redox feeds.

#### Salt Cycle Process

Liquidus Curve for NaCl-KCl-UO<sub>2</sub>Cl<sub>2</sub> System - A differential thermal analysis apparatus has been used to determine the melting points of equimolar NaCl-KCl mixtures with various amounts of UO<sub>2</sub>Cl<sub>2</sub>. As the mole ratio of NaCl:KCl:UO<sub>2</sub>Cl<sub>2</sub> is varied from 1:1:0 to 1:1:1.39 the melting point decreases monotonically from 660 C to 490 C. Measurements could not be carried to UO<sub>2</sub>Cl<sub>2</sub> concentrations greater than 41 m/o because of thermal decomposition of the UO<sub>2</sub>Cl<sub>2</sub>.

Electrolytic Deposition of UO<sub>2</sub> - The feasibility of cathodically depositing UO<sub>2</sub> out of various chloride mixtures melting at lower temperatures than the equimolar NaCl-KCl system (MP 660 C) has been explored in scouting experiments.

To date the most attractive possible alternate to the NaCl-KCl melt appears to be the KCl-PbCl<sub>2</sub> eutectic (52.7 m/o PbCl<sub>2</sub> - 47.3 m/o KCl, MP 411 C). Electrolyses in this melt at one volt and 0.5 ampere current and at temperatures of 450 to 500 C produced adherent crystalline UO<sub>2</sub> deposits ranging in oxygen/uranium ratio from 2.011 to 2.028 and with Pb and K contents of the order of 200 ppm each. In addition to its lower melting point, this melt has the advantage that it can be readily maintained dry. Likewise (and probably because of the lower temperature of operation) there is much less tendency for UCl<sub>4</sub> to be formed through reaction of UO<sub>2</sub>Cl<sub>2</sub> with the graphite anode than is the case with the NaCl-KCl melt. The principal disadvantage of this melt is the low aqueous solubility of lead chloride which makes its removal from UO<sub>2</sub> deposits difficult.

Attempts to cathodically deposit UO<sub>2</sub> from other chloride mixtures of lower melting point than the NaCl-KCl mixture have met with varying success.

Electrolyses in equimolar KCl-ZnCl<sub>2</sub> containing up to 2 m/o TiCl<sub>3</sub> produced adherent, crystalline UO<sub>2</sub> deposits only at temperatures above 550 C. At lower temperatures

he deposit was very finely divided, poorly adherent, and there was some evidence that metallic zinc was present in the deposit. Likewise, the effective cell resistance was substantially higher at low temperatures. Deposits at the lower temperatures showed oxygen/uranium ratios of 2.13 to 2.29 vice 2.0097 in a deposit made at 600 C. Generally similar behavior was noted with the KCl-ZnCl<sub>2</sub>-CuCl system with metallic copper being co-deposited out of 0.5 or 0.3 w/o CuCl systems. No metallic copper was apparent in a deposit out of a melt containing 0.15 w/o CuCl.

The equimolar NaCl-MgCl<sub>2</sub> system (which melts at about 550 C) proved difficult to dry but once dried showed no great tendency to take on moisture from the air. Dissolution of U<sub>3</sub>O<sub>8</sub> in this system proceeded at a rate comparable to that in NaCl-KCl and electrolysis produced a coarse, adherent deposit. Interest in this system will probably be largely contingent on the outcome of the present studies seeking to determine the effect of hydroxide in melts on the nature of the UO<sub>2</sub> deposit formed.

No successful depositions were obtained out of the NaCl-KCl-AlCl<sub>3</sub> systems and the graphite anode was badly swollen. Depositions out of the NaCl-AlCl<sub>3</sub> system with an aluminum anode produced adherent cathode deposits but these were very finely divided.

Pilot Quantities of UO<sub>2</sub> - Electrolysis of the salt bath with repeated uranium charging has been demonstrated with little effect on the product UO<sub>2</sub> quality. During a four week period eleven electrolyses were carried out with a single charge of equimolar NaCl-KCl under conditions previously described. The salt was cooled, broken up and reheated each week. During this period electrolytic UO<sub>2</sub> with an average O/U ratio of 2.015 was produced from 25 lb. of UO<sub>2</sub>Cl<sub>2</sub>·H<sub>2</sub>O, 25 lb. of UO<sub>3</sub>, and 3 lb. of U<sub>3</sub>O<sub>8</sub>. About one percent of the total uranium charged was left in the salt bath at the end of the run.

The UO<sub>2</sub> is deposited on the graphite cathode in continuous sheets up to 4 mm thick. Examination of a cross section of one deposit shows that in a thin layer next to the electrode the crystals are quite small (10-50 microns). In the next 1.5 mm the crystal structure is chaotic with voids and equiaxial crystals which are generally much larger than at the electrode surface. In the outer 2.5 mm of the deposit the UO<sub>2</sub> forms columns perpendicular to the electrode surface with the surface toward the salt bath having crystal faces up to 2.5 mm across. The outer formation appears to be most desirable because of its large crystals, apparent high density, and regular crystal shape.

Long runs with thick UO<sub>2</sub> deposits may promote growth of large columnar crystals. However, run times have been limited to less than 4 hours by depletion of the uranium in the salt bath and conversion of as much as 50% of the uranium in solution to U(IV) which results in high potential drops or low currents. The U(IV) is believed to be a product of a side reaction between UO<sub>2</sub><sup>++</sup>, Cl<sub>2</sub> and graphite. A recirculating system providing for continuous uranium addition and U(IV) destruction would decrease this difficulty.

Decladding Studies - Laboratory scale studies were conducted to determine whether chlorinating agents could be used to dissolve oxidized Zircaloy in molten equimolar NaCl-KCl at approximately 800 C. HCl and Cl<sub>2</sub> were used successfully in the tests. The Zircaloy dissolves in an uneven manner presumably because of the pitting attack

necessary to penetrate the oxide film on the metal. The dissolution rate for each gas was dependent on the rate of gas flow through the reaction area. Little difference was observed between the reaction rates of  $\text{Cl}_2$  or  $\text{HCl}$ . Most of the  $\text{ZrCl}_4$  formed during the reaction was found in the molten salt.  $\text{ZrO}_2$  which is flaked off during the reaction is insoluble in the salt.

Materials of Construction - Samples of Armco 17-14 Cu-Mo and 15-7 Mo, INOR 1, Inconel X, Hastelloy W, Monel, Alchrome D, Alnico 5, Alnico 2, and 25 and 50 percent cold-reduced Armco 17-7 PH were exposed to  $\text{HCl}$ -sparged equimolar  $\text{NaCl-KCl}$  melt at 750-800 C. Only Alchrome D, Alnico 2 and Alnico 5 had corrosion rates equal to or less than 100 mils/mo. The rate for Alnico 2 was 35 mils/mo.

During exposure to  $\text{HCl}$ -sparged equimolar  $\text{PbCl}_2\text{-KCl}$  melt at 500 C, samples of Hastelloy B, D, and W and Alchrome D corroded at rates of 100, 18, 81 and 50 mils/mo, respectively.

### RADIOACTIVE RESIDUE FIXATION

#### Radiant-Heat Spray Calcination

Additional spray calciner runs were made with synthetic alkaline waste corresponding to a mixture of neutralized Purex 1W and organic wash waste (OWW). Results substantiated those reported last month but included a run with no sugar addition. This, too, calcined without difficulty and actually produced the highest powder and sintered densities of the series (0.735 and 2.08 g/cc, respectively). However, residual nitrate concentration in the powder was 5.66 percent. Use of 70 to 100 grams/liter of sugar (0 to 30 percent stoichiometric excess) gave a residual nitrate concentration of only 0.04 percent.

A spray calciner run with continuous melt-down was made with simulated Purex acid waste to produce a melt comparable in size to those produced in the 321 Building experimental pot calciner. The 4-inch diameter by 13-inch long schedule 40 stainless steel pot was attached to the bottom of the filter section of the spray calciner and heated to 800 C. A total of 30 liters of feed was calcined and produced about 1.6 liters of melt, a volume reduction factor of over 18. Melt density was 3.0 g/cc, and there was no evidence of corrosion of the pot. Sodium to metal ion ratio ( $\text{Na/M}$ ) was 1.05 rather than 1.5, suggesting that a good melt may be obtained at a somewhat lower sodium concentration than previously supposed. Sulfate to metal nitrate ratio was 5.3.

In the proposed A-Cell spray calciner, as well as in one configuration for a plant-scale unit, the filter unit is connected to the bottom of the column by a slanting diagonal pipe. It is intended that the powder blown off of the filter would slide back down the pipe counter-current to the off-gas flow.

A test rig including a nitrated 6-inch by 4-foot aluminum pipe was set up to determine allowable gas flow rates and optimum slant angle. Results showed that the scheme is workable and that optimum inclination angle is about 50 to 55 degrees from horizontal. Further tests will be made on the laboratory calciner.

The filter media test program continued with testing of National Filter Media glass cloths G-201-a and G-202-c and Carborundum Company's Fiberflax cloths L-136 and L-144 T. The latter two are composed of aluminum silicate. Decontamination factors ranged from 667 to 4370 depending on filter media and dust loading. The Fiberflax materials gave better decontamination performance than the glass or quartz cloths,

and the pressure drop was not significantly higher. In all cases, the filter cake is probably doing most of the filtering since the decontamination performance seems to vary linearly with the pressure drops. The cloths will now be tested with blow-back.

### Mineral Reactions

Laboratory experiments were performed to investigate the influence of flow rate on the capacity of clinoptilolite for decontaminating coating waste. For this purpose a synthetic coating waste supernatant solution was spiked with radiocesium and radiostrontium and passed through a bed of clinoptilolite at a flow rate of 6 gal/ft<sup>2</sup>/hr. Forty-five bed volumes passed through the column before radiocesium was detected in the effluent. This appears to indicate a mineral bed capacity at this flow rate considerably improved over that which was earlier obtained with faster flows (50 gal/ft<sup>2</sup>/day). No strontium breakthrough was detected at this point, even though no phosphate was present in the synthetic waste solution to react with calcite in the mineral bed.

Preliminary experiments were performed in which synthetic, partially-neutralized Purex 1W waste was passed through beds of clinoptilolite. The solution was adjusted to pH 1.5 before passage through the bed. The solution would not pass through a bed of the mineral until it was thoroughly leached with acid. As was expected, radiostrontium broke through the column immediately under these conditions but a fair capacity for cesium was found.

Examination of the fusion of clinoptilolite indicated the fusion temperature to be about 1200 C with a hard, shiny, green product being formed.

Calcite was identified by X-ray diffraction in selected impurities removed from surfaces of several pieces of clinoptilolite. No gypsum could be detected in this material. Neither calcite nor gypsum could be identified in crushed and washed clinoptilolite, probably because of the low concentrations involved. The reported content of calcite and gypsum based on chemical analyses is 1.4 percent and 0.1 percent, respectively. It was not possible to detect differences between unirradiated clinoptilolite and samples irradiated to  $5.5 \times 10^9$  R by means of X-ray diffraction or differential thermal analyses.

The calcite-phosphate reaction was found to be ineffective for removing Ce-144, Ru-106, and Zr-95 - Nb-95 from Purex tank farm condensate. The reaction does improve strontium removal over that by a bed of clinoptilolite.

### Condensate Stream

During Micro Pilot Plant Run 10, Purex Tank Farm condensate was passed through activated carbon to remove organic and then through a bed of 1/16-inch pellets of Linde Molecular Sieve 4A. At a constant flow rate of 6 ml/min/cm<sup>2</sup> the decontamination factor for cesium increased from 380 after 40 column volumes had been passed through the bed to 2000 after 180 column volumes had been treated.

Modifications were made to the Micro Pilot Plant to allow long term evaluation of the decontamination ability of activated carbon followed by clinoptilolite on Purex Tank Farm condensate. Run 11 was started toward the end of the month. About 1000 column volumes of waste have been passed through the clinoptilolite with about 90 percent or more of the gross beta activity being removed.

BIOLOGY AND MEDICINE - 6000 PROGRAMGeology and Hydrology

Standard churn-drilling methods, long employed at Hanford, have been the mainstay of Hanford's sub-surface exploration and monitoring program, but fail to provide some of the detailed information now needed. The new drilling proposal now under consideration envisions studies to determine ways of procuring more information, a greater variety of information, and more accurate data.

Wells in process of drilling at month end appeared to have encountered previously undetected but suspected channels in the surface of the Ringold formation. Well 699-57-83 encountered an evidently southeastward-trending channel south of Gable Butte and north of 200 West Area. This channel, the depth of which is not yet known, was not detected by pre-existing wells in the vicinity on a one to one-and-a-half mile spacing. A considerable part of the ground water from the 200 West Area ground water mound is believed to flow through this channel.

The second channel, in a relatively inaccessible and previously unexplored area, was located by well 699-26-3. It lies between Route 2S and the Columbia River. It provides a means of rapid egress of water from beneath the Hanford Works into the Columbia River, hence is a crucial site for monitoring.

Two research wells were completed at a location one mile west of the 200 West Area to provide a facility for testing instruments for measuring in-well ground water velocities. One of these was drilled to basalt bedrock, encountering a confined aquifer directly above the basalt. The aquifer is confined by a 100-foot thick bed of impermeable clay. After this well was perforated in the zone of the confined aquifer the static water level in the well was 212 feet below the land surface. The second well, 20 feet away, bottoms in the clay bed and is perforated above the clay layer in the zone of the unconfined ground water aquifer. The static water level in this well is 170 feet below the land surface. Thus, the piezometric head in the confined aquifer is 42 feet lower than that of the upper, unconfined aquifer. A strong flow of water would occur in any well penetrating the clay bed and which was perforated throughout its length. This unusually large head difference between the two aquifers is ascribed to the nearby 200 West artificial ground water mound.

A laboratory flow system was used to test the validity of a derived mathematical relationship between solution density and viscosity and the flow pattern. The system studied involved the flow of the miscible liquids having different densities and viscosities. A readily-detected point of change in the flow path of the high-density liquid as the head gradient across the system was diminished was used as a test of the derivation. A scale transformation was found that defined a new hydraulic potential from which predicted changes in the flow system coincided with observations.

Of ten samples of Hanford Works soil submitted to the University of California, Department of Irrigation, for hydraulic testing, five were completed. The tests involve the determination of capillary conductivity and the relationship between moisture content and capillary pressure in the imbibition cycle. The incomplete results examined during an informal contact with the laboratory seem satisfactory. The results of these measurements are expected to assist with estimates of flow paths and moisture distribution patterns in unsaturated systems, such as would be found beneath a leaking waste tank.

visit by Chemical Effluents Technology personnel to the NRTS, Idaho Falls, at the invitation of U.S. Geological Survey personnel there, resulted in the profitable mutual exchange of information. Geological and hydrological problems at the two sites are remarkably parallel although NRTS problems center largely around the basalts, whereas Hanford problems are more concerned with post-basalt sediments. Exploration techniques used at each site are readily applicable at the other site in comparable rock environments.

#### Soil Chemistry and Geochemistry

Many radioisotopes, including ruthenium, can be removed from waste solutions by adsorption on a continuously-generated hematite ( $\text{Fe}_2\text{O}_3$ ) layer formed by oxidation of ferrous iron upon contact with calcite ( $\text{CaCO}_3$ ). The calcite reacts with hydrogen ions to increase hydroxyl ion concentration in a thin layer of solution, leading to hematite precipitation at the location of dissolved calcite. Radioisotopes such as Ru-106 and P-32 are adsorbed on the forming hematite. The process continues as long as the supply of calcite and ferrous ions lasts. Low concentrations (5-50 ppm) of ferrous sulfate initiate the reaction. In passing through limestone ships a solution containing 5.6 ppm  $\text{FeSO}_4$  was decontaminated with respect to P-32 about twice as effectively as a solution without  $\text{FeSO}_4$ . The discovery is the subject of an invention report.

Molten salt experiments using Na-22 traced erionite and clinoptilolite in fused lithium nitrate and potassium nitrate systems confirmed the conclusions reached with cesium-traced erionite and clinoptilolite. The hydration state of a cation before entering the zeolite lattice does not cause the observed selective replacement series. The reversal at high temperatures from selective to coulombic replacement series occurs most readily with clinoptilolite. This tends to indicate a favorable stereochemical relationship between internal water, cations, and cationic adsorption sites as a probable cause of the intense selective replacement action of the zeolite.

#### Ground Waste Investigations

Laboratory research was completed in currently planned phases of a study of soil adsorption in unsaturated systems. Of the experimental results obtained, those from five unsaturated flow experiments and five saturated flow experiments are deemed satisfactory and warrant comparison. The experiments involve ion exchange in soils ranging from 36 to 100 percent moisture saturated. From the breakthrough curves, the soil ion-exchange capacity for radiostrontium from the common influent solution used in all cases was calculated. No significant difference in adsorption capacity was found, regardless of the degree of moisture saturation. This finding is of significance in evaluating the importance of lateral spreading of wastes disposed to the ground.

#### Field Apparatus Development

The scintillation well probe was calibrated for quantitative field use. Calibrations were performed in simulated well structures, with and without water contacting the probe. It was determined that 70 percent of the response from 0.51 Mev gamma photons is contributed by the isotope within the well casing. Overall sensitivity for Sr-85 (and Ru-106) is  $2 \times 10^{-6}$  uc/cc, a value low enough to make the method attractive for studying wells known to contain ruthenium.

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The thermistor vertical flow meter was used in the field after resealing leads. In a well where the depth to ground water is shallow, vertical currents were 20 - 40 cc per minute at 4 feet below the ground water level and ranged down to 0 - 15 cc per minute at lower points. A new type flowmeter is being developed using an orifice and sensitive pressure difference detectors.

#### Bioassay Procedures

A Np-237 bioassay procedure was developed through modification of the routine Pu-239 bioassay procedure. By addition of ferrous iron to reduce plutonium to the non-extractable trivalent state and use of three 0.45 M TTA-in-benzene extractions, Np-237 is separated with a yield of 90 to 95 percent from the Pu-239. After electro-deposition and exposure to nuclear track emulsions the Np-237 is determined with a yield of 70 percent and a sensitivity of about 0.05 d/m per 24 hour sample. Although this procedure is satisfactory further work to increase the yield at the electrodeposition step is planned.

#### Radiation Protection Studies

Experiments were begun in cooperation with the Pharmacology Operation to test the ability of erioglaucine to protect dogs from an acute lethal exposure to X-rays. The larger size of the test animal allows its physiological responses to the dye to be measured more easily than was possible with mice or rats. Upon injection of the dye the dog turned blue and stayed blue for several days (in contrast to mice and rats which lost color and presumably the effectiveness of the dye in a few hours). Upon completion of the physiological tests, bi-lateral X-ray exposure is planned to give normally lethal dosages.

The irradiation of agar gels was examined further to provide information for bridging the gap between the radiation chemistry of solutes in dilute aqueous solution and in living tissue. The effect of radiation on the gel structure itself was not found to alter the diffusion rate of erioglaucine in 4 percent agar up to the syneresis point of the gel at  $2.6 \times 10^6$  rad. Further diffusion experiments and radical-scavenging reactions in specially-purified agar are planned.



Manager  
Chemical Research and Development

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## BIOLOGY OPERATION

## A. ORGANIZATION AND PERSONNEL

No significant changes occurred during October.

## B. TECHNICAL ACTIVITIES

## FISSIONABLE MATERIALS - 2000 PROGRAM

## BIOLOGICAL MONITORING

An expanded biological monitoring program, planned for one year duration was initiated during October, 1960. This study is designed to check present patterns of geographical and interspecies levels of contamination relative to the biological indicator organism values. In addition, extensive sampling of waterfowl taken by sportsmen from the hunting area surrounding the HAPO reservation was initiated to determine levels and incidence of contaminants originating from HAPO.

Radiiodine Contamination

Concentrations of  $I^{131}$  in the thyroid glands of jack rabbits were about five times less than those observed one year ago. Values follow:

<u>Location</u>	<u>µc/g Wet Thyroid</u>		<u>Trend Factor</u>
	<u>Average</u>	<u>Maximum</u>	
Wahlake Slope	$2 \times 10^{-4}$	$3 \times 10^{-4}$	+ 2

For the study of incidence of waterfowl in the game bag of sportsmen, heads of game supplied by the hunters are being analyzed for radioelement composition. Preliminary analyses of approximately 200 samples indicate that about 12 per cent contain amounts of radioelements slightly above background levels. These samples are being measured for specific isotopes.

#### Salmon Survey

Aerial survey of the salmon nesting in the Columbia in the vicinity of WAPO were continued. Two areas were observed where nests had occurred in shallow water during the latter part of September and were subsequently destroyed by drop in water level produced by water control actions of the upstream dams.

#### Effect of Reactor Effluent on Aquatic Organisms

Equipment necessary to test the comparative toxicity of effluent passed through a bed of aluminum turnings is in place at the 1706-KE laboratory and the test will be started early next month.

#### C. columnaris

Fall collection trips have shown extensive columnaris infection in the artificial salmon spawning channel just below McNary Dam. Scrap fish were found to be fully as heavily infected as were salmon collected in the same area. Organisms were so plentiful in one collecting period that they were readily obtained from small aliquots of the water. Most of the organisms have been obtained from gills, only a few from kidneys of fish.

Occasional organisms have been isolated from fish from areas of the Snake River and other locations on the Columbia River. These strains which are being collected at the present time will be evaluated for their virulence when salmon fingerlings are available as test organisms.

#### BIOLOGY AND MEDICINE - 6000 PROGRAM

##### METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

#### Zinc

The intracellular distribution of  $Zn^{65}$  in the liver at 1, 3, and 5 days post injection was studied in normal, starved, and partially hepatectomized rats. In all cases the highest  $Zn^{65}$  uptake was seen at one-day post injection. The supernatant fraction showed the highest  $Zn^{65}$  activity per ml protein; the mitochondrial fraction was lowest on this basis. At one-day post injection,  $Zn^{65}$  concentration in the regenerating liver was more than twice that of the control animals, which in turn was somewhat greater than the concentration of  $Zn^{65}$  in the livers of starved animals. These differences were less marked at three and five days post injection. Precipitation of proteins with 0.5 N perchloric acid releases  $Zn^{65}$  while precipitation with acetone results in retention of the  $Zn^{65}$  in the precipitate. At least a portion of the  $Zn^{65}$  in the supernatant fractions was shown to be non-dialysable.

In compiling data on zinc-65, it was noted that some workers report that the body burden of stable zinc in man was 1 - 3 g with a daily intake of 10 - 15 mg/day. On the basis of these data, the values for the MPC for Zn<sup>65</sup> in drinking water for occupational exposure may be high by at least a factor of 5.

### Calcium

In an experiment to distinguish between active and passive uptake of calcium by barley seedlings, the transpiration rate was observed to be eight times higher in the light than in the dark. In addition, a four-fold reduction in transpiration rate was observed in plants which had their roots in 10<sup>-5</sup> M dinitrophenol. This effect of DNP is contrary to results obtained by other workers using legume seedlings. In view of these results, the effect of DNP on transpiration of bean seedlings will be investigated. Calcium uptake by the barley seedlings is presently being determined and will be related to transpiration. Calcium is being determined both through EDTA titration and by tracer techniques.

### Strontium

In studies of the absorption of Sr<sup>85</sup> and Ca<sup>45</sup> from the perfused intestine of the intact rat, it was shown that neither flow rate nor perfusate volume had an appreciable effect on results.

Sampling of tissues of fish which had been force fed Sr<sup>90</sup>-Y<sup>90</sup> was completed. These were fish which had been sacrificed or had died during the course of the experiment. The samples will be assayed for Sr<sup>90</sup> in order to define more precisely the body burden and the distribution of the nuclide. Included is an evaluation of the reliability of using one or a few scales from a fish as an index of total body burden.

Cooperative studies with the Biological Analyses Operation in obtaining differential counts on leukocytes in fish blood showed much promise.

Studies were initiated on the movement of Ca<sup>45</sup> across the gills of trout using the perfusion technique. Results are to be integrated with measurements with Sr<sup>85</sup> to establish Sr-Ca relationships.

The addition of 2 to 3 times normal calcium to the diet of three ewes had no appreciable effect on the relative movement of Ca<sup>45</sup> and Sr<sup>90</sup> (added in vitro in serum) through a dialysis membrane under centrifugation. Stable calcium is now being fed at about four to six times normal dietary levels in an attempt to verify the high diffusibility of Sr<sup>90</sup> relative to calcium observed previously in serum of lactating ewes fed large amounts of calcium gluconate. (In vitro spiking of Ca<sup>45</sup> and Sr<sup>90</sup> is also planned for milk to determine if calcium is bound more readily than strontium.)

### Iodine

Equations were derived for the retention of inhaled I<sup>131</sup> in the thyroid following exposure for varying periods of time. The equations (are for the retention for periods greater than 1 hour and) are based upon a formulation derived by Healy on the basis of experimental work on sheep at the Experimental Animal Farm and are for the retention of I<sup>131</sup> in the thyroid following single

oral administration. The use of these equations appears reasonable since Willard and Bair observed that the time for maximum thyroidal uptake and the effective half-life of  $I^{131}$  are comparable for acute exposure by inhalation and single oral administration. Using the maximum value of 8 per cent uptake of an inhaled dose in the thyroid observed in sheep, calculations suggested that the MPC for  $I^{131}$  could be relaxed by a factor of ten for the inhalation case. However, relaxation of the limits in air could possibly result in vegetation contamination that would exceed permissible limits.

Multiple adenomas occurred in the thyroid gland of a 13-year-old original control ewe. This is the first such finding in a control animal and probably reflects the natural incidence of thyroid adenomas in aged sheep maintained on a diet low in stable iodine content. Since the age is substantially greater than our experimental animals bearing tumors, it is not a strict control for them but requires mentioning to illustrate that sheep may exhibit thyroid adenomas without the administration of  $I^{131}$ .

#### Neptunium

$Np^{237}$  administered as the citrate, pH 4, by stomach tube to rats was absorbed to the extent of 0.35 per cent. This is a substantially higher absorption than is observed with plutonium under comparable conditions. Protactinium-233 in equilibrium with the neptunium was absorbed to the extent of approximately 0.16 per cent.

#### Plutonium

The amount of plutonium nitrate retained following intradermal administration in young miniature swine appears to be at least partially dependent upon the dose injected. About two months after administration the retained dose was 20 to 30 per cent in the 0.008  $\mu$ c sites while in the 1 and 5  $\mu$ c sites, 50 to 60 per cent retention was observed. This difference is thought to be due to greater damage and the formation of a sizeable scab in the high level sites. Most of the retained dose appeared to be contained in the scab at the 1 and 5  $\mu$ c sites. In order to verify the counting efficiency of the new scintillation probe, a scab was removed from a 1  $\mu$ c site (52 days post-injection). External monitoring indicated it contained 0.48  $\mu$ c  $Pu^{239}$  and radiochemical analysis reported it contained 0.46  $\mu$ c - a good agreement.

#### Radioactive Particles

Nine dogs were exposed to plutonium oxide aerosols to study the effect of particle size and type of aerosol on pulmonary retention and excretion in urine and feces. Assembly of equipment for exposure of animals to various radioactive aerosols and aerosols of potential therapy agents was completed. Other equipment for pulmonary function tests was assembled.

Preliminary exposures of bean leaves to Paducah dust yielded material which was readily identified by autoradiographic procedures. Leaves which were washed with a jet of water lost approximately half of the initially deposited material. Nearly total removal of the deposited dust was accomplished by collodion stripping. There was no evidence of any translocation from an exposed primary leaf to the rest of the plant over a three-day period (post exposure).

#### Microbiological Studies

Previous curves relating radiation dose with increased permeability suggested that a relationship might exist between nuclear ploidy and permeability changes. Further evidence on this point was obtained using radiomimetic drugs. Neither colchicine nor nitrogen mustard had any effect on leakage of cellular materials, although both agents will cause genetic damage. It seems probable that leakage is not under direct control of the nucleus.

The inhibition of potassium transport leakage in yeast cells was shown to differ from that on mammalian cells. The glycoside, anabain, had no effect on potassium uptake by yeast cells at concentrations many times higher than required to completely inhibit potassium uptake by mammalian red blood cells.

#### Fish Embryos as Biological Dosimeters

Development of equipment required to define conditions necessary for development of fish eggs in a closed and recirculated water system was started.

#### Chariot Studies

Precounting processing for gamma emitters in all vegetation samples from Project Chariot site was completed. Processing of animal samples was initiated.

#### Protective Agents

A study is in progress to determine the protective effect of cysteine against repeated irradiation of the abdomen as compared with repeated irradiation of total body. Rats in groups of 12 are receiving 1,000 r of X-ray to the abdomen, 250 r total body, or 500 r total body, twice a week. Another group of animals is receiving 250 r per day five days a week. Groups treated with 1,000 mgm/kg of cysteine 10 minutes before irradiation are compared with untreated controls. In the groups receiving 1,000 r abdominal irradiation semi-weekly, 7 of 12 unprotected rats were dead after 4,000 r and 11 of 12 were dead after 6,000 r. None of the pretreated animals showed gross irradiation effects after 8,000 r.

In collaboration with Dr. Kalkwarf, a preliminary study of the pharmacology of dye, erioglaucline, in dogs was completed. A transitory drop in mean arterial and pulse pressure followed intravenous administration of 40 ml of 0.22 M dye. The dye will be tested in dogs for protection against whole-body X-radiation.

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C. Lectures

## a. Papers Presented at Meetings

Foster, R. F., R. L. Junkins, and C. E. Linderoth, "Waste Control at the Hanford Plutonium Production Plant," October 5, 1960, Water Pollution Control Federation Meeting, Philadelphia, Pennsylvania.

## b. Off-Site Seminars

F. P. Hungate, "Effects of Radiation on Biological Systems," October 14, 1960, Skagit Valley Junior College Workshop, Mount Vernon, Washington.

H. A. Kornberg, "The Influence of Atomic Energy on Agriculture," Industrial and Economic Development Conference, October 6 and 7, 1960, Pasco, Wash.

A.C. Case, "Biology at Hanford," Kennewick High School Science Club, Sept. 21.

D. E. Warner, "Radiobiology at Hanford," Northwest Regional Conference of YWCA Leaders, Richland, October 15, 1960.

## c. Seminars (Biology)

Dr. L. M. van Putten, Radiological Institute of the Netherlands, October 7, 1960 - "Bone Marrow Therapy".

## d. Seminars (other than Biology)

J. R. McKenney, "Gonad Dose" - October 20 - HM Parker's Research Staff Meeting.

D. Publications

## a. Open Literature

J. J. Davis, "The Effects of Environmental Factors Upon the Accumulation of Radioisotopes by Ecological Systems," Proceedings of the Second Annual Texas Conference on the Utilization of Atomic Energy, A & M College of Texas, College Station, Texas, November 12-13, 1959 (published in 1960).

## b. HW Publications

Kornberg, H. A. and Staff, "Hanford Biology Research Annual Report for 1959," Document HW-65600 (Unclassified) dated January 15, 1960 (issued October 1960).

OPERATIONS RESEARCH AND SYNTHESIS OPERATION  
MONTHLY REPORT - OCTOBER, 1960

ORGANIZATION AND PERSONNEL

D. C. Gray, Jr., who has been on assignment with the Operation as a part of the Western Regional Rotational Trainee Program, accepted permanent assignment with the Operation as of October 1, 1960.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Models

A study was made to determine the effect on an operational learning curve of adding incremental facilities at different times in the operating history. Some of the variations in the HAPO learning curve can be explained in this way.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

Initial analyses have been performed on data from some 2000 fuel elements measured thus far under this program. Some very significant results have been found. One report has been issued, co-authored with IPD personnel, dealing with the observed relationship between warp and hot spots, and pointing out that there are distinct variations in "metal quality" from time to time. It is also evident that significant relationships will be found when dimensional instability is expressed as a function of reactor operating variables. Work is continuing in this area.

Optimization of Reactor Operations

Some pertinent results have been found in connection with the problem of improved scheduling of reactor operations. An expression relating length of outages to time since last outage was derived. Comparisons were made between outages as classified by cause of outage (rupture, water leak, scheduled, etc.). Also, it was proved, as previously conjectured, that the expected time operated efficiency is  $1/(1 + \lambda \theta)$ ,  $\lambda$  being the average number of outages per unit time, and  $\theta$  being a constant denoting the length of outage. The case where  $\lambda$  and  $\theta$  are functions of time since startup will be considered next.

Process Tube Leaks

The rough draft giving the proposed mathematical model relating probolog activities to external corrosion leak rates was circulated for comment.

Internal corrosion data from B reactor were submitted to Data Processing personnel, together with the general model proposed to fit these data. This proposed model differs from the one in current use, which is unsatisfactory, in that corrosion rate is assumed to be a function of the amount of corrosion already exhibited.

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Z Plant Information Study

Logic for the GE-312 computer application has been completed. Coding of this structure started October 24. Lack of experience with G-E computer equipment is causing some difficulty. This is due to the subtleties associated with a drum memory unit and the impact this electronic system has on the coding structure for the machine.

A review of the status of this project indicates that the best estimate for programming completion is 60 days, which means the original schedule for implementation is being moved forward in time by 30 days. The computer is scheduled to be shipped November 18 in order to meet the bid specification for a December 5 HAPO receipt. Unless a discrepancy between the clearance date for installation personnel and the computer deliver date is resolved, the equipment will have to be held in abeyance until installation personnel can be admitted to the assigned Z Plant space.

Radiation Protection Studies

Currently, doses indicated by film badge readings are determined by comparing the film badge density with a specific density-dose relationship established for the particular batch of film run at the same time. This means that dose indicated by a particular badge cannot be determined until the standard film is processed and the best relationship established. An attempt is being made to establish a standard curve which will give the dose for a given density within certain limits for all batches and allow more rapid interpretation of results. To do this, a relationship other than the currently used cubic curve has been found which simplifies the calculations and better explains the relationship.

Reliability Studies

Work continued on the problem of designing a testing program to determine reliability parameters of pannellit gage switches.

Inventory Studies

The physical inventory of General Supplies, valued at over one million dollars, was completed on October 31 by the sampling procedure.

Work was begun on the construction of a mathematical model of a spare parts inventory.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Assistance was given in the evaluation of an FPD proposal to increase core length without increasing over-all fuel element length based on data which indicates that the present methods of machining the fuel elements leave cap and base end thicknesses well within tolerances.

Data were analyzed from a designed experiment, employing the cuboctahedron design for three factors at three levels, intending to locate optimum cycle times for the canning of four-inch I and E fuel elements. Within the optimum region given by this analysis, a second experiment was designed to further investigate this region.

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Assistance is being given in the development of wettability specifications for aluminum components. These are proposed to replace currently used process specifications designed to insure wettability.

An analysis was made of stud-pull data to compare bond strengths of fuel elements canned with and without paddles attached to the canning basket. Theoretically, the paddles should reduce the within-furnace variations in silicon content and hence result in tougher bonds.

A series of power curves were prepared useful in designing production tests involving two, three, and four treatments. Yield variables under consideration were warp, TFC, and weight loss.

A comparison was made of the acceptance sampling plans for two-sided specifications (unknown sigma) presented in Bowker and Goode and those given in Military Standards 414. They differ primarily in the statistics used, and in the fact that the Military Standards 414 plans permit greater flexibility in the choice of AQL's for each of the upper and lower specifications and for the total.

#### Irradiation Processing Department

Assistance is being provided in the design of tests to insure that the reactor front face nozzles, which are being reamed to permit charging of bumper fuel elements, are not being weakened excessively as a consequence.

Several nomographs and a worksheet were provided Reactor Operating personnel for use in simplifying calculations necessary to determine trip after instability settings for panellit gages.

A continuous sampling plan, proposed by IPD personnel to use in the inspection of panellit gages, was reviewed as requested. The plan provides stringent operating characteristics at the cost of more involved administrative procedures.

Mathematical formulas were developed which express the maximum allowable fuel element warpage as a function of tube and fuel element dimensions and the positioning and dimensions of the fuel element self-support mechanism.

Consultation services continued on mathematical methods used in analyzing various aspects of the electrical circuitry of proposed coolant pressure monitor systems.

#### Chemical Processing Department

Several more meetings were held with 234-5 Development personnel designed to acquaint them with statistical aspects of experimental design.

A mathematical method of completing a contour description from a finite number of specified points in such a manner, so as to satisfy certain "smoothness" criteria is being developed. The method, based on the theory of the elastic behavior of an idealized spline, presents some computational difficulties in that it employs the generous use of elliptic integrals.

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HW-67254

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN ELO

2000 Program

Reactor Studies

Cooperation continued with Systems Research on the study of the properties of the solutions of the reactor kinetic equations with sinusoidally varying reactivity. It is now known that the solutions of these equations are always unstable for all values of amplitude and frequency of oscillation and for all values of reactor parameters. Work continues on obtaining simpler methods of relating the degree of instability to the parameters involved.

A statistical analysis was completed of the effects of temperature, water flow rate, exposure, and surface to volume ratio on the reactivity of graphite.

Corrosion Studies

Work continued on the analysis of Al-Ni-Fe alloy corrosion data from an experiment performed by Corrosion and Coatings Operation.

4000 Program

Swelling Studies

Consideration was given to means of presenting pore distribution data and derived void fraction and density values so that pore growth and movement might be identified for changing irradiation temperatures and times.

Chemical Effluent Technology

Further analysis has been devoted to the difficult problem of estimating the steady-state gravity-flow of a contaminant from a source located above an inclined water table.

6000 Program

Biology

A meeting was held to discuss the findings of an application of the multicompartiment migration model to data from a rat experiment involving a single administration of W-185.

At the request of the Biology Operation work was begun on the construction of a simple linear kinetic model to describe the behavior of radioiodine within a biological system. The differential equations of the system have been written and the feasibility of an analogue computer solution is being explored.

Work was begun on a statistical evaluation of the effects of varying amounts of radiation on the sex ratio and other population parameters of Ephestia kuehniella Zeller (Mediterranean flour moth).

General

A preliminary analysis of the first four weeks data from the work sampling study being conducted by the Analytical Laboratories Operation was performed and reported.

Analysis continued of data from high energy anti-coincident gas sample counting instruments to devise a good method of estimating background counting data. A method of estimating the effect of the gas pressure within the sample tubes on the background count is now under consideration.

MISCELLANEOUS

Activities continued in connection with the Plant Improvement Program task force. A draft of proposed revisions was to be presented to W. E. Johnson.



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PROGRAMMING OPERATION  
OCTOBER 1960

A. FISSIONABLE MATERIALS - 2000 PROGRAM

In order to provide a basis for more accurate control of decontamination in the separations processes, factors which influence total gamma activity of the feed were reviewed. Activity is essentially dependent on power level, exposure, production efficiency and cooling time. It was concluded that of these factors, more complete information on production efficiency could provide a basis for improved decontamination control since variations by as much as 40 per cent in gamma activity could be shown for practical ranges of production efficiency. The other factors are already adequately recorded. A report on this study was in draft form.

Consideration of the chemical and technical feasibility of coupling conventional aqueous and solvent extraction, with fused salt fluoride volatility steps for separations processing particularly in new plants was continued. The critical feature of converting partially decontaminated concentrated aqueous uranium to an oxide slurry in fused salt may be resolved by reasonably conventional engineering techniques. The technology of subsequent reduction to produce uranium tetrafluoride dissolved in fused salts and finally removal of the uranium as purified  $UF_6$  would depend on the results of current research and development on fused salt fluoride volatility processes as being studied elsewhere on a pilot plant scale. The prospects for these latter steps appear good in view of the continued interest in the fused salt reactor as being developed at ORNL.

B. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. Work continued on the final debugging and updating of the Puck code which analyzes plutonium recycle in a broad spectrum of reactors. The updating of the reactor physics portion (GPR) and checking out with the Meleager code was continued. Indications to date are that the impact of equilibrium Pu-242 is greater than indicated in the old GPR but it takes 30 to 100 years to achieve equilibrium. For this reason, consideration is also being given to evaluating the plutonium batches occurring after 10 and 20 years of recycle operation rather than the rigorous equilibrium composition only.

In the studies of the alternative cladding materials a series of functions were generated which depicted the minimized total fuel costs as

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a function of the reactor parameters,  $f_0$ , (the thermal utilization factor of the reactor charged with natural uranium measured at operating temperature at initial charging), and  $p_0$  (the resonance escape probability measured under similar conditions). This was done for various fuel element fabricating costs. Several sets of these are required to cover the reactor characterizations and economic climates within which comparisons are likely to be desired. The use of these functions would be facilitated, if there were means of quickly estimating the  $f_0$  and  $p_0$  factors for a given reactor type and cladding material. One can know relative  $f_0$ 's with greater accuracy than absolute values. To be specific, if two materials were first compared in a given reactor configuration, then compared in another reactor configuration, it would likely be found that the absolute values of  $f_0$  to be affected more (by changing reactor configuration) than would the incremental difference in  $f_0$  for the two materials. It is the incremental  $f_0$  which determines the relative value of alternate cladding materials when using the minimized total fuel cost functions.

Studies are proceeding using the best available diffusion codes to validate this hypothesis and to derive the generalized functions which could become so useful in making economic comparisons of various cladding materials and geometries. This has potential interest to reactor and fuel designers because while  $p_0$ 's may change, because of different fuel geometries the effect on total minimized fuel costs is diminished by operating each fuel element at its respective minimized fuel cost enrichment. Within reasonable limits, this also allows selection of fuel density and reactor lattice spacings at the discretion of the reactor designer. This should lead to lower over-all power costs by allowing the designer to "trade off" reactor and fuel costs. It appears that additional latitude to the designer would result from knowing the economic "trade off" of the various plutonium enrichment methods and compositions because of the resonance absorption characteristics.

It is intended to extend this study to include such information as rapidly as firm plutonium information becomes available.

Fuel Cycle Analysis. A brief investigation was made of the fissile content of the "ashes" which remain after a single once-through fuel cycle. Numbers were selected from calculations made with the Meleager code with physics parameters approximating those of the Dresden reactor. As expected, plutonium (uniformly mixed with depeleted uranium) fueled reactors generally gave a discharged fuel containing less fissile material than those fueled with U-235. However, the difference in the discharged fissile atoms between a U-235 and a Pu-239 fueled reactor amounted to only about 10 per cent versus the 20 to 30 per cent difference which would be predicted from simple absorption to fission ratios for the two isotopes. However, cases may be found, specifically for fuels initially containing a larger fraction of Pu-241, where plutonium fueled reactors actually have greater terminal concentrations of fissile atoms in the discharged fuel than those initially enriched with U-235.

Other Activities. The estimate made last month of plutonium production from power reactors was revised to reflect more accurately the elapsed time between reactor startup and availability of plutonium on a routine basis. The estimate was also extended from 1970 to 1975. Previously it was assumed the elapsed time between start-up and availability of plutonium was one year. More detailed study showed that, in general, for the U.S. reactors elapsed time would be between two and three years, and for the British type gas-cooled reactors, about four years. Annual plutonium production by 1975 was estimated to be 2,600 kilograms from domestic power reactors, 3,700 kilograms from British reactors, and 5,900 kilograms from power reactors in operation in the rest of the free world.

Activities in support of PRTR startup included review of process specifications, operating procedures, and power tests. Startup Council has now approved 43 of the 45 process specifications and 72 of the 92 operating procedures.

Liaison on procurement of high exposure plutonium continues to require attention. The integration of this production campaign with similar requirements of others whose needs are possibly even more urgent encourages a greater than normal degree of attention to assure the adequacy of the volume of product recovered for PRTR. Although unexpected removals from the accumulation intended for PRTR have occurred, study has continued to show that by careful scheduling and recovery of fabrication scrap at Hanford such removals appear to be tolerable but near the limit. The requested procurement of some of the Canadian material, though relatively minor, is still a significant factor in this situation.

## 2. SPECIFIC FUEL CYCLE ANALYSIS

### Computer Code Development

The first draft of the APWR study results was prepared and orally presented to AEC Division of Reactor Development personnel on October 19, 1960. Slight improvements are being made in the report preparation section of the Quick and Puve codes used for this study so that much of the final report data can be prepared directly by the IBM machine.

In future analyses, similar to the APWR study, it will be necessary to do studies of continuous ("graded") fuel discharges as well as studies of batch irradiations for which the Quick code is now written. Accordingly, Quick will be supplemented with a cost for the unusual startup and shutdown charges associated with continuous charge discharge. These unusual startup and shutdown charges are usually more than compensated for by the reduction in enrichment level of the reactor from those necessary for batch irradiations. Not all reactors benefit by operating on the graded rather than batch cycle particularly those reactors that incur high costs to shutdown and shuffle the fuel many times during a fuel lifetime.

Changes are also being made to the Five code which solves for the value of successive plutonium batches from output of the Quick code. It now appears that a statistical method can be used to reduce the number of successive recycle batches to ascertain the value of the first batch within desired accuracy. The major savings affected by this is the reduction of the necessary physics calculations which require far more time than the relatively simple additional economics iterations.

Final programming of the FEFJ (Fuel Element Fabrication and Jacketing) sub-code continued. Its logic was revised to allow consideration of fixed, semi-variable and variable fabrication and jacketing costs and of extra costs of preparing recycle for re-entering the normal FEFJ process.

The logic for computing excess start-up and close-down costs inherent to graded discharge was refined. This was done to: (1) account for the extra costs of the various startup and closedown discharge batches at their respective electrical power revenue mid-points rather than at the time of startup or closedown and (2) set income mid-points of each batch at the weighted average of the discharge period exposures rather than at its linear exposure mid-point. This more accurate mid-point computation is expected to have its greatest effect in the computation of equilibrium costs.

A rigorous debug of the Nuclear Process Cost Code (NPC) is currently being prepared. The NPC code is far more rigorous as regards accounting practices than its simplified counterpart "Quick".

### 3. OTHER ACTIVITIES

A laboratory course in Nuclear Engineering involving the use of an operable reactor is planned during 1961 at the Center for Graduate Study. Preliminary analysis of the course requirements indicates the suitability of HLO's Thermal Test Reactor. Administrative arrangements and integration of a similar course to be conducted at the University of Washington are under study in cooperation with university representatives.

OPG 5.4 relating to the Plant Improvement Programs was revised in order to offer a more effective means of presenting HAPPO's capital facility needs. The deadline date for submitting plant improvement programs was changed from December 1, 1960 to January 15, 1961.

A proposal for a composite news story encompassing all of our many foreign visitors, who came during October, was generated and accepted by the Relations Operation. This mutual effort results in the achievement of one of our finest "spreads" in the Works News.

Assistance was provided in making arrangements for 31 visits involving 200 persons including 18 persons from foreign countries. Of special interest was the visit of Dr. V. K. Moorthy of the Indian Atomic Energy Establishment; Mr. I. Ishikawa, Commissioner of the Japanese AEC; and the U.S./U.K. Conference on Uranium Dioxide.

  
Acting Manager, Programming

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RADIATION PROTECTION OPERATION  
REPORT FOR THE MONTH OF OCTOBER 1960

A. ORGANIZATION AND PERSONNEL

R. W. Meisinger, Specialist - Radiological Defense transferred to the Professional Placement and Relations Practices Operation effective October 1. R. F. Ballard was deactivated for personal illness effective October 24. Lillian E. Benson retired on October 31, 1960. The force of the Radiation Protection Operation totals 135.

B. ACTIVITIES

For the two-week period beginning September 26, R. L. Junkins served as a consultant for the International Atomic Energy Agency (IAEA) in Vienna, Austria. While on this assignment, he assisted in preparing papers for the Panel on "Radioactive Waste Disposal into Fresh Waters". Nine nations have been invited to send representatives to the IAEA Panel which meets in late November in Vienna. R. L. Junkins will return to Vienna as the U. S. representative to the Panel.

There was one new case of plutonium deposition confirmed in October. The total number of deposition cases that have occurred at HAPO is 260 of which 190 are currently employed.

Tritium bioassay analyses were performed for PRTR operating and maintenance personnel prior to startup of the facility. Sixty-seven moderator water samples were also analyzed for tritium concentrations as a further service to PRTR Operation. Tritium concentrations in the heavy water from background to 27  $\mu\text{c}/\text{ml}$  were found. The tritium content of the individual drums varies by several orders of magnitude.

The third quarterly report, Evaluation of Radiological Conditions in the Vicinity of Hanford, is now ready for issue. The most notable observation to be reported is the apparent increase in  $\text{P}^{32}$  concentrations found in farm products from the Riverview and Ringold irrigation districts. These observations are probably due to the lower river flow and, hence, increased water concentrations experienced in 1960.

On October 4, a planned fire was started in the 100-H Area burial ground to reduce the paper volume in the burial trench. The fire went out of control and it was necessary to call the Fire Department to put out the fire. One fireman was overcome by heat and exhaustion while fighting the fire and was treated at First Aid. Another fireman received second and third degree burns from an explosion and was hospitalized at Kadlec Hospital. No contamination spread to the firemen or environs occurred.

Plutonium oxide stored in a covered metal can inside a glovebox in 231 Building apparently ignited, resulting in an explosion that temporarily pressurized the glovebox and forced plutonium oxide out into the room.

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Contamination on horizontal surfaces in the room ranged from 1000 d/m near the door to 40,000 d/m near the plastic bag which ruptured. There was no exposure to personnel as a result of this incident which occurred during the off-shift hours. The room has been successfully decontaminated.

Five aerial survey flights were made during the month. At least two background measurements are now available for each routine flight path. The routine aerial monitoring plans and procedures were 80 per cent completed.

Studies of the fuel element rupture loop of the PRTR facility resulted in a recommendation for a noble gas collection system. The recommendation results from the calculated production rates of  $Kr^{89}$  and  $Xe^{137}$ .

A thorough study of air sampling procedures has been initiated. The program calls for a thorough study of the air sampling techniques, equipment, and evaluation procedures. Information is now being collected concerning the equipment necessary to complete these studies and to compile a list of work locations to be considered in the primary study.

A meeting to discuss the first year's use of the Hurst criticality dosimeter system was held in Santa Barbara, California, by Edgerton, Germeshausen & Grier. C. M. Unruh attended as the Hanford representative. A total of 800 of these systems will be in use throughout the United States. During the first year, it was not necessary to evaluate a single system due to a criticality incident. No damage or contamination spread has resulted from the use of these systems to date. A potential for serious contamination spread resulting from a system involved in a fire was thoroughly discussed. Steps to provide a sealed system for the threshold foils, that would maintain its integrity throughout a typical fire, will probably result in a reworking of the 90 systems now at HAPO. Efforts to develop a system using nonradioactive materials was emphasized at the meeting by the HAPO participant.

Studies of the nuclear track films denoted NTA and NTB have been completed. Although the Type A is less sensitive to neutrons than Type B, it is also sufficiently less sensitive to gamma doses to make it the preferred choice. Evaluation of the type NTB film with appreciable gamma dose is very difficult and many errors in track counting are introduced due to the gamma dose fogging of the film.

The Annual Information Meeting of the Health Physics Division, ORNL, was held on October 27 and 28, 1960, and was attended by A. R. Keene.

### C. EMPLOYEE RELATIONS

One suggestion was submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to 32. Five suggestions were evaluated and rejected. One suggestion was adopted with the award split between two RPO employees. Total amount of award was \$20. Five suggestions submitted by RPO personnel are pending evaluation.

There was one medical treatment injury during the month for a frequency of 0.45. No security violations occurred during October.

Radiation protection training included: One 90-minute orientation talk to four Biology Research personnel; personnel assigned to the PRTR attended the lecture series and training program on Critical Tests; attendance of RMO exempt and nonexempt personnel at 13 meetings on various PRTR operations.

D. SIGNIFICANT REPORTS

- HW-67060 "Analysis of Radiological Data for the Month of September, 1960"  
by R. L. Junkins.
- HW-67248 "Monthly Report - October 1960, Radiation Monitoring Operation"  
by A. J. Stevens.
- HW-66891 "The Automatic Columbia River Monitoring Station" by T. C. Mehas.
- HW-66728 "A performance Study of Miniature Glass-Dosimeters" by P. E. Bramson.

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ENVIRONMENTAL MONITORING - RESULTS - (Mid-September 1960 - Mid-October 1960)

<u>Sample Type and Location</u>	<u>Activity Type</u>	<u>Monthly Average</u>	<u>Units</u>
<u>Drinking Water</u>			
100-F Area	Isotopic	< 0.5	% MPC <sub>w-GI</sub> *
Separations Areas	Gross Beta	1.2 x 10 <sup>-7</sup>	µc/cc
Pasco	Isotopic	7.5	% MPC <sub>w-GI</sub> **
Kennewick	Isotopic	< 0.7	% MPC <sub>w-GI</sub> **
Richland	Gross Beta	< 3.0 x 10 <sup>-8</sup>	µc/cc
<u>Columbia River Water</u>			
Above 100-B Area	Gross Beta	8.0 x 10 <sup>-9</sup> ***	µc/cc
100-F Area	Isotopic	1.8	% MPC <sub>w-GI</sub> *
Hanford	Isotopic	3.9	% MPC <sub>w-GI</sub> *
Pasco	Isotopic	20	% MPC <sub>w-GI</sub> **
McNary Dam	Gross Beta	1.2 x 10 <sup>-6</sup>	µc/cc
Vancouver, Washington	Isotopic	< 0.4	% MPC <sub>w-GI</sub> **
<u>Atmosphere</u>			
I <sup>131</sup> Separations Areas	I <sup>131</sup>	2.3 x 10 <sup>-13</sup>	µc/cc
I <sup>131</sup> Separations Stacks	I <sup>131</sup>	0.2	Combined curies/ ptle/100 m <sup>3</sup>
Active Particles - Project	--	1.4	ptle/100 m <sup>3</sup>
Active Particles - Environs	--	0.1	ptle/100 m <sup>3</sup>
<u>Vegetation</u> (Control limit for vegetation is 10 <sup>-5</sup> µc I <sup>131</sup> /g)			
Separations Areas	I <sup>131</sup>	2.5 x 10 <sup>-6</sup>	µc/g
Residential	I <sup>131</sup>	< 1.5 x 10 <sup>-6</sup>	µc/g
Eastern Washington and Oregon	I <sup>131</sup>	< 1.5 x 10 <sup>-6</sup>	µc/g
Fission Products less I <sup>131</sup> - Wash. and Ore.	Gamma Emitters	< 1.0 x 10 <sup>-5</sup>	µc/g

\* The % MPC<sub>w-GI</sub> 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<sub>w-GI</sub> 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 RECORDSExposure Incidents above Permissible Limits

	<u>Whole Body</u>	<u>Localized</u>
October	0	0
1960 to Date	1	3

Gamma Pencils

	<u>Pencils Processed</u>	<u>Paired Readings 100-280 mr</u>	<u>Paired Readings Over 280 mr</u>	<u>Lost Readings</u>
October	9,790	237	7	0
1960 to Date	145,884	2,326	44	12

Beta-Gamma Film Badges

	<u>Badges Processed</u>	<u>Readings 100-300 mrad</u>	<u>Readings 300-500 mrad</u>	<u>Readings Over 500 mrad</u>	<u>Lost Readings</u>	<u>Average Dose Per Film Packet</u>	
						<u>mrad(ow)</u>	<u>mr(s)</u>
October	10,422	979	128	35	61	13.89	15.19
1960 to Date	112,172	9,202	1,654	414	577	11.54	17.64

Neutron Film Badges

	<u>Film Processed</u>	<u>Readings 50-100 mrem</u>	<u>Readings 100-300 mrem</u>	<u>Readings Over 300 mrem</u>	<u>Lost Readings</u>
<u>Slow Neutron</u>					
October	2,521	0	0	0	12
1960 to Date	13,766	3	0	0	56
<u>Fast Neutron</u>					
October	251	20	36	0	0
1960 to Date	1,831	163	68	0	21

Whole Body Counter

	<u>Male</u>	<u>Female</u>	<u>October</u>	<u>1960 to Date</u>
<u>GE Employees</u>				
Routine	95	4	99	746
Special	16	0	16	53
Terminal	0	0	0	1
<u>Nonemployees</u>				
	14	0	14	55
<u>Pre-employment</u>				
	0	0	0	10
<b>Total</b>	<b>125</b>	<b>4</b>	<b>129</b>	<b>865</b>

Bioassay

	<u>October</u>	<u>1960 to Date</u>
<u>Confirmed Plutonium Deposition Cases</u>		
	1	16*
<u>Plutonium: Samples Assayed</u>		
Results above $2.2 \times 10^{-8}$ $\mu\text{c/sample}$	562	6,480
	29	399
<u>Fission Products: Samples Assayed</u>		
Results above $3.1 \times 10^{-5}$ $\mu\text{c FP/sample}$	597	6,396
	11	34
<u>Uranium: Samples Assayed</u>		
	258	2,686

\*Bringing the total number of plutonium deposition cases which have occurred at Hanford to 260.

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Uranium Analyses

<u>Sample Description</u>	<u>Following Exposure</u>			<u>Following Period of No Exposure</u>		
	<u>Units of <math>10^{-9}</math> <math>\mu</math>c U/cc</u>		<u>Number</u>	<u>Units of <math>10^{-9}</math> <math>\mu</math>c U/cc</u>		<u>Number</u>
	<u>Maximum</u>	<u>Average</u>		<u>Maximum</u>	<u>Average</u>	
Fuels Preparation	17	4.2	56	8.1	2.6	50
Fuels Preparation*	0	0	0	0	0	0
Hanford Laboratories	28	4.9	30	14	3.4	29
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	54	7.3	35	13	4.0	46
Chemical Processing*	22	9.2	6	34	12	4
Special Incidents	0	0	0	0	0	0
Random	0.8	0.5	2	0	0	0

\*Samples taken prior to and after a specific job during work week.

<u>Thyroid Checks</u>	<u>October</u>	<u>1960 to Date</u>
Checks Taken	0	179
Checks above Detection Limit	0	5

<u>Hand Checks</u>	<u>October</u>	<u>1960 to Date</u>
Checks Taken-Alpha	34,132	319,361
-Beta-gamma	43,770	446,523

<u>Skin Contamination</u>	<u>October</u>	<u>1960 to Date</u>
Plutonium	31	231
Fission Products	34	386
Uranium	0	39

CALIBRATIONS

	<u>Number of Units Calibrated</u>	
	<u>October</u>	<u>1960 to Date</u>
<u>Portable Instruments</u>		
CP Meter	866	9,120
Juno	222	2,864
GM	718	7,771
Other	154	1,775
Total	1,960	21,530
<u>Personnel Meters</u>		
Badge Film	648	12,550
Pencils	-	1,912
Other	337	4,061
Total	985	18,523
Miscellaneous Special Services	527	5,750
Total Number of Calibrations	3,472	45,803

*Carl M. Murch*  
for the  
Manager  
Radiation Protection

LABORATORY AUXILIARIES OPERATION  
MONTHLY REPORT - OCTOBER, 1960

GENERAL

There was one security violation charged to the Operation.

There were no major injuries; the minor injury frequency rate was 1.98, which is considerably below average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the month was 19,222 hours. This includes 14,752 hours performed in the Technical Shops, 3,188 hours assigned to Minor Construction, 301 hours assigned to other project shops and 981 hours assigned to off-site vendors. Total shop backlog is 17,988 hours, of which 60% is required in the current month, with the remainder distributed over a three-month period.

Distribution of time was as follows:

	<u>Man-hours</u>	<u>% of Total</u>
Fuels Preparation Department	3,495	18.2
Irradiation Processing Department	540	2.8
Chemical Processing Department	667	3.5
Hanford Laboratories Operation	13,553	70.5
Construction Engineering & Utilities	940	4.9
Miscellaneous	27	.1

Requests for emergency service were slightly higher than the previous month, requiring an overtime rate of 5.9% (1365 hours).

One Sheetmetal Journeyman was exchanged for another Sheetmetal Journeyman from FPD. There are no current open requisitions.

Security performance was considered satisfactory with no violations. There were six medical treatment injuries, which is on the low side of the level forecast for this period.

RADIOGRAPHIC TESTING OPERATION

A total of 4,655 tests were made, of which 663 were radiographic (including x-ray and gamma-ray) and 3,992 were supplementary tests. Out of a total of 2,866 man-hours, 498 (17%) were used in connection with radiographic tests, and 2,368 (82%) were used on supplementary tests. The supplementary test work included: autoclaving; eddy current; penetrant (fluorescent O.D. and I.D.); stress analysis; surface treatment (pickling, steam detergent cleaning, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements).

The number of pieces handled this month totaled 2,953 items. The feet of material represented by these items amounted to 28,553 feet. Work on tubular components continued to account for a large percentage of the footage of material tested; the work includes both fuel element sheath tubes and reactor process tubes.

Work was done for 22 organizational components representing most of the operating departments and service organizations. A total of 59 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 40 different occasions for advise and information on general testing theory and applications for other than the jobs tabulated in Part - II Testing Statistics.

Two full length NPR process tubes were pickled and one was autoclaved as a preliminary evaluation of the pickling and autoclave process. Unfortunately, erratic autoclave operation did not permit final conclusions as to the success of the procedure. The outside surfaces of the autoclaved tube were generally satisfactory except for some hook marks where contact was not changed. The inside surfaces were poor with a continuous indication for most of the length of the tube and some bad local areas.

Material and equipment for the tube shop is finally reaching the point where full scheduling of NPR process tube testing and treatment will soon be possible. Fifty-seven tubes have been received for testing and processing. Pending the successful demonstration of the pickling and autoclaving facility, testing is going forward on the new tubes including ultrasonic thickness measurements, ultrasonic flaw testing, and fluorescent penetrant testing.

Preliminary evaluation of a dry blasting method for autoclave film removal and wall conditioning was made at a Seattle firm. The method utilizes a recirculated dry abrasive featuring a vacuum pickup at the working head. The operation of the unit is much cleaner and somewhat simpler than the present wet method.

#### Testing Statistics

<u>Component</u>	<u>No. of Tests</u>	<u>Ft. of Weld or Material</u>	<u>No. of Pieces</u>	<u>Description</u>
CPD	223	52	16	Radiograph welds & mark U dissolver assembly s/s; Radiographic welds on 1 formaldehyde reactor TK-F-2; 1 formaldehyde tower T-F-15-2; 1 condensate receiver tank TK-F-3; Perform ultrasonic thickness test on four vessels in 200-W Area; Perform ultrasonic thickness measurements on vacuum fractionator in 200-E Area.

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<u>Component</u>	<u>No. of Tests</u>	<u>Ft. of Weld or Material</u>	<u>No. of Pieces</u>	<u>Description</u>
FPD	30	21	7	Radiograph four welds of drain system in 340 Bldg., 300 Area - Carbon steel, 3" Sch.40 pipe; Radiograph can-to-cup welds on UT-4 fuel element jackets to develop technique 1-1/2" I.D. aluminum rings.
HLO	3,841	22,741	2,711	Aluminum clad U fuel element; zr-2 clad U fuel elements; 6" tapered thermocouples; zr-4 s/s brazed samples; s/s creep test capsule; NaK swelling capsule; .495" I.D., zr-4 tubes; Mg oxide canned slugs; Al-Pu fuel rods; .425" O.D., zr-4 clad Al-Pu; .750" O.D., longitudinal welded s/s tube; Radiograph aluminum UO <sub>2</sub> fuel rods for Birch Fabrication & Development Program; .680" I.D., zr-4 tubes; 1-3/4" O.D., zr-2 tubes; 1-1/2" O.D., zr-2 clad U fuel; 1.76" O.D. x 43'-6" long zirc-2 "C" type tubes; 4-1/2" O.D. x 108" long zircaloy-2 tubes; 2.40" O.D. x 46'-6" long zircaloy-2, KER type tubes; 2-1/2" x 153" long - zircaloy tubes; Perform ultrasonic thickness test on pressure vessels in Bldg. 326, 327, & 328 - 300 Area; 0.50 x 4' long, Hastalloy tubes.
IPD	361	5,639	212	Radiograph welds on Elmo-7, s/s-4" Sch.160; PRTR test sections & welds on CEP-3 Loop (s/s 1-1/2" Sch.160); Radiograph three welds on three sections of 2-1/2" Sch.XX strong carbon steel; Radiograph welds on two NPR tube shop autoclave injection steam superheaters s/s; Radiograph ends of five Al reactor front face nozzles; Radiograph welds on seal test flanges 1-1/4" Tk x 8" O.D. s/s; 2.40 O.D. x 46'-6" long, zircaloy - 2 KER type tubes; 3-1/4" O.D. x 53'-6" long zircaloy-2 NPR tubes; Straingage installation and stress analysis of cell #4 piping system - 1706 KER Bldg; stress analysis on crossheaders, risers, and down-comer of 105-DR reactor; Installation

<u>Component</u>	<u>No. of Tests</u>	<u>Ft. of Weld or Material</u>	<u>No. of Pieces</u>	<u>Description</u>
				of four straingage rosettes plus two temp compensating gages on No. 25 rear crossheader.
JA Jones	200	100	7	Radiograph two s/s welder qualification test coupons, 3/8" tubing; Radiograph instrument leads at bottom of Calandria PRTR site.
<b>TOTAL</b>	<b>4,655</b>	<b>28,553</b>	<b>2,953</b>	

CONSTRUCTION OPERATION

There were 47 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of \$284,758. Seventy-three new orders, 6 supplements and adjustments for underruns amounted to \$62,951. Expenditures during the month on HLO work were \$150,215. Total J. A. Jones backlog at month's end was \$189,885.

Summary

	<u>HL</u>		<u>CE&amp;U</u>	
	<u>No.</u>	<u>Unexpended Balance</u>	<u>No.</u>	<u>Unexpended Balance</u>
Orders outstanding beginning of month	46	\$ 277,149	1	\$ 7,609
Issued during the month (Inc. Sup. & Adj.)	73	62,951	0	0
J.A. Jones Expenditures during month (Inc. C.O. Costs)		148,461		1,754
Balance at month's end	48	184,030	1	5,855
Orders closed during month	71	89,898*	0	0*

\*Face Value of Orders Closed

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FACILITIES ENGINEERING OPERATIONProjects

There were 13 authorized projects at month's end with total authorized funds of \$2,741,265. The total estimated cost of these projects is \$4,718,700. The unexpended balance on these projects amounts to about \$3,500,000.

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	0
Projects completed during the month	0
New project proposals submitted to AEC during month	0
New projects awaiting AEC approval:	3
CGH-832 Full Scale Physical Constants Test Reactor	
CGH-902 Uranium Scrap Burning Facility	
CAH-914 Rattlesnake Springs Radioecology Facility	

Note - Proposals complete or nearing completion are as follows:

Fuels Recycle Pilot Plant  
Atmospheric Physics - Field Service Center

Project CGH-874, Consolidation of Plutonium Metallurgy Facility, was returned by the AEC for revision.

The attached project report contains details of individual project work.

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals.

<u>Title</u>	<u>Status</u>
329 Building Ventilation Mod.	Work complete.
Pressure Vessel and Code Piping- Engineering & Inspection Service	This is a continuing work program on HLO vessels, pressure systems and related safety devices. Periodic auditing is nearly complete. Of the first twenty vessels reviewed, it appears that three will be derated.
Glove Boxes, 325 Building	Fabrication is complete and appurtenances are being installed.

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<u>Title</u>	<u>Status</u>
"Split-half" Machine for Critical Mass Studies	Materials on order. Detail design is about 80% complete.
Criticality Alarm - 300 Area	Installation work will be postponed due to funds limitation.
Improvement to Animal Waste Disposal System	Design and field work is nearly complete. Acceptance tests and minor modifications will be performed during November.
Horizontal Control Rod and Drive for Tamper Tank (Critical Mass)	Design work is substantially complete.
Basement Access Enclosure - 325	Construction work is authorized.
Special Laboratory Air Conditioning 222-U Building	Engineering work is complete. Field work to start during November. Procurement has started,
Irradiation Studies Loop	Design complete. Fabrication in progress.
Breakaway Corrosion Loop	Design in progress. Procurement has started.
Review of Pressure Systems, PRTR	Inspection is complete on all systems. Recording and documentation work is continuing.
Misc. Animal Quarters & Pasture 100-F	Field work in progress.
Design special dust filters - 306	Design in progress
Intercom System - 231-Z Building	Design is being performed.
Cooling System - 314 Building	Design is complete. Costs are being reviewed.

#### Drafting and Design Services

Work load in central drafting room (3706) is very heavy. Branch offices in 306 and 308 Buildings have steady work loads with heavy backlog in 308 office.

Major design and drafting work in progress includes the following:

1. High Level Utility Cell - 327 Bldg. - Special Tools (60% complete).
2. PRP Critical Facility - Detail of in-cell piping, ventilation, instrumentation and electrical work (18 dwgs. - 90% complete).
3. Physical and Mechanical Properties Test Cell - 327 Bldg. - Special equipment design (35 dwgs - 50% complete).
4. Structural Materials Irradiation Test Facility - design - (25 dwgs required - 30% complete).
5. Strontium Purification Project - Work underway.

Drafting and Design Services (Cont'd.)

6. Fuel Element Wire Wrapping Machine (12 dwgs required - 95% complete).
7. Split-half mechanism, Critical Mass Laboratory.
8. Thermal precipitator - (5 dwgs required 30% complete).
9. PRTR special tools - (approx. 45 dwgs. - 55% complete).
10. Breakaway Corrosion Loop - Approximately 35% complete.
11. Critical Facility - Approximately 20 dwgs. required - Estimated 30% complete.
12. Stress Rupture Facility - Estimated 60% complete.
13. Fuels Recycle Pilot Plant - Conceptual work in progress.
14. Length Measurement Telescope - Work started.

In addition to the above work, miscellaneous small design-drafting jobs are in progress.

Approximately 175 drawings including sketches, work sheets, and formal drawings were completed during the month of October.

Plant Maintenance and Operation - Costs (September)

\$ 138,556                      104.4 %

Analysis of Costs

The expenditures continue about 4% above forecast. This reflects the emphasis on preparing the buildings for winter.

Improvement Maintenance

<u>Item</u>	<u>September</u>
Crane	\$ 1,607
Relocation & Alteration	1,310
Painting	477
Misc.	<u>511</u>
Total	\$ 3,905

Miscellaneous

Approximately 31,000 square feet of prints were reproduced during the month.

The total estimated value of the 14 requisitions issued during the month was \$7,600.

Appropriation Requests for hoods and for laboratory furniture were prepared and submitted.

The following painting was performed: 305-B interior, 325 (spot), 3760 (spot).

Conversion to a standard fire gong system is continuing. It was de-emphasized during the installation period of the criticality alarms.

Investigations have been made of air flows in 747 Building.

The effect of supply air shutdown while exhaust fans run in 308 Building was measured. The system had been designed for such supply shutdown in the event of fire. Tests indicated that excessive vacuums were built up which threatened the ductwork, emptied floor drain traps and rendered exterior doors unopenable. This fire alarm connection has been de-activated pending further studies.

A study has been initiated on changing the level of the 326 Building basement access.

An order has been issued to lower the #3 pump house near 329 Building.

An order has also been issued to provide a covered connection between the basement and main entrance in 325 Building.

#### TECHNICAL INFORMATION OPERATION

A detailed summary of the proposed system for the control of access to documents in the Classified Files has been written and sent to the Departments for comment. It is planned that the revised copies, incorporating Department suggestions, will be used for (1) further negotiations with the AEC and (2) as instructions for distribution to the field when the plan is implemented. Comments received to date indicate that an educational campaign of some intensity will be needed before Plant personnel fully understand the proposed changes.

Additional instructions on classifying NPR Fuel Element information was received. The new instructions were primarily related to production capacities and rates. They were distributed to the field via HW-66932 "Classification: NPR Fuel Elements" dated October 3, 1960.

Two Classification Information Bulletins were distributed. They are:

"Poison Splines"  
"Replacement Code Word"

The bulletin on Poison Splines contained the topics recently approved by the AEC. After distribution of the topics to the field several questions regarding interpretation of two of the topics were raised. Work on clarifying these topics is underway.

Efforts were continued on bringing the plant inter-area uranium transfer records into compliance with Topic 201.7.2 of the Hanford Guide. The question of need to classify individual copies of records for transfer of fuel elements from the fuels production plant to the reactor areas remains to be resolved.

Recommendations for changes in the roster of HAPO Responsible Reviewers were made to the Chief of the AEC's Declassification Branch. Because of the small number of declassification referrals in the field of Chemistry and Chemical Engineering, it was suggested that the number of reviewers be decreased from five to one. Simultaneously a request was made for the appointment of an additional reviewer in the field of Reactors and Physics, the field which comprises the majority of the declassification referrals.

The program for automating the Classified Files issuance, routing, and mailing routines, which has been stalled for some weeks pending information from IBM on some adaptations to standard equipment, began to move again at month's end. An order for the equipment will be placed shortly. Rental charges will be about \$550 per month. A six months delay in receiving the equipment is anticipated, which would place installation in April 1961.

Microfilming of the Classified Files document holdings began on October 3. To date 1,521 documents have been microfilmed, which is satisfactory progress. Fire proof cabinets for storing the completed "jackets" have been received in 300 Area as has the Minnesota Mining Reader-Printer. Trial runs on the latter are producing excellent reproductions from the microfilm.

The automation of the Library's procedures for handling subscription renewals advanced nearer reality during the month. The program has been worked out and is being "debugged". The transfer of subscription information from cards to tape is expected to take place in November.

#### Work Volume Statistics

	<u>September</u>	<u>October</u>
<u>Document Distribution and Files</u>		
Documents routed and discharged (copies)	14,453	16,100
Documents issued (copies)	15,227	14,281
Documents sent off-site (copies)	6,597	8,257
Document reserves filled (copies)	586	641
Documents picked up and delivered	16,679	18,229

#### Document Accountability

Holders of classified documents whose files were inventoried	425	627
Documents inventoried in Files (copies)	0	0
Documents destroyed or retired (copies)	8,349	6,055
Documents revised (copies)	1,078	1,398
Documents pulled and documents filed (copies)	10,511	12,010
Documents reclassified	467	731
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	212,761	210,390

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	<u>September</u>	<u>October</u>
<u>Reference and Publication</u>		
Books cataloged (new titles)	26	49
Books added to the collection (volumes)	136	205
Ready reference questions answered by professional staff	235	205
Literature searches by professional staff	67	68
Reports abstracted (titles)	242	260
Formal reports prepared (titles)	17	16
Off-site requests for HAPO reports (copies)	277	299
Reports released to CAP (titles)	42	43

Library Acquisitions and Circulation

Books ordered (volumes)	493	297
Periodicals ordered	91	29
Books circulated (volumes)	2,148	1,777
Periodicals circulated (issues)	4,745	3,353
Inter-Library Loans	92	79
Films borrowed or rented	22	5
Industrial film showings	83	51
Bound periodicals added to the collection	293	62

Library Collection

	<u>Main Library</u>	<u>W-10 Library</u>	<u>108-F Library</u>	<u>Ind. Med.</u>	<u>Total</u>
No. of books	30,209	8,546	1,677	2,018	42,450
No. of bound periodicals	59	9	1,689	97	16,075
	<u>30,268</u>	<u>8,555</u>	<u>3,366</u>	<u>2,115</u>	<u>58,525</u>

Classification and Declassification

	<u>September</u>	<u>October</u>
Documents, including drawings and photographs reviewed for downgrading or declassification	203	497
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	39	24
Documents submitted to Declassification Branch, Oak Ridge	75	227

*P. J. Lucas*  
for Manager,  
LABORATORY AUXILIARIES

JL Boyd:jw

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SEMI-MONTHLY PROJECT STATUS REPORT							HW-		
HANFORD LABORATORIES OPERATION							DATE 10-28-60		
PROJ. NO.		TITLE				FUNDING			
CCF-914		Rattlesnake Springs Radioecology Facility				61-j			
AUTHORIZED FUNDS		DESIGN \$		AEC \$		COMMIT'TO \$		0	
\$ None		CONST. \$		GE \$		ESTIMATED TOTAL COST		\$ 72,000	
STARTING DATES	DESIGN. CONST.	DIRECT COMPL. DATES	DESIGN CONST.	EST'D. COMPL. DATES	DESIGN CONST.	PERCENT COMPLETE			
	1*					WT'D.	SCHED.	ACTUAL	
ENGINEER						DESIGN			
FEO - HE Ralph						AE			
<u>MANPOWER</u>						GE			
FIXED PRICE									
COST PLUS FIXED FEE						CONST.			
PLANT FORCES						PF			
ARCHITECT-ENGINEER						CPFF			
DESIGN ENGINEERING OPERATION						PP			
GE FIELD ENGINEER									
SCOPE, PURPOSE, STATUS & PROGRESS									
Project proposal submitted to HOO-AEC on 9-19-60.									
* Months after authorization.									

PROJ. NO.							TITLE				FUNDING		
AUTHORIZED FUNDS		DESIGN \$		AEC \$		COMMIT'TO \$		ESTIMATED TOTAL COST					
\$		CONST. \$		GE \$									
STARTING DATES	DESIGN. CONST.	DIRECT COMPL. DATES	DESIGN CONST.	EST'D. COMPL. DATES	DESIGN CONST.	PERCENT COMPLETE							
						WT'D.	SCHED.	ACTUAL					
ENGINEER						DESIGN							
<u>MANPOWER</u>						AE							
FIXED PRICE						GE							
COST PLUS FIXED FEE						CONST.							
PLANT FORCES						PF							
ARCHITECT-ENGINEER						CPFF							
DESIGN ENGINEERING OPERATION						PP							
GE FIELD ENGINEER													
SCOPE, PURPOSE, STATUS & PROGRESS													
1234335													

SEMI-MONTHLY PROJECT STATUS REPORT							HW- 67254	
HANFORD LABORATORIES OPERATION							DATE 10-23-60	
PROJ. NO.	TITLE						FUNDING	
CGE-902	Uranium Scrap Burning Facility						61-j	
AUTHORIZED FUNDS		DESIGN \$		AEC \$		COMMIT'S. TO \$		
\$ -0-		CONST. \$		SE \$		ESTIMATED TOTAL COST \$ 36,000		
STARTING DATES	DESIGN. 2*	DIRECT COMPL. DATES	DESIGN CONST.	EST'D. COMPL. DATES	DESIGN 8*	PERCENT COMPLETE		
	CONST. 5*				CONST. 38*	WT'D.	SCHED.	ACTUAL
ENGINEER						DESIGN		
FEO - RK Waldman						AE		
<u>MANPOWER</u>						GE		
FIXED PRICE								
COST PLUS FIXED FEE						CONST.		
PLANT FORCES						PF		
ARCHITECT-ENGINEER						CPFF		
DESIGN ENGINEERING OPERATION						FP		
GE FIELD ENGINEER								
SCOPE, PURPOSE, STATUS & PROGRESS								
This project proposal was submitted to HOO-AEC for authorization on June 16, 1960.								
* Weeks after authorization.								

PROJ. NO.	TITLE						FUNDING	
CGE-907	Strontium-90 Interim Program						Special	
AUTHORIZED FUNDS		DESIGN \$ 35,000		AEC \$		COMMIT'S. TO 10-16-60 \$ 68,090		
\$ 420,000		CONST. \$ 335,000		SE \$ 420,000		ESTIMATED TOTAL COST \$ 420,000		
STARTING DATES	DESIGN. 9-3-60	DIRECT COMPL. DATES	DESIGN CONST. 3-1-61	EST'D. COMPL. DATES	DESIGN 3-1-61	PERCENT COMPLETE		
	CONST. 9-8-60				CONST. 3-1-61	WT'D.	SCHED.	ACTUAL
ENGINEER						DESIGN	100	55# 55
FEO - E Radow						AE		
<u>MANPOWER</u>						GE	100	55# 55
FIXED PRICE								
COST PLUS FIXED FEE						CONST.	100	12# 12
PLANT FORCES						PF	11	0 0
ARCHITECT-ENGINEER						CPFF	89	13# 13
DESIGN ENGINEERING OPERATION						FP		
GE FIELD ENGINEER								
SCOPE, PURPOSE, STATUS & PROGRESS								
The underground pipe repair is complete and backfilling has begun. Work in "C" Cell is complete and acceptance with exceptions has been attained. Pipe and equipment removal in "A" Cell is essentially complete.								
The Plant Force welders to fabricate the Titanium vessel have passed the qualification tests. The pipe for this vessel has been shipped and the plate is scheduled for shipment November 7, 1960.								
* Based on schedules submitted for approval signatures.								
1234336								

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 67251			
HANFORD LABORATORIES OPERATION						DATE 10-28-60			
PROJ. NO.	TITLE					FUNDING			
JAE-896	Stress Rupture Test Facility					223-60-1 Design 223-61-j Const.			
AUTHORIZED FUNDS	DESIGN \$ 7,500	AEC \$ 72,500*	COMMIT'S. TO	10-16-60	\$ 6,013				
\$ 80,000	CONST. \$ 72,500	GE \$ 7,500*	ESTIMATED TOTAL COST		\$ 80,000				
STARTING DATES	DESIGN DATES	DIRECT COMPL. DATES	DESIGN DATES	EST'D. COMPL. DATES	DESIGN DATES	PERCENT COMPLETE			
	7-29-60		---		12-1-60	WT'D.	SCHED.		
	2-1-60		10-15-61		10-15-61	ACTUAL			
ENGINEER						DESIGN	100	70	70
FEO - RK Waldman						AE			
MANPOWER						GE	100	70	70
FIXED PRICE									
COST PLUS FIXED FEE						CONST.	100	NS	0
PLANT FORCES						PF			
ARCHITECT-ENGINEER						CPEE			
DESIGN ENGINEERING OPERATION						FP			
GE FIELD ENGINEER									
SCOPE, PURPOSE, STATUS & PROGRESS									
<p>Detail design progressing according to schedule submitted to AEC.</p> <p>* AEC Directive No. HW-514, Mod. 1, authorized HOO-AEC total project funds. Work Authority designating GE funds has not been issued.</p>									

PROJ. NO.	TITLE					FUNDING			
JAE-901	Structural Material Irradiation Test Equipment - ETR					2900 Program			
AUTHORIZED FUNDS	DESIGN \$ 15,000	AEC \$ 21,000	COMMIT'S. TO	10-16-60	\$ 269				
\$ 125,000	CONST. \$ 110,000	GE \$ 104,000	ESTIMATED TOTAL COST		\$ 125,000				
STARTING DATES	DESIGN DATES	DIRECT COMPL. DATES	DESIGN DATES	EST'D. COMPL. DATES	DESIGN DATES	PERCENT COMPLETE			
	9-15-60		2-15-61		2-15-61	WT'D.	SCHED.		
			10-15-61		10-15-61	ACTUAL			
ENGINEER						DESIGN		NS	
FEO - KA Clark						AE			
MANPOWER						GE			
FIXED PRICE									
COST PLUS FIXED FEE						CONST.			
PLANT FORCES						PF			
ARCHITECT-ENGINEER						CPEE			
DESIGN ENGINEERING OPERATION						FP			
GE FIELD ENGINEER									
SCOPE, PURPOSE, STATUS & PROGRESS									
<p>The revised project proposal is being routed for approval. Design is continuing based on the revised scope. Evaluation of the project status and effects of the revised plans for the ETR facility is progressing concurrently with the proposal revision.</p> <p>Purchase specifications for engineered equipment not affected by the requested scope change are in preparation.</p>									

1234337

SEMI-MONTHLY PROJECT STATUS REPORT							HW- 67254		
HANFORD LABORATORIES OPERATION							DATE 10-28-60		
PROJ. NO.		TITLE				FUNDING			
CAH-885		Geological and Hydrological Wells - FY 1960				223-60-1			
AUTHORIZED FUNDS		DESIGN \$ 1,000		AEC \$ 59,000		COMMIT'T'S TO		10-16-60 \$ 6,782	
\$ 69,000		CONST. \$ 68,000		SE \$ 9,100		ESTIMATED TOTAL COST		\$ 69,000	
STARTING DATES	DESIGN. DATES	DIRECT COMPL. DATES	DESIGN. DATES	EST'D. COMPL. DATES	DESIGN. DATES	PERCENT COMPLETE			
	2-15-60		---		4-1-60	WT'D.	SCHED.	ACTUAL	
	6-8-60		11-15-60*		2-15-60	DESIGN	100	100	100
ENGINEER						AE			
FEO - HE Ralph						SE			
<u>MANPOWER</u>						AVERAGE	ACCUM. MANDAYS		
FIXED PRICE									
COST PLUS FIXED FEE									
PLANT FORCES									
ARCHITECT-ENGINEER						CONST.	100	51	62
DESIGN ENGINEERING OPERATION						PF	15	48	48
SE FIELD ENGINEER						CFFF			
						FP	85	52	65
<b>SCOPE, PURPOSE, STATUS &amp; PROGRESS</b>									
Of the ten wells on this project, six have been completed, and two more are in progress. To date, approximately 3,000 feet of hole have been drilled.									
* The 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.									

SEMI-MONTHLY PROJECT STATUS REPORT							HW- 67254		
HANFORD LABORATORIES OPERATION							DATE 10-28-60		
PROJ. NO.		TITLE				FUNDING			
CAH-888		Biology Laboratory Improvements				60-h-1			
AUTHORIZED FUNDS		DESIGN \$ 40,000		AEC \$ 30,000		COMMIT'T'S TO		\$	
\$ 40,000		CONST. \$		SE \$ 10,000		ESTIMATED TOTAL COST		\$ 340,000	
STARTING DATES	DESIGN. DATES	DIRECT COMPL. DATES	DESIGN. DATES	EST'D. COMPL. DATES	DESIGN. DATES	PERCENT COMPLETE			
	8-8-60		2-1-61		3-1-61	WT'D.	SCHED.	ACTUAL	
						DESIGN	100	46	28
ENGINEER						AE	83	35	13
FEO - JT Lloyd						SE	17	100	100
<u>MANPOWER</u>						AVERAGE	ACCUM. MANDAYS		
FIXED PRICE									
COST PLUS FIXED FEE									
PLANT FORCES									
ARCHITECT-ENGINEER						CONST.			
DESIGN ENGINEERING OPERATION						PF			
SE FIELD ENGINEER						CFFF			
						FP			
<b>SCOPE, PURPOSE, STATUS &amp; PROGRESS</b>									
Six drawings and specifications on Title I work received from the Architect-Engineer were reviewed and comments were prepared which were reviewed with the AEC. Title II work is temporarily held up by AEC pending the funding problem being resolved. The preliminary estimate of project cost is considerably more than the indicated total funds made available.									
1234338									

SEMI-MONTHLY PROJECT STATUS REPORT							HW- 67254		
HANFORD LABORATORIES OPERATION							DATE 10-28-60		
PROJ. NO.	TITLE					FUNDING			
AE-870	Facilities for Recovery of Radioactive Materials-325-A					60-B-1			
AL	DESIGN \$ 46,000	AEC \$ 446,000		COMMIT'S. TO 10-16-60		\$ 26,608 (GE)			
\$ 486,000	CONST. \$ 440,000	GE \$ 40,000		ESTIMATED TOTAL COST		\$ 486,000			
STARTING DATES	DESIGN. 9-18-59	DIRECT COMPL. DATES	DESIGN 3-1-60	EST'D. COMPL. DATES	DESIGN 3-1-60	PERCENT COMPLETE			
	CONST. 3-22-60		CONST. 6-1-61		CONST. 6-1-61	WT'D.	SCHED.	ACTUAL	
ENGINEER						DESIGN	100	100	100
FEO - RW Dascenzo						AE	90	100	100
<u>MANPOWER</u>						GE	10	100	100
FIXED PRICE						AVERAGE	ACCUM. MANDAYS		
COST PLUS FIXED FEE						24	1650		
PLANT FORCES									
ARCHITECT-ENGINEER									
DESIGN ENGINEERING OPERATION									
GE FIELD ENGINEER						2			
CONST.						100	63	60	
PF									
CFFF									
FP						100	63	60	
SCOPE, PURPOSE, STATUS & PROGRESS									
<ol style="list-style-type: none"> <li>Erection of structural steel is continuing. The tie-ins into the existing building at high roof elevation have been completed. Finished bolting up floor beams and set part of precast floor beams. Installed all siding angles on structural steel frames.</li> <li>Grouted in all column bases and recesses.</li> <li>Completed forms, re-steel and placed concrete in Vaults "B" &amp; "C" to elev. 393'-9".</li> <li>Placed re-steel to top of Vault "A".</li> <li>Completed forms, placed re-steel, pipe sleeves and concrete for 16" thick floor slab in crane bay area of main building.</li> <li>Some backfill was placed on the north end of the building and excavation was performed for ventilation pipes.</li> <li>Several holes were made in existing concrete walls for ventilation pipes.</li> </ol>									

PROJ. NO.	TITLE					FUNDING			
GCE-874	Consolidation of Plutonium Metallurgy Facilities					61-j			
AUTHORIZED FUNDS \$ -0-	DESIGN \$	AEC \$		COMMIT'S. TO \$		ESTIMATED TOTAL COST \$ 300,000			
	CONST. \$	GE \$							
STARTING DATES	DESIGN. 9-18-59	DIRECT COMPL. DATES	DESIGN 3-1-60	EST'D. COMPL. DATES	DESIGN 3-1-60	PERCENT COMPLETE			
	CONST. 3-22-60		CONST. 6-1-61		CONST. 6-1-61	WT'D.	SCHED.	ACTUAL	
ENGINEER						DESIGN			
FEO - JI Lloyd						AE			
<u>MANPOWER</u>						GE			
FIXED PRICE						AVERAGE	ACCUM. MANDAYS		
COST PLUS FIXED FEE									
PLANT FORCES									
ARCHITECT-ENGINEER									
DESIGN ENGINEERING OPERATION									
GE FIELD ENGINEER									
CONST.									
PF									
CFFF									
FP									
SCOPE, PURPOSE, STATUS & PROGRESS									
<p>The justification and estimate is in the process of being updated by General Electric Company.</p>									

\* Months after authorization.

1234339

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 67254	
HANFORD LABORATORIES OPERATION						DATE 10-28-60	
PROJ. NO.	TITLE					FUNDING	
CAH-866	Shielded Analytical Laboratory - 325 Building					60-a-1	
AUTHORIZED FUNDS		DESIGN \$ 60,000	AEC \$ 45,000	COMMIT'S TO 10-16-60		\$ 9,746(1)	
\$ 60,000		CONST. \$ ---	GE \$ 15,000	ESTIMATED TOTAL COST		\$ 750,000	
STARTING DATES	DESIGN. 6-27-60	DIRECT COMPL. DATES	DESIGN 11-31-60	EST'D. COMPL. DATES	DESIGN 11-11-60	PERCENT COMPLETE	
	CONST. ---		CONST. ---		CONST. 1-1-62	WT'D.	SCHED. ACTUA
ENGINEER						DESIGN	100 79 79*
FEO - RW Dascenzo						AE	90 87 87*
MANPOWER						GE	10 100 100
FIXED PRICE							
COST PLUS FIXED FEE							
PLANT FORCES							
ARCHITECT-ENGINEER							
DESIGN ENGINEERING OPERATION							
GE FIELD ENGINEER							
AVERAGE						9	580
ACCUM. MANDAYS							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>* The decrease in percent completion is due to the modifications required by a change in scope. The exhaust for this facility was previously to be exhausted by the building exhaust system. As the building did not have enough capacity to handle it, a separate exhaust system will be designed.</p> <p>All specifications have been issued for comment and reviewed.</p> <p>A trip was made to the A-E's office on 10/17-19/60 by Messar's W. L. Delvin, J. P. Derouin and R. W. Dascenzo to review the nearly completed detailed design.</p>							

PROJ. NO.	TITLE					FUNDING	
CAH-867	Fuel Element Rupture Test Loop					58-e-15	
AUTHORIZED FUNDS		DESIGN \$ 130,000	AEC \$ 770,000	COMMIT'S TO 10-16-60		\$ 97,580(GE)	
\$ 1,500,000		CONST. \$ 1,370,000	GE \$ 730,000	ESTIMATED TOTAL COST		\$ 1,500,000	
STARTING DATES	DESIGN. 8-1-60*	DIRECT COMPL. DATES	DESIGN ---	EST'D. COMPL. DATES	DESIGN 2-1-61	PERCENT COMPLETE	
	CONST. ---		CONST. 10-1-61		CONST. ---	WT'D.	SCHED. ACTUA
ENGINEER						DESIGN	100 54 40
ALO - PC Walkup						AE	14 NS 0
MANPOWER						GE	86 63 47
FIXED PRICE							
COST PLUS FIXED FEE							
PLANT FORCES							
ARCHITECT-ENGINEER							
DESIGN ENGINEERING OPERATION							
GE FIELD ENGINEER							
AVERAGE							
ACCUM. MANDAYS							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>* Scope design was started November 2, 1959, and completed March 15, 1960. Detail design was started August 1, 1960.</p>							

1234340

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 67254	
HANFORD LABORATORIES OPERATION						DATE 10-28-60	
PROJ. NO.	TITLE					FUNDING	
CGH-857	Physical & Mechanical Properties Testing Cell-327 Bldg.					2900 Program	
<b>A</b>	<b>AUTHORIZED FUNDS</b>	DESIGN \$ 75,000	AEC \$ ---	COMMIT'S. TO	10-16-60	\$ 24,958	
<b>B</b>	\$ 75,000	CONST. \$ ---	GE \$ 75,000	ESTIMATED TOTAL COST	\$ 500,000		
STARTING DATES	DESIGN. DATE	DIRECT COMPL. DATE	DESIGN CONST.	EST'D. COMPL. DATE	DESIGN CONST.	PERCENT COMPLETE	
	10-29-59				1-1-60 7-1-63	WT'D.	SCHED. ACTUAL
<b>ENGINEER</b>						DESIGN	100 95 80
FEO - RW Dascenzo						AE	
<b>MANPOWER</b>						GE	100 95 80
FIXED PRICE						CONST.	
COST PLUS FIXED FEE						PF	
PLANT FORCES						CPFF	
ARCHITECT-ENGINEER						PF	
DESIGN ENGINEERING OPERATION							
SE FIELD ENGINEER							
<b>SCOPE, PURPOSE, STATUS &amp; PROGRESS</b>							
<p>All drawings for the cell and services have been issued to HLO from CE&amp;UO for comment. An investigation is presently being made by V. G. Aquino, the customer engineer, of equipment at various hot laboratory sites and vendor's plants in the East to determine if suitable dilatometer and electrical resistivity machines are available for hot cell use. Due to this investigation, the design work has been held up. All drawings for the impact tester have been issued for comment. The design on the fatigue testers, creep machine and Universal test machine will be ready for comment by Nov. 15, 1960.</p>							

PROJ. NO.	TITLE					FUNDING	
CGH-858	High Level Utility Cell - 327 Building					2900 Program	
<b>A</b>	<b>AUTHORIZED FUNDS</b>	DESIGN \$ 70,000	AEC \$ ---	COMMIT'S. TO	10-16-60	\$ 31,379	
<b>B</b>	\$ 70,000	CONST. \$ ---	GE \$ 70,000	ESTIMATED TOTAL COST	\$ 500,000		
STARTING DATES	DESIGN. DATE	DIRECT COMPL. DATE	DESIGN CONST.	EST'D. COMPL. DATE	DESIGN CONST.	PERCENT COMPLETE	
	10-20-59		---		1-15-61 2-1-62	WT'D.	SCHED. ACTUAL
<b>ENGINEER</b>						DESIGN	100 67 64
FEO - RW Dascenzo						AE	
<b>MANPOWER</b>						GE	95 69 66
FIXED PRICE						Vendor	5 0 0
COST PLUS FIXED FEE						CONST.	100 NS 0
PLANT FORCES						PF	
ARCHITECT-ENGINEER						CPFF	
DESIGN ENGINEERING OPERATION						PF	
SE FIELD ENGINEER							
<b>SCOPE, PURPOSE, STATUS &amp; PROGRESS</b>							
<p>All of the cell and service drawings, except for electrical and structural have been issued for comment. Preliminary design has been completed on the slitting machine and it is being detailed. A design specification has been prepared on the decladder machine and will be submitted to six vendors for proposals the first week in November. The design for the machine to prepare flat tensile test specimens is being scaled up from an existing design. Design has not started on the round tensile test specimen machine. A can opener, scaler and a NAK opener are being designed.</p>							
1234341							

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 67254			
HANFORD LABORATORIES OPERATION						DATE 10-28-60			
PROJ. NO. CGE-834		TITLE Modifications & Additions to High Pressure Heat Transfer Apparatus - 189-D Building				FUNDING 2900 Program			
AUTHORIZED FUNDS \$ 700,000		DESIGN \$ 66,000 CONST. \$ 634,000		ACC \$ -- GE \$ 700,000		COMMIT'S TO 10-16-60 \$ 672,072 ESTIMATED TOTAL COST \$ 700,000			
STARTING DATES	DESIGN. 4-20-59	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN 7-1-60**	PERCENT COMPLETE			
	CONST. 4-22-59		CONST. 10-15-60		CONST. 3-1-61*	WT'D.	SCHED.	ACTUAL	
ENGINEER EPO - E Radow						DESIGN	100	100	99**

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 67254	
HANFORD LABORATORIES OPERATION						DATE 10-28-60	
PROJ. NO.	TITLE					FUNDING	
77-819	Increased Laboratory Waste Facilities - 300 Area					223-60-1	
AUTHORIZED FUNDS		DESIGN \$ 27,000	ARC \$ ---	COMMIT'S. TO 10-16-60		\$ 119,840	
\$ 193,765		CONST. \$ 116,765	GE \$ 193,765	ESTIMATED TOTAL COST		\$ 193,765	
STARTING DATES	DESIGN	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE	
	3-30-59		---		4-29-60	WT'D.	SCHED. ACTUAL
	CONST. 6-8-60		CONST. 5-31-61		CONST. 2-1-61		
ENGINEER						DESIGN	100 100 100
EEO - KA Clark						AE	
MANPOWER						GE	100 100 100
FIXED PRICE							
COST PLUS FIXED FEE						CONST.	100 54 56
PLANT FORCES						PF	4 80 80
ARCHITECT-ENGINEER						CPFF	30 51 53
DESIGN ENGINEERING OPERATION						PF	66 62 75
GE FIELD ENGINEER							
AVERAGE							
ACCUM. MANDAYS							
6							300
-							229
--							400
.2							9
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>The Loadout Building has been made available to operations for use, with remaining construction work to be scheduled (10-24-60).                      Storage building piping, painting and electrical work is in progress.                      J. A. Jones has started excavation for continuation of the piping trench to tie-in to the existing facilities.</p>							

PROJ. NO.	TITLE					FUNDING	
CAH-822	Pressurized Gas Cooled Facility					58-e-15	
AUTHORIZED FUNDS		DESIGN \$ 40,000*	ARC \$ ---	COMMIT'S. TO 10-16-60		\$ 773,214	
\$ 995,000		CONST. \$ 955,000	GE \$ 995,000	ESTIMATED TOTAL COST		\$ 995,000	
STARTING DATES	DESIGN	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE	
	8-19-59		---		4-29-60	WT'D.	SCHED. ACTUAL
	CONST. 10-17-60		CONST. 6-30-61		CONST.		
ENGINEER						DESIGN	100 100 100
HLO - DF Schively						AE	
MANPOWER						GE	100 100 100
FIXED PRICE							
COST PLUS FIXED FEE						CONST.	100 NS 10
PLANT FORCES						PF	
ARCHITECT-ENGINEER						CPFF	100 NS 10
DESIGN ENGINEERING OPERATION						PF	
GE FIELD ENGINEER							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>The first two sub-assemblies from Struthers-Wells were received in damaged condition. Claims will be processed against the carriers, for damages incurred during shipment, after repairs have been made.</p>							

\* Does not include design performed by Struthers-Wells.

1234343



SEMI-MONTHLY PROJECT STATUS REPORT							HW- 67254		
HANFORD LABORATORIES OPERATION							DATE 10-28-60		
PROJ. NO.	TITLE					FUNDING			
CG-731	Critical Mass Laboratory					58-h-4			
AUTHORIZED FUNDS		DESIGN \$ 142,000	AEC \$ 0	COMMIT'S. TO		\$			
\$ 1,000,000		CONST. \$ 858,000	GE \$ 1,000,000	ESTIMATED TOTAL COST		\$ 990,000			
STARTING DATES	DESIGN	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE			
	5-22-58		---		2-26-59	WT'D.	SCHED.	ACTUAL	
	CONST. 6-4-59		CONST. 6-30-60		CONST. 6-30-60				
ENGINEER						DESIGN	100	100	100
FEO - DS Jackson Project Engineer - DL Ballard, CE&IO						AE			
<u>MANPOWER</u>						GE	100	100	100
FIXED PRICE						AVERAGE	12	2950	
COST PLUS FIXED FEE						ACCUM. MANDAYS	1	150	
PLANT FORCES						CONST.	100	100	100**
ARCHITECT-ENGINEER						PF			
DESIGN ENGINEERING OPERATION						CPEP	14	100	100**
GE FIELD ENGINEER						PP	86	100	100
<p><b>SCOPE, PURPOSE, STATUS &amp; PROGRESS</b> Allied Engineering has completed modification of safety rod drive assembly, however, various limit switch problems have caused further delay in shipment of reactor components. Very little progress can be made toward completing startup of this facility until equipment is received. Heat treatment of Reactor Vessels at Portland Copper and Tank Works was not necessary. Shipment is pending completion of polishing by vendor. Shipment of the first vessel (sphere) is expected by 11/4/60. As-Builts for Phase I Construction have been completed.</p> <p>* Phase I only; Phase II design was completed 3-31-60.  ** Complete with exceptions as noted on Physical Completion Notice.</p>									

PROJ. NO.	TITLE					FUNDING			
CA-744	Metallurgical Development Facility, 306 Building Addition					58-b-4			
AUTHORIZED FUNDS		DESIGN \$ 137,200	AEC \$ 1,366,000	COMMIT'S. TO 9-30-60		\$ 2,581,449			
\$ 2,685,000		CONST. \$ 2,547,800	GE \$ 1,319,000	ESTIMATED TOTAL COST		\$ 2,685,000			
STARTING DATES	DESIGN	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE			
	6-30-58		---		9-30-59	WT'D.	SCHED.	ACTUAL	
	CONST. 3-20-59		CONST. 9-1-60		CONST. 9-1-60				
ENGINEER						DESIGN	100	100	100
FEO - KA Clark Project Engineer - JF Hall						AE			
<u>MANPOWER</u>						GE	100	100	100
FIXED PRICE						AVERAGE	--	10,600	
COST PLUS FIXED FEE						ACCUM. MANDAYS	--	2,330	
PLANT FORCES						CONST.	100	100	100
ARCHITECT-ENGINEER						PF	2	100	100
DESIGN ENGINEERING OPERATION						CPEP	42	100	100
GE FIELD ENGINEER						PP	56	100	100
<p><b>SCOPE, PURPOSE, STATUS &amp; PROGRESS</b></p> <p>The last modification of the Jensen-Rasmussen contract, AT(45-1)-1440, has been settled.</p> <p>Johnson Service Co. has agreed to replace temperature sensing elements in the pre-heat temperature controls. Replacements are requested from the supplier with air-freight delivery.</p> <p>The J. A. Jones Co. is completing partition changes and minor equipment installation work, including the air receiver.</p> <p>The Pacific Scientific Co. representative is completing modifications to the vacuum tube annealing furnace.</p>									

1234345

PROFESSIONAL PLACEMENT AND  
RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of October 31, 1960 the staff of the Hanford Laboratories totalled 1380 employees, including 662 exempt and 718 weekly salaried. Of the total 568 possess technical degrees, including 341 B.S., 123 M.S., and 104 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for October was 1.80 as compared with 1.21 for the preceding month. There were no disabling injuries or serious accidents during the month. There were 4 security violations, bringing the total for the year to date to 28, as compared with 40 for the corresponding period last year.

Hanford Laboratories qualified for the Manager's Safety Award on October 19 in recognition of 321 accident free days.

PROFESSIONAL PLACEMENT

During October there were two visits by Ph.D. candidates seeking employment, and an inexperienced Ph.D. theoretical physicist reported for work in Hanford Laboratories. Hanford Laboratories extended an offer to an experienced Ph.D. chemist.

Three Technical Graduates were added to the rolls including two members of the Company Engineering and Science Program, seven accepted permanent assignments including one Engineering and Science Program member, and one terminated for military service.

The Company's starting rate structure for inexperienced Technical Graduates will be increased 2-1/2% over last year's rates.

EMPLOYMENT

There were 17 weekly salaried vacancies filled during the month and 15 requisitions for additional weekly salaried personnel received. As of October 31, 21 weekly salaried vacancies existed.

TRAINING

The Seminar, "Business Operations in Our Changing Environment," continued as did a class for 15 participants in "Understanding People."

  
Acting Manager  
Professional Placement  
and Relations Practices

TABLE II NONEXEMPT EMPLOYMENT

<u>Nonexempt Employment Status</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nonexempt Transfer Request</u>	<u>Sept</u>	<u>Oct.</u>
Requisitions			Transfers		
At end of month	24	21	Active Cases at end of mo.	81	78
Cancelled	2	1	Cancelled	0	3
Received	20	15	New	4	2
Filled	16	17	Effectuated	0	2

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAO - September 1, 1960 to Date

	Cases Considered	Visits to Richland		To Visit	Offers			On the Roll
		Invited	Visited		Extended	Accepted	Open	
PhD	120	32	5	6	7	-	2	-
Exp. BS/MS	127	20	13	2	11	7	1	4
Prog. BS/MS	56	-	-	-	3	-	2	2

B. Technical Recruiting Activity - HIO - September 1, 1960 to Date

	Cases Considered	Visits to Richland		To Visit	Offers			On the Roll
		Invited	Visited		Extended	Accepted	Open	
PhD	120	32	5	6	3	-	-	-
Exp. BS/MS	10	4	3	1	2	-	-	-

In addition to the above activity, 3 exempt employees have transferred into HIO from other HAO departments and 6 technical graduates have accepted Off-Program placement in HIO to date.

C - Technical Graduate Program  
Month ending October 31, 1960

Number of Personnel on Assignment	70
(HAPO Tech Grad Program .....	64
(Western District E.P. ....	6

Distribution of Assignments by Departments

IPD	30
HLO	17
FPD	10
CPD	6
CE&UO	5
C&AO	2

Distribution of Assignments by Function

R&D or Engineering	45
Other	25

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FINANCIAL OPERATION MONTHLY REPORT  
OCTOBER 1960

Personnel

There were no personnel changes during October.

Activities

GENERAL ACCOUNTING

As of the end of October, travel was running at a slightly higher level than in the previous year, a reversal of an earlier trend.

Reconciliation of the inventory of movable cataloged equipment in custody of the Radiation Protection Operation is complete. Inventory documents were forwarded to C&AO for completion of the reconciliation and for use in updating HLO records. All of the equipment on record at the time of inventory was physically located. Upon completion of the reconciliation, a formal report of findings will be issued.

The reconciliation by C&AO of the physical inventory of the Hot Semi-Works facility continues. C&AO advises reconciliation will not be completed until December.

Eighty-two items valued at \$36,633 were received at the Laboratory Equipment Pool during October. Eleven items valued at \$6,597 were placed in lieu of placement of requisitions. There were 559 items valued at \$224,987 in the Pool at month end. Activity within the Laboratory has been gaining momentum, and the number of calls and visitors requesting information on the availability of equipment has increased considerably.

Over nine thousand pounds of usable, type 3, zirconium scrap was transferred to the Pool during the month. This material will be held on a memorandum quantity record basis at no cost. The following materials were on hand as of October 30, 1961:

Beryllium	\$ 33
Palladium	1 571
Platinum	10 978
Silver	77
Gold	2 952
Zirconium	72 954
	<u>\$ 88 565</u>

Justification was assembled to substantiate our request for additional equipment funds in the O4 Program. The current Financial Plan provides \$715,000 for equipment while our indicated needs are \$1,235,000.

COST ACCOUNTING

Preparation of the FY 1961 Mid-Year Budget Review is progressing. Although the September personnel forecast was approved for budget purposes, receipt of the October Financial Plan prompted a review of the personnel requirements which resulted in revising the forecast slightly as follows:

	<u>September Forecast</u>	<u>Mid-Year Review</u>
Personnel at 12-31-60	1 391	1 392
3-31-61	1 393	1 386
6-30-61	1 390	1 380

The above numbers compare with a current force of 1,381 at 10-31-60.

Program amounts for inclusion in the Mid-Year Review have been determined. Compilation and consolidation of these amounts is currently under way for submission to the Manager - Hanford Laboratories and to Contract Accounting.

Three special requests from AEC were received by Hanford Laboratories during the month as follow:

- (1) Repair and service microscopes and balances for the Kadlec Methodist Hospital. No total amount authorized, but a billing rate of \$7.50 per hour has been established.
- (2) Approval of O. J. Wick to serve as a member of the Review Committee for Metallurgical Engineering at ANL. Salaries and continuity of service plus travel expenses have been authorized for billing to the University of Chicago.
- (3) Approval of W. L. Nicholson to teach at the University of Idaho during the period 9-1-60 through 1-31-61. Salaries and continuity of service have been authorized for billing to the University of Idaho.

Program code .29 "Strontium-90 Purification" was established during the month and three organizational codes within Physics and Instrument R&D Operation were established and one was cancelled as follows:

<u>Code</u>	<u>Organization Title</u>
7421	Theoretical Physics (Cancelled)
7460	Applied Physics Operation
7461	Theoretical Physics
7462	Reactor Analysis

A major step towards conversion of the HLO cost accounting system to electronic data processing was accomplished during October. Arrangements were completed to utilize individual Time Distribution Reports with certain pre-printed information supplied by Data Processing. The TDR's will be completed by components and

submitted weekly for further processing. Data Processing will compute the distribution of salaries and indirect expenses to programs and customers as well as provide manpower information. All components in Hanford Laboratories were contacted concerning the use and preparation of TDR's.

After analysis of the potential problems involved in accounting for FRTR fuel costs in accordance with recent revisions to the AEC Manual, the counter proposal was prepared, modifying the application of the Manual to FRTR. This proposal was then presented to HOO-AEC representatives and a representative from the AEC Controller's office. Pending review of the problems with other Washington-AEC officials during November, no decisions have been made regarding the acceptability of the proposed changes.

Action as indicated occurred on the following projects during the month:

New Funds Authorized HLO

AEC-167 Plutonium Recycle Test Reactor	\$150 000
CAH-841 High Pressure Loop (Project abandoned)	(50 000)

Physical Completion Notices Issued

CGH-877 Pyrochemical Test Facility, 321-A building

GENERAL

Payroll Statistics

Number of HLO Employees

	<u>Total</u>	<u>Exempt</u>	<u>Non-Exempt</u>
Changes During Month			
Number on Payroll at Beginning of Month	1 372	667	705
Additions and Transfers In	22	5	17
Removals and Transfers Out	(13)	(10)	(3)
Employees on Payroll at Month-End	<u>1 381</u>	<u>662</u>	<u>719</u>

Overtime Payments During Month

	<u>October</u>	<u>September</u>
Exempt	\$ 9 212	\$ 8 825
Non-Exempt	<u>19 108</u>	<u>18 417</u>
Total	<u>\$28 320</u>	<u>\$27 242</u>

Gross Payroll Paid During Month

Exempt	\$579 695	\$ 581 436
Non-Exempt	<u>360 597</u>	<u>431 505</u>
Total	<u>\$940 292</u>	<u>\$1 012 941</u>

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UNCLASSIFIED

Participation in Employee Benefit Plans at Month End

	October		September	
	Number	Percent	Number	Percent
Pension Plan	1 217	99.4	1 215	99.4
Insurance Plan				
Personal Coverage	1 372	99.8	1 363	99.8
Dependent Coverage	985		976	
U.S. Savings Bonds				
Stock Bonus Plan	75	36.9	75	37.1
Savings Plan	90	6.5	91	6.6
Savings and Security Plan	1 051	85.2	1 054	85.9
Accident Insurance	797	57.8	795	58.0

	October		September	
	Number	Amount	Number	Amount
<u>Insurance Claims</u>				
Employee Benefits				
Life Insurance	-0-	\$	-0-	\$
Weekly Sickness and Accident	10	730	5	317
Comprehensive Medical	55	2 456	94	4 431
Dependent Benefits				
Comprehensive Medical	84	8 139	125	13 956
Total	149	\$11 325	224	\$18 704

Good Neighbor Fund

	October	September
Number Participating	941	947
Percent Participating	68.1	69.0

*W Sale*  
Manager - Finance

W Sale:bk

11-15-60

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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

J. Dunn

Hydraulic Ram Intensifier

L. L. Ames, Jr.

Removal of Ru and Other Radioisotopes from Low-Level Wastes

R. Fullerton

D. W. Pearce

D. G. Foster, Jr.

A possible invention is being investigated. This possible invention concerns the use of bearings for rotating electrical contacts in a slip ring application. This possibility is documented by an entry in HWN-2617, page 8, 10/28/60.

J. E. Hammond

The Method for Assembling Models of Nuclear Reactor Fuel Elements

F. B. Quinlan

The Art of Gripping Materials

J. W. Weber

Fuel Element Support Bearing Surface Materials to Prevent Scratching of Autoclave Zircaloy-2 Process Channels

