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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT

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NOVEMBER, 1959

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HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
NOVEMBER, 1959

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Compiled by
Operation Managers

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DS Rewick 6/30/92
DD Krishen 8/10/92
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December 15, 1959

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE November 30, 1959

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	128	101	229	129	101	230	0	3	1	3
Reactor & Fuels Research & Development	196	172	368	195	172	367	2	2	1	2
Physics & Instrument Research & Development	65	34	99	63	34	97	2	0	0	0
Biology Operation	35	45	80	35	45	80	0	0	0	0
Operation Res. & Syn.	16	4	20	16	4	20	0	0	0	0
Radiation Protection	34	101	135	33	99	132	1	3	0	1
Laboratory Auxiliaries	52	193	245	52	191	243	1	3	1	1
Financial	14	13	27	14	13	27	0	0	0	0
Prof. Plcmt. & R. P.	78	18	96	82	19	101	2	0	6	1
Programming	15	4	19	16	4	20	0	0	1	0
General Totals	1	1	2	1	2	3	0	0	0	1
	634	686	1320	636	684	1320	8	11	10	9
Totals excluding internal transfers	634	686	1320	636	684	1320	4	8	6	6

Composite Separation Rate ---------- 1.4393

Separation Rate (based on separations leaving G. E.) ---------- .4545

Controllable Separations Rate ---------- .1515

BUDGETS AND COSTS

Costs for November were $1,948,000, a decrease of $23,000 from October. Fiscal year-to-date costs are 41% of the amounts currently authorized to Hanford Laboratories. The amounts currently authorized have been adjusted to include the increase of $1,140,000 as authorized by the Division of Reactor Development this month. Hanford Laboratories programs at November 30, 1959 have the following cost - budget relationship.

(In Thousands)

	Cost	Budget	% Spent
2000 Program	$ 222	$ 616	36
4000 Program	2 851	7 052	40
5000 Program	195	541	36
6000 Program	885	2 198	40

Research and Development costs for the Hanford Product Departments were in line with amounts authorized except for the New Production Reactor. Funds for FY 1959 were 55% spent at the end of November.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

PRTR Phase II-A (River Pump Structure) has been completed, and over-all PRTR construction is 54% complete. The Plutonium Fabrication Pilot Plant Phase III equipment installation contract was terminated November 15, 1959, with contract completion estimated at 96%. The remaining work will be done by the J. A. Jones Construction Company.

Design and analysis work on PRTR and associated facilities included completion of the Pressurized Gas Cooled Loop transient analysis, issue of the PRTR Final Safeguards Analysis, completion and circulation for approval of the High Pressure Loop (Project CAH-841) Project Proposal, completion of the scope description for the PRTR Rupture Loop (Project CA-867), and issue for comment of design criteria for the PRTR Critical Reactivity Measuring Facility (Project CAH-842).

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HW-62734, a report summarizing findings of the PRTR helium compressor test program, was issued.

The plutonium fuel rods to be used at PRTR startup consist of an extruded Al-Pu core in an unbonded Zr-2 jacket. In ex-reactor thermal cycling tests warping and dimensional change have frequently occurred. It now appears that by careful control of gap dimensions between core and cladding this difficulty can be overcome. Three elements having a minimum gap of 0.0049 inch withstood 77 thermal cycles without dimensional change.

Three semi-prototypical irradiations of PRTR Pu-Al elements are in progress: a 19-rod cluster in the ETR 6"x9" loop facility, a seven-rod cluster in the ETR 3"x3" facility, and a seven-rod cluster in KER Loop 1.

High density 0.0259 a/o PuO_2-UO_2 mixed crystal oxide pellets irradiated to 4.4×10^{20} nvt had a microstructure very similar to that of irradiated UO_2. Fission gas release data are being obtained.

The liquidus of the PuO_2-UO_2 system has been determined; the curve follows the general form for simple systems of this type, and no deviations from uniformity were observed. Indications of slight loss of oxygen of PuO_2 at high temperatures were also obtained. PuO_2 held for one hour at 2000 C in vacuo formed some Pu_2O_3.

Fabrication of cold swaged UO_2 fuel elements for the first PRTR loading was started about nine months ago. During that period intensive process development has reduced unit fabrication costs several-fold. Quantitative cost data are being developed as the work proceeds.

The grain size of UO_2 appears to have a marked effect on its thermal conductivity.

Electron microscope studies of thin films of UO_2 irradiated at low temperatures reveal discrete fission tracks at low exposures and agglomeration of the UO_2 particles at higher temperatures, presumably by sublimation.

An in-reactor creep test capsule is still functioning properly after three months exposure in KW Reactor, a gratifying performance in view of the difficulties in this kind of experiment. Creep has not

been observed on the Zircaloy-2 test specimen or the ex-reactor control specimen as temperatures and stresses have been progressively raised to the present 315 C and 22,000 psi.

Unirradiated sections of heavy-wall Zircaloy-2 tubing are being burst tested at room temperature in preparation for burst testing sections of irradiated KER Zircaloy-2 tubing at essentially room temperature.

Three smooth-bore Zircaloy-2 replacement process tubes, to be installed in C Reactor, have arrived on-site after fabrication by Bridgeport Brass Company.

A simple electrographic technique has been developed to detect both copper contamination on pickled coextruded NPR fuel tubes and uranium contamination of the weld area.

A viewing cell has been constructed which permits visual observation and time-lapse photography of rupturing (predefected, unirradiated) metallic uranium fuel rod exposed in hot water at 300 C and 1500 psi The hydrogen gas evolved by the reaction is also collected and measured as an indicator of the water-uranium reaction rate.

Failures due to hot spots from touching fuel rods are regarded as possible. Two coextruded uranium-Zircaloy fuel rods electrically heated (30 kw/ft), and in surface contact at one point, did not rupture after 3.75 hours in a flow loop at 300 C and 20 fps water velocity.

The use of HNO_3 vice H_3PO_4 to adjust water pH to 4.5 resulted in an eight-fold increase in the corrosion rate of X-8001 aluminum in a 600-hour out-of-reactor loop test at 300 C.

Samples of needle coke graphite irradiated at 600 C and above, consistently undergo less contraction than samples of CSF graphite or other non-needle coke graphites. Also, the out-of-reactor oxidation rate of one candidate needle coke graphite, measured in CO_2 at 750 C, was slightly less than the rate for CSF graphite.

Initial results indicate the feasibility of increasing the size of outlet hydraulic connectors on old reactor process tubes; however, Panellit protection would be reduced slightly.

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HW-62798, "Single Tube Flow Rates at Low Header Pressures with Nozzle Caps Removed - - All Reactors," was issued.

2. Chemical Research and Development

First experiments indicated that plutonium may be dissolved and subsequently precipitated as PuO_2 from the Salt Cycle Process media by using appropriate reagents. The PuO_2 precipitation was done with uranium present in the melt, thus permitting a simultaneous partition. Exploratory tests were started on potential pyrochemical decladding schemes to handle Zircaloy-clad UO_2 in a fashion compatible with the Salt Cycle Process.

Summary analysis of fourteen pilot plant tests showed the dissolution behavior of standard HAPO fuel slugs in the recirculating Flooded Tray Dissolver to be essentially identical with a conventional batch dissolver.

Special methods of "potting" with metallic or plaster materials were shown to be effective ways to prevent excessive vibration while extraneous hardware was cut off of power fuels. Power hacksaws were employed for the test series.

Electrolytic methods were shown to be an effective way to depassify stainless steel in a sulfuric acid medium (Sulfex) even when low concentrations of nitrate ion were present.

Concurrent precipitation of iron salts complicates recovery of fission product strontium by the sulfate precipitation method reported last month. The use of complexing reagents may solve the problem. Tests also indicated it may be possible to utilize a carrier precipitate to recover strontium.

The original scintillation phosphor on the contact alpha counter located on the Purex 2BP stream operated for twenty-two months before failure to demonstrate the durability of this development.

3. Physics and Instrument Research and Development

In the Plutonium Recycle Program, measurements of the lattice parameters of low exposure plutonium fuel elements are progressing satisfactorily in spite of a large neutron background arising from the (α,n) reaction of the plutonium on the aluminum matrix. The intermediate

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exposure plutonium containing 20% Pu^{240} which we had expected to use in continuing this work to higher exposure plutonium will be unavailable. Extension of the work to higher exposures will be undertaken when material is available from the MTR.

Acceptance testing of phototubes and crystals for the PRTR rupture monitor continued during the month. The rejection rate on phototubes was 20-25% and that on crystals was considerably higher.

In the NPR Program it has been necessary to redesign the graphite for the exponential experiments to correspond more closely to a similar redesign of the actual NPR stack. Meanwhile measurements continue on lattices and fuel elements of types similar to that of the NPR. These data will permit a better assessment of the neutron economy in the NPR when combined with measurements with the actual NPR lattice.

Mechanical design of the NPR fast scan fuel rupture monitor is 5% complete while fabrication of equipment to simulate its action for laboratory tests is nearing completion. Other work for the development of radiation monitoring instruments for use around reactors included the development of a long flexible light pipe for investigating pigtail contamination and the development of an improved head for the 105-N Building beta-gamma air monitor.

In the Nuclear Safety Program a series of experiments was begun to determine the relationship of other geometrical shapes to the cylindrical shape in which such experiments have customarily been carried out for reasons of convenience. Measurements also continued to higher concentrations of 3%-enriched uranium homogeneously mixed in hydrogeneous moderator.

The construction of the Critical Mass Laboratory is proceeding nearly on schedule to date, but delayed delivery of the control panel and associated instrumentation may result from the effects of the steel strike.

During the month nuclear safety advice was furnished to CPD on the design of equipment for processing non-production fuels and in the design of casks and cask cars for the transportation of NPR fuel elements. An experimental check of the nuclear safety of the NPR cask design is planned when sufficient NPR fuel elements become available.

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In the Nondestructive Testing Program promising preliminary results were obtained on a method for simultaneously measuring zirconium jacket thickness and the thickness of the air gap between the jacket and the contained fuel rod. If successful this method will have direct application in the Plutonium Recycle Program as well as in other fuel element fabrication programs throughout the AEC.

One source of the small amounts of Zn^{65} detected in people examined at the Shielded Personnel Monitoring Station, as previously reported, is now believed to be Pacific Ocean seafood. Similar results, but showing lower concentrations, have been recently reported from other sites on Atlantic Coast seafood. Maximum concentrations found to date occurred in oysters but were less than 50% of the maximum permissible concentration for Zn^{65} in water.

In the Gas-Cooled Reactor Program measurements were completed on the effect of a control rod inserted into a gas-cooled reactor lattice. Results obtained were in excellent agreement with predictions from theoretical calculations.

Development of a satisfactory calibration technique by the Analytical Chemistry Operation has greatly aided work on the compilation and analysis of the results obtained in last summer's atmospheric physics program. A schedule has been laid out in collaboration with the Air Force for the preparation of the reports.

Orderly progress was made on the many projects in the radiation monitoring instrument field. Noteworthy was the decision to prepare as-built drawings on the Alpha-Beta-Gamma Scintillation Transistorized Hand and Shoe Monitor which had operated continuously for 9 months with only minor servicing in the 329 Building.

The mass spectrometer developed for the Division of Research operated routinely during the month with sample runs being made on 16 of the 19 working days.

4. Biology

Biological monitoring tests proceeded without notable changes in contamination levels or effects of reactor effluents.

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Work on a strontium and calcium problem, which earlier suggested the lack of validity in assumptions being made in assessing Sr^{90} hazards in terms of a ratio, is now contributing to some important knowledge of calcium metabolism, particularly in terms of relationship between dietary calcium and physiological turnover of the substance.

Ce^{-144}-Pr^{144} injected into a ram showed interesting variation in tissue concentration. The pituitary, for example, had a concentration 20 times greater than the plasma.

Work at Rochester several years ago suggested that the pulmonary lymph nodes may be the critical organ for inhaled radioactive particles. Since then, we have noted similar concentrating abilities of the nodes. Recent work on $Pu^{239}O_2$ in lungs of dogs indicate that somewhere between two and ten weeks after inhalation the lymph nodes contain a higher concentration of plutonium than the lung.

Although caution must be exercised in drawing any conclusions from this, a tumor was found under the skin of a rabbit which had been exposed to 16,000 rads from P^{32} four years ago We believe this to be the first skin tumor caused by irradiation of rabbit skin.

Polyvinylpyrrolidone may be a reasonable substance for diagnosing intestinal radiation injury. Work with the substance, when labelled with I^{131}, showed that 750 r whole-body exposure doubled the normal loss of the substance into the intestine. One thousand r quadrupled it.

Swine were given bone marrow cells after exposure to 900 r, total body X irradiation (LD/100). One of the pigs is still alive. Although this may be the first time a lethally irradiated pig has survived beyond two weeks, the result is still preliminary.

5. Programming

A report on ionium (thorium-230) for preparation of the potentially useful radioisotopes U-232 and Th-228 was prepared. Related work involved a brief survey of uranium ore processing industry. The survey was sufficient to show that a large fraction of the industry has a potential for providing thorium concentrates ranging from 2 to 5 per cent thorium-230.

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To check out the recently developed Meleager code, the Yankee reactor lattice calculations performed last year using other codes were repeated. As before long-burning "Phoenix" fuel performance was noted for certain instances; in particular when using plutonium feed with an artificially high ratio of Pu-240 to Pu-239. Phoenix behavior was also found to depend strongly on resonant absorption in the fuel, and thus to be influenced greatly by fuel geometry considerations.

A detailed schedule of critical start-up tests for the PRTR was drawn up.

Assistance was rendered to the AEC Division of Reactor Development in preparing the Plutonium Recycle Program portion of a 10 year reactor development program.

TECHNICAL AND OTHER SERVICES

A simple method was developed of assigning supplemental crew personnel which minimizes total charge-discharge time for the reactor complex.

Further work was done in relating dimensional distortion experienced by co-extruded tubes during heat treating to the reduction ratio employed in the co-extrusion process.

Work on 10 operations analysis programs continued during the month. In addition, statistical and mathematical assistance on 10 problems was given within HLO and to other departments and operations.

Positive findings of Zn^{65} in 95% of the subjects examined in the Shielded Personnel Monitoring Station led to investigation of sources of this radioisotope in humans. In addition to previously reported Zn^{65} in Columbia River water, some Pacific Ocean sea foods were examined as possible sources of this radioisotope. Pacific oysters showed the highest concentration of Zn^{65} in the sea foods examined and averaged 4 to 5 x 10^{-5} $\mu c/gm$ oysters. A steady dietary habit of one pound of such oysters per week would result in less than 5% of the permissible body burden for Zn^{65}.

Analyses of Columbia River water obtained at Vancouver, Washington, for the past several months indicated Cr^{51}, Np^{239}, Zn^{65} and P^{32}, in that order, to be the most abundant radioisotopes and account for over 90% of the total radioisotopic content of the river at that point. The

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daily quantity (in curies) of these radioactive materials passing a point near Vancouver was estimated at Cr^{51} - 900, Np^{239} - 70, Zn^{65} - 20, and P^{32} - 20. These radioisotopes in the Columbia River water at Vancouver represent 0.2% - 0.5% of the drinking water MPC for persons in the neighborhood of controlled areas. The large residual in terms of total curies entering the Pacific Ocean has perhaps not been appreciated by those observing the river system. It has been clear from simple decay arithmetic applied to the discharge passing Pasco. Such a calculation overstates the ocean discharge (no allowance for uptake in river organisms or mud) but not by a major factor.

There were 23 authorized projects at month's end with total authorized funds of $7,683,600. The total estimated cost of these projects is $9,570,365. Two new projects were authorized and two were completed during the month. Three new projects are awaiting AEC approval and two new projects were submitted to AEC during the month. Five proposals for new projects are in preparation.

Total productive time for Technical Shops for the month was 13,321 hours. This includes 12,159 performed in the Technical Shops, 730 assigned to Minor Construction, 158 to other project shops, and 274 hours to off-site vendors. The total shop backlog is 25,547 hours of which 50% is required in the current month, with the remainder distributed over a three-month period. Overtime worked during the month was 3.8% (599 hours) of the total available hours.

Radiographic Testing made a total of 8,565 tests, of which 970 were radiographic (including x-ray and gamma-ray) and 7,595 were supplementary tests. Out of a total of 3,066 man-hours, 727 (23.7%) were in connection with radiographic tests, and 2,339 (76.3%) were used on supplementary tests.

The procedure for off-site distribution of uncategorized classified reports is being reviewed and will be modified. It is expected that the new procedure will require that HOO-AEC approve all off-site distribution of such reports.

SUPPORTING FUNCTIONS

The laboratory equipment pool (Building 3718) is ready for operation. Equipment is in the process of being tagged prior to transfer to the storage area.

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Equipment expenditures and commitments are running substantially ahead of FY 1959 at November 30 but are within approved ceilings.

The HLO contribution for "1959 at HAPO" is being prepared. Several groups have been contacted for pictures and the narrative is being prepared. Deadline for the first rough draft is January 8.

Recent reallocation of funds by the HAPO - General Manager which is based on the Mid-Year Budget Review indicates a reduction of equipment funds available to Hanford Laboratories in the amount of $233, 000.

As of November 30th, the staff of the Hanford Laboratories totalled 1320 employees, including 634 exempt and 686 nonexempt. There were 547 employees possessing technical degrees, including 336 B. S., 112 M.S., and 99 Ph. D.

The medical treatment frequency for November was 1. 48 as compared with 1. 51 last month. There were 4 security violations during November, bringing the total for the year to date to 42.

During the month, a pressure accumulator in 314 Building basement failed while under pressure of 18, 000 psi. The end plug was ejected as a result of an inadequate number of threads of the proper quality to withstand the pressure. There were no employees injured although the damage totalled $3500.

During November, HAPO participated in Ph. D. recruiting at M. I. T., Ohio State, Colorado, Utah, Wisconsin, Iowa State, Iowa, Oregon State, Oregon, and California. Referrals from these and schools previously visited this year are being received in increasing numbers for HAPO consideration. Three Ph. D. candidates visited for interviews during November and one offer was extended to a Ph. D. candidate.

Mid-year campus visitations have been completed except for four southwestern schools scheduled early in December. No mid-year offers have been extended to date; however, an appreciable number of June graduates have been developed as candidates. Seven offers were extended to BS/MS experienced personnel during the month and five offer acceptances were received.

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Two Technical Graduates were added to the Program during the month and four were placed on permanent assignment. On November 30th there were 67 Technical Graduates and 7 Technician Trainees on the Programs.

Eleven requisitions were filled during November. With the receipt of 8 requisitions, 2 cancellations and 5 placed on a hold basis, there were 7 openings at month's end, for which 4 candidates are in process, 2 transfers pending and one yet to be procured.

H M Parker

Manager
Hanford Laboratories

HM Parker:pmg

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REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Hydriding of Zircaloy in Simulated NPR Gas Atmosphere. Eight Zircaloy coupons were exposed in a "high hydrogen" simulated NPR gas atmosphere. This gas atmosphere was produced by passing helium at atmospheric pressure through water undergoing electrolysis. The resulting gas mixture of helium, oxygen, hydrogen, and water vapor was then passed through a heated (1100 C) one-inch diameter tube packed with graphite. As a result of reaction with the hot graphite, a product gas of the following mass spectrometer analysis (in mole %) was obtained: 86.4 He, 7.04 H_2, 5.13 CO, 1.25 N_2, 0.11 H_2O, and less than 0.01 each for O_2, A, and CO_2.

This reaction gas was then passed over the Zircaloy samples which were held at 400 C. After 21 days of exposure the samples were removed and analyzed for hydrogen, with results as follows:

Furnace Position	Alloy	Surface Preparation	Vacuum Fusion Analysis Hydrogen Found After 21 Days at 400 C
1	Zr-2	Etched	410 ppm
1	Zr-4	Etched	635 ppm
2	Zr-2	Vapor Blast	810 ppm
2	Zr-2	Vapor Blast + 22 hr preautoclave 400 C, 1500 psi steam	37 ppm
3	Zr-2	Etched & preautoclave 22 hr; 400 C, 1500 psi steam	29 ppm
3	Zr-3	Etched	286 ppm
4	Zr-2	Etched	230 ppm
4	Zr-4	Etched	340 ppm

The starting hydrogen values were, for the Zircaloy-2, 20 ppm; the Zircaloy-4, 25 ppm. The gas from the vacuum fusion analysis was confirmed to be hydrogen by mass spectrometer analysis.

Although all the samples (except those preautoclaved) picked up considerable concentrations of hydrogen, the carbon monoxide and/or water vapor exerted a marked inhibiting effect on hydrogen pickup, because

it is known from previous hydriding studies that if no inhibition had occurred, destructive hydriding would have resulted. Nevertheless, the amounts of hydrogen picked up by the unautoclaved samples indicate an unacceptable hydriding rate for reactor applications, although the 400 C Zircaloy sample temperature is somewhat higher than the normal maximum NPR process tube temperature. The fact that the preautoclaved samples did not hydride indicates that autoclaving or some other coating process may give at least short-term protection against transient over-temperature conditions. Even in hydriding experiments at 500 C, preautoclaving has been found protective for a few hours.

Inhibiting Effect of Water on Hydriding of Zircaloy. Etched samples of Zircaloy-2 and Zircaloy-4 were exposed seven days at 400 C in a mixture of 23 mm H_2O vapor pressure and 400 mm hydrogen pressure. The samples were removed and analyzed for hydrogen by vacuum fusion analysis, with data as follows:

	Corrosion Wt. Gain - 7 days	H_2 Found
1. Zr-2	19 mg/dm^2	33 ppm
2. Zr-2	19 mg/dm^2	33 ppm
3. Zr-4	20 mg/dm^2	80 ppm
4. Zr-4	17 mg/dm^2	30 ppm

With the exception of the No. 3 Zr-4 sample, none of the samples picked up any hydrogen from the atmosphere. The corrosion weight gains for this atmosphere are the same as without hydrogen present.

Fuel Element Rupture Studies. The fuel element autoclave-type rupture testing facility has been modified by the addition of a viewing cell. The cell is four inches long by one inch inside diameter. It is suitable for viewing rupture experiments and corrosion tests in water at temperatures up to 300 C. The sample is brought to test temperature within three minutes.

Rupture experiments on defected coextruded rod elements have been viewed and photographed using time-lapse photography. A simultaneous hydrogen evolution curve is also obtained. The viewed ruptures have confirmed the correspondence between the hydrogen evolution curves and the sample's rupture behavior.

Reactor Pigtail Corrosion. Two of the newer rear face connectors (pigtails) that failed in service have been examined metallographically. One of these connectors was in service about 10 months on H Reactor, while the other failed in about six weeks on F Reactor. Both of these 18-8 stainless steel connectors showed cracking similar to the cracks found on H Reactor pigtails previously. The H Reactor sample had been badly sensitized and showed some intergranular cracking as well as the typical transgranular stress corrosion cracks. Similar cracking was also observed in gamma sample lines which failed on the rear face of H Reactor recently. These lines had been in service for several years.

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The reason for the apparent increase in the frequency of this cracking in recent years cannot be stated with certainty at this time. However, several factors which tend to cause this type of corrosion have changed in recent years, viz., the wetness of the rear face during operating, stresses, temperature, and vibration generated by high flows through the connectors. The wetness of the rear face is indicated as a large contributor to the problem on the basis of current data. Unfortunately, this wetness is nearly inherent in the newer connector designs; thus, the need for a material of construction resistant to this type of cracking is indicated.

Reactor Decontamination. A solution of 0.5 M ammonium citrate and 0.01 M ethylene diamine tetracetic acid proposed for use in decontaminating reactors displayed excessive corrosion rates on mild steel when tested in stainless steel loops. A laboratory investigation of this corrosion problem using normalized A-212 carbon steel and 304L stainless steel coupons at 90 C shows air-saturated solutions are more corrosive than argon-saturated solutions. The corrosiveness of the argon-saturated solutions decreased with time for the first two hours, while the corrosiveness of the air-saturated solutions increased during the same period. The galvanic current between coupons is sensitive to the pretreatment of the stainless steel and to the stirring rate, and this is not reproducible with great accuracy. In these laboratory-scale tests the galvanic currents between coupons account for less than half of the observed corrosion on the carbon steel, and usually for only 20 to 30% of the observed corrosion.

The decreasing corrosion rate observed in argon-saturated solutions suggests the saturation of the ethylene diamine tetracetic acid with ferrous ions from the corrosion of the steel. However, the possibility of impurities causing this rate change has not been eliminated. If the higher initial corrosion rate is due to the ethylene diamine tetracetic acid, it might be mitigated by either changing the complexing agent or saturating it with ferrous ion before use.

Radiometallurgy Laboratory Studies

Two enriched (1.6%) 7-rod clusters with 20 and 30-mil Zircaloy-2 jackets were received. Examination of the ruptured cluster with 20-mil jackets revealed a 3/4-inch long crack near the center of an outside rod. The Zircaloy jackets on both clusters had a uniform black oxide coating and no indication of corrosion or pitting after irradiation exposure of 2200 MWD/T (RM-555).

The examination of one natural uranium, 7-rod cluster (20-mil Zircaloy-2 jackets) with swaged and welded end closures was completed. The cluster had been irradiated to 400 MWD/T. Although the end closures were in excellent condition, some growth of the uranium was observed, and it is concluded that more severe irradiation conditions would be required to evaluate the end closure method conclusively (RM-552).

Evaluation continued on the capability of coextruded, 30-mil thick Zircaloy-2 cladding to restrain swelling of natural uranium during irradiation to 2000 MWD/T in the ETR (GEH-3-59). A ruptured sample exhibited radial macrocracks, very large grain size, and many macrocracks in the Zircaloy-2-uranium bond. OD measurements revealed an expansion of from three to seven percent (RM-275).

The results and conclusions from these tests will be reported in connection with the respective programs of Fuel Design and Physical Metallurgy Operations.

Basic Metallurgy Studies

Electron and Optical Microscopy. Thin evaporated films of carbon supported on 200 mesh copper grids have been irradiated to exposures as high as 1.5×10^{19} nvt (thermal), and irradiations to higher exposures are in progress. These films, after decay of radioactivity, will be studied by electron diffraction techniques to establish whether copper can sublime onto the carbon during irradiation. If sublimation does occur, then copper contamination of all thin films or foils irradiated on copper grids can be expected during irradiation.

Evaporated films of aluminum containing particles of uranium dioxide one micron in diameter have been irradiated to exposures as high as 3.4×10^{19} nvt (thermal). As the exposure increases, the small particles of uranium dioxide break away from the aluminum film. The diffraction patterns of such films show the presence of small crystallites of uranium dioxide distributed uniformly over the surface of the film. The uranium dioxide apparently heats up to high temperatures during fission and redistribution of the oxide by sublimation or its equivalent occurs.

A capsule has been developed for the irradiation of thin films or foil specimens for electron microscopy that will permit the encapsulation of the specimens in a (1×10^{-5} mm Hg) vacuum while keeping the temperatures of the specimen below 175 F(80 C). The capsule is of high purity aluminum, 99.999 plus percent, so the capsules, when returned from exposure in the reactor, can be handled with no shielding after a short decay period. Welding of the final assembly is accomplished in the electron beam welder in a special cooling block designed to keep the specimen temperature low.

Solid State Reactions. Optimum conditions of heat treatment for zirconium, Zircaloy-2, and Zircaloy-3 are being studied as a function of cold work, temperature, time and heat treatment atmosphere. Analysis of the recovery kinetics of zirconium has revealed that there is considerable softening before recrystallization begins and that this "work-softening" is at least a three-step process. When recrystallization finally begins, it is by a nucleation and growth mechanism. This microstructural change is accompanied by further softening and is characterized by a variable activation energy. The rate of recovery

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can be expressed in terms of percent recovery, f, at any time, t, by the equation

$$\frac{df}{dt} = F(\delta_i, \tau_i, \eta_i)e^{-[E_o - a(f - f_o)]/kT}$$

where δ_i is a parameter describing the density and distribution of dislocations, η_i is a parameter describing the concentration and spatial distribution of impurity atoms, τ_i is a parameter describing the internal stress fields between line and point defects, $E = E_o - a[f - f_o]$ is the activation energy for recovery of any given f and kT is the absolute temperature multiplied by Boltzmann's factor. This type of equation adequately expresses the complexity of recovery processes in general.

In-Reactor Measurements. A prototype creep capsule has been charged and is in operation in the KW Reactor. This capsule has been designed to make continuous measurements of the creep deformation of an annealed Zircaloy-2 specimen during irradiation. A creep test identical to the in-reactor test is being run out of the reactor to provide a direct comparison with the in-reactor results. No measurable creep occurred in either test after incremental increases in temperature to 575 F (302 C) and 600 F (315 C). The specimen temperatures were then lowered to 500 F (260 C) and the stress increased to 25,600 psi. Temperatures will again be increased in 25 degree F increments until a measurable creep rate is obtained in-reactor. The capsule is still operating satisfactorily. No gas leaks have occurred in the ceramic seals, all thermocouples are working, and the heaters are intact. Some limitations have been observed in this prototype capsule. The heating element power leads are too small to carry the power necessary to maintain capsule temperature when the reactor is shut down. The heat transfer characteristics of the capsule shifted markedly when the helium pressure was increased in the capsule causing a temperature gradient along the specimen which cannot be eliminated. Heat transfer under load could not be checked before in-reactor operation as both pressure and temperature could not be applied simultaneously to the capsule without straining the creep specimen. A second capsule is being procured off-site which will embody design changes to rectify most of these difficulties.

The thermocouple stability capsule, containing an iron-constantan, a chromel-alumel, and a copper-constantan thermocouple, has been irradiated 6940 hours at approximately 300 C. It has been necessary to stop the flow of cooling air and helium-16% CO_2 thermocouple environmental atmosphere to both the in-reactor and an identical ex-reactor capsule, during the past month, due to a plugged reactor test-hole vent. The in-reactor thermocouple temperatures have varied between 300 and 325 C due to gamma heating in the absence of the cooling gas. Gas atmosphere and temperatures in the ex-reactor capsule have been maintained as nearly identical to those in the in-reactor capsule as they reasonably could.

Resistance between the in-reactor iron-constantan couple and the bottom of the thermocouple well has become very erratic, varying between about 600 and 1000 ohms. Deterioration of this couple is possibly due to the

action of HNO_3, produced by the effect of irradiation on moist air in the test hole, during the absence of the helium-CO_2 flow. The resistance between the in-reactor copper-constantan couple and the bottom of the thermocouple well has, as in the five previous months, remained high. This couple has continued to indicate a temperature approximately 15 C lower than indicated by the iron-constantan and chromel-alumel couples. Under the test conditions, imposed thus far on the in-reactor couples, only the chromel-alumel couple has not shown an increase in resistance between the couple and the bottom of the well.

Metallic Fuel Development

Cluster Fuel Elements. The ruptured 7-rod cluster fuel element discharged from KER Loop 2 on October 15, 1959, was shipped to Radiometallurgy and has been visually examined. The cluster has been identified as one of the 20-mil clad elements and not the 30-mil clad element which was in the charge. No evidence of crud film formation was observed on the element nor was there any evidence of corrosion of the Zircaloy-2 cladding. It was not possible to tell whether or not the uranium under the split in the cladding was also split.

Tubular Fuel Elements. Tubular fuel elements for the NPR are being tested at the Hanford KER loops and at the ETR. Zircaloy-2 clad uranium tube and rod elements ran to 2000 MWD/T at KER Loop 4 without incident. Two elements from the Loop 4 test are at BMI for hot cell examination. Both rod components have increased in diameter about 0.6 percent. Both tubes appear to be oval after irradiation to the extent of up to 0.040" difference in diameter. A section cut from one tube shows extensive radial cracks in the uranium which may or may not have existed at the time the element was discharged. The other tube is free of cracks. The clad surfaces of the rods showed pitting corrosion attack and heavy crud formation. Loop 4 operated on pH 4.5 water for this test.

Three, 36-inch long tube and tube elements were built for KER Loop 3. These were made from Zircaloy-2 clad, 1.47 percent enriched uranium heat treated with copper jacket intact. A 15-day autoclave test showed white oxide corrosion on the inside diameter of all components. This is probably due to air contamination during welding. All elements were rejected.

The quality of tubular 1.8-inch OD Zircaloy clad uranium fuel element material is being evaluated on four extrusions received from Nuclear Metals. Metallographic examination shows small areas, about 0.004-inch diameter, which appear as slag or dirt inclusions randomly distributed in the uranium. These inclusions are frequent enough to show many of them at the U-Zr interface. In such instances the Zircaloy is pushed into the inclusion causing an irregular interface at this point. Positive identification of these inclusions has not been made, and complete processing history of the material is not available at this time. These defects are more pronounced on two of the four extrusions, while the other two are relatively clean. Zircaloy clad thickness of these sizes varies from 0.019 inch to 0.025 inch in a single extrusion. Measurements

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on three additional extrusions of inner KER size tubes of this same lot show variations of Zircaloy clad thickness of 0.016 inch to 0.027 inch in a single extrusion.

Current procedures for making closures on the Zircaloy clad elements frequently results in the contamination of the weld bead with uranium. This forms a spot of U-Zr alloy in the weld which is less corrosion resistant than the uncontaminated Zircaloy. It has been found that uranium contaminated spots, even those of low concentration, may be quickly and simply located by a modification of the electrographic technique previously reported for copper contamination. Since the organic reagent used to identify uranium (8-Quinolinol) is ineffective in the presence of fluoride ion, the HNO_3-HF electrolyte used for copper detection is replaced by a $NaNO_3$-Na_2CO_3 solution.

While the vectorscope with the special probe head to fit the ID of NPR fuel elements has been found to indicate the degree of thickness variation in the Zircaloy wall of a given specimen, it does not appear possible to calibrate the instrument to give absolute wall thickness. Recent experiments with autoradiograph methods offer some promise for improved accuracy of thickness measurement; the success of this approach will depend largely on the possibility of using a suitable densitometer and of controlling the variables other than wall thickness which affect the darkness of the film.

Fuel for Present Reactors. Approval has been given for the irradiation of two hot press canned fuel elements in the GEH-4 loop of the MTR. These elements were placed in a standard MTR basket which was equipped with upstream and downstream thermocouples for power generation measurement. This assembly has been shipped to the MTR and is awaiting irradiation.

Component Fabrication. Four attempts were made to expand and size the ID of coextruded KER inner tubes. Two attempts were successful with a total increase of 0.018 inch on the internal diameter and 0.009 inch increase in outside diameter. Spring back after the fourth pass is from 0.004 to 0.005 inch. Two of the tubes split during the expanding process. One split during the fifth pass, and the other split during the second pass. Both pieces are being prepared for metallographic examination. The fracture zone on the piece that split during the second pass shows a defective area in the uranium where considerable oxidation was present. The uranium also exhibits a radial crack oriented 90° around the tube from the fracture. Both tubes have a swaged history. Further studies are planned to determine drawing and swaging effects on tube quality.

Twenty-inch lengths of Zircaloy-2 clad uranium coextruded KER inner tubes (1.050 inch OD by 0.500 inch ID) have been hot headed with tooling fabricated for heading long lengths of tubes. The formed tube ends appear satisfactory for projection welding a ring cap for the final closure. Tooling consists of a grip device for holding the tube while

heading and a resistance heated container mounted in a 50-ton vertical draw press. The end of the tube extending above the grip is induction heated to 600 C just prior to heading. The tube end preparation for heading consisted of a thin copper chemical plate on the tube surface to prevent the Zircaloy clad from seizing to the tube container and mandrel and a thin graphite lubricant over the copper plate. Slight swelling occurs at the junction of grip and the container which is inherent in this method of end forming due to the difference in temperature of the tube contained within the grip and the container. This swelling is 0.010 inch on the OD (the ID is not altered) and with proper tube preheating is smooth and can be removed by a light drawing or swaging operation.

The design is nearly complete and fabrication should start in a few weeks on equipment capable of hot heading KER and NPR outer tubes. This equipment will be of the same nature as the equipment described above for hot heading KER inner tubes.

Allied Fuel Studies. Reactor swelling experiments of Zircaloy clad uranium fuel rods with selected uranium temperatures, cladding thickness, and exposure are being conducted. Metallographic examination of GEH-3-59 which operated to an exposure of 2100 MWD/T at an estimated average central uranium temperature of 825 C has started. Very large grains in the center of the uranium rod and large elongated grains oriented radially confirm the high estimated operating temperature of this rod. Severe radially oriented macro-cracking can be seen. At several locations these cracks proceed into and along the U-Zr bond but do not propagate into the Zircaloy cladding.

One of the four swelling capsule assemblies with thermocouple leads charged in the MTR to extend the coverage of temperature exposure and cladding restraint was discharged as a suspected rupture. The rupture was later found in the capsule of another sponsor. As the leads were cut when the GEH capsule was discharged, another identical capsule will be charged in its place at the next MTR shutdown. The remaining three capsules are still operating 25-100 C below the temperature desired. Two capsule experiments to investigate the influence of various carbon contents and low zirconium additions on the swelling characteristics of uranium are being designed for irradiation in the MTR. Nineteen capsules in D Reactor have reached approximately two-thirds of their 1500 MWD/T goal exposure. Uranium center temperatures are still approximately 100 C below design conditions.

Open end corrosion tests of Fuels Fabrication Operation coextruded Zircaloy-2 clad U-low carbon and U-low Zircaloy fuel alloys have been made in an autoclave at 200 and 300 C. The corrosion rate of the U-carbon alloys over the composition range of 30 - 1700 ppm C increase slightly at both 200 and 300 C with increasing C content. The corrosion rate of the U-Zr alloys over the composition range of 450-20,100 ppm Zircaloy (0.045-2.01 w/o) decreases moderately at 300 C and decreases quite significantly at 200 C with increasing Zircaloy content. Of the samples tested, the most significant gain was made with the U-1 w/o Zircaloy alloy.

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Two coextruded fuel rods were operated at 30 kw/ft each in a 300 C water loop while in contact with each other for three hours and forty minutes without obvious hydriding damage at the point of contact. The test was terminated when the rods failed at the power lead fuel rod connection. Metallographic examination is to be made for jacket hydriding or heat effects in the bond.

NPR size coextruded tube and tube specimens are being defect tested in a 300 C water loop with varying size coolant annuli between the defect and adjacent components (Zircaloy-2 process tube or coextruded fuel tube). As was the case in similar type autoclave tests, as the component-component or component-tube separation decreased, the inception of damage at the defect was retarded.

A high temperature, high pressure defect testing facility for 0.6-inch diameter rods with a sight glass for observing and photographing defect behavior has been developed by Coatings and Corrosion Operation. A pin-hole type defect test conducted in this facility at 300 C and 1500 psi revealed that after the fuel clad is ripped open by the accumulated corrosion product, UO_2 is readily released from the corroding fuel rod in a finely divided state and at a rather continuous rate. This behavior indicates that fuel element failure should be firmly established and readily located because of the steady release of a significant quantity of corroded fuel.

The in-reactor fuel element jacket burst test program is now producing mechanical properties data for extruded Zircaloy-2 jackets tested during irradiation. The fifteen test capsules were irradiated in a 100 KE test hole for ten days before internal nitrogen pressure was applied. Five of the fifteen capsules burst during the following ten days of exposure at temperature and pressure. Any conclusions must be tentative until the test assembly is finally discharged and the specimens examined, but there appears to be no gross departure in-reactor from the behavior predicted from ex-reactor tests. There appears to be a subtle change in the burst properties which is probably not significant from an engineering standpoint. The test has experienced one reactor shutdown and produced a qualitative indication of the absence of a reoccurrence of primary creep when irradiation is terminated and then started again. The test will continue for several months depending, to some extent, on the behavior of the remaining ten capsules.

Design Analyses and Computations. A detailed stress analysis of the PRTR process tube was completed. Elastic analyses were made for bending stresses due to connections to ex-reactor piping, thermal stresses from gamma heating and transient cooling, and the stresses in the steel Zircaloy sealing flanges. The flange process tube calculations included analyses of the bending resistance and circumferential expansion resistance of the ring of material attached to the process tube. Shearing forces resisting seizure and longitudinal bending stresses were calculated for both non-rotating and rotating end restraints on the process tube. Use was made of combined mean load and cyclic stress criteria to determine the estimated number of cycles to failure.

2. REACTOR PROGRAM

Coolant Systems Development

Fuel Element Testing for Present Reactors. A test was started to determine the corrosion effects of a scratch resistant coating applied to the fuel elements to protect them during shipment and charging. The basic composition of the coating material is a combination of sodium and potassium silicates with a wetting agent. The material is sprayed onto the elements and dries to a hardness of 80 on the Rockwell C scale.

Carbon Steel Corrosion. Completion of this test and examination of the test samples indicates that 200 and 300 ppm of $Na_2Cr_2O_7$ is about 90% effective in preventing corrosion of carbon steel in filtered water.

Raw Water Heat Exchanger. The raw water side (shell side) of the ELMO-1 heat exchanger was chemically descaled using 10% H_3PO_4 inhibited with Rodine 82. The acid solution was recirculated for four hours at 60 C. Prior to the descaling the carbon steel shell surface was covered with numerous tubercules and rust scale estimated to be 1/4-inch thick. Beneath each tubercule was a pit. The tubercules were up to 1/2-inch in height. The stainless steel tubes were covered with a thin uniform scale estimated to be three to five mils thick. The acid descaling solution removed the uniform scale from both the carbon steel and stainless steel but did not remove the tubercules. A-212 carbon steel coupons and sensitized 304 stainless steel coupons placed in a low velocity section during the descaling exhibited 0.122 and 0.00214 mil average penetrations.

In December 1958, the lower heat exchanger was descaled using inhibited H_2SO_4. Of the two solutions tested, the H_2SO_4 solution was more effective in descaling, but the carbon steel penetration was twice as high as for the H_3PO_4 descaling run.

Out-of-Reactor Rupture Tests. Four NPR size tube-in-tube coextruded uranium and Zircaloy-2 fuel elements with annulus spacings from zero to 0.20 inch were tested in an isothermal loop for two one-hour exposures. The tubes were defected near the center of the outside wall with 0.025 inch pin holes and were exposed at 300 C, 1650 psi, and 16 fps. The tubes with annulus spacings of 0.120 inch and above exhibited typical 3/8-inch diameter raised and torn mounds. The tube with a 0.060 inch annulus exhibited a 3/8 inch diameter ruptured area which was raised, torn and flattened on top. The zero-annulus pieces had raised slightly (one or two mils next to the defect) and were flattened on top. None of the rupture distortion had progressed to the inside of the tubes in the two one-hour tests. Testing of these fuel tubes will be extended to longer exposures.

Two coextruded U-Zircaloy-2 rods were run for 3-3/4 hours at 300 C, 1650 psi, and 20 fps, with electrical resistance heating of the rods of 30 kw/ft. The rods were not defected but were touching at the center. No rupturing had occurred at the point of contact of the rods. Metallurgical examination of the Zircaloy cladding and the bond is being made.

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KER Fission Product Activity. Abnormal activity developed in KER Loop 3 subsequent to the rupture of an enriched tube-and-tube element September 30. For about two weeks of operation at low temperature following the rupture, activity levels were at or below normal. The loop temperature was raised at this time (still with a dummy charge) and a high delayed-neutron activity resulted. Water samples taken at this time showed high activities of Np. On subsequent reduction of temperature the activity remained high. Clean-up for several days by both mixed-bed ion exchange (up to 6 gpm) and feed and bleed (1 gpm) did not significantly reduce the activity. The activity was not affected by raising and lowering the loop temperature, nor by an increase in pH from 6 to 8-9. On October 30, the dummies were discharged, and seven hot-headed 7-rod clusters were charged. On subsequent operation at high temperature, pH 10 LiOH, no abnormal activity has been evident.

NPR Component Testing. A Graylok jumper connection has been thermally cycled 2170 times between 250 and 550 F with no observed leakage. This joint appears to be acceptable for use on out-of-reactor corrosion test loops and should save from one-third to one-half of the cost of regular pipe flanges.

A screwed NPR nozzle-to-tube connection using a bell-ring seal was thermally cycled 862 times between 250 and 550 F with no observed leakage. An NPR nozzle-cap sealed with a flexitallic gasket using the manufacturer's recommended gasket compression (e.g., 200-ft-lb bolt torque) began leaking after 75 cycles between 250 and 550 F at 1850 psi, but testing has continued to a total of 1617 cycles. The same design using a 500 ft-lb bolt torque had previously been cycled 1369 times at the same conditions with no observed leakage.

Decontamination Studies. Two procedures appear acceptable for decontaminating stainless steel systems: APACE and the Turco 4501-4502-HNO_3 processes. Twelve decontamination cycles using the Turco process have been completed in CEP-1. After each decontamination the loop was operated at 300 C for one week. The corrosion rates measured for stainless steel, sensitized stainless steel, and Zircaloy-2 were all very low, averaging well under 0.01 mil/cycle. Stellite 6 and Stellite 12 exhibited considerably more corrosion, averaging 0.10 and 0.15 mil/cycle, respectively.

Three procedures which appear most promising for decontaminating carbon steel systems consist of two or three steps. If UO_2 and fission products are present, as in the case following a rupture, a bicarbonate-peroxide solution is employed as the first step, primarily to remove the UO_2. Several experiments have been completed to evaluate variations in the formula for this solution. The next step is an alkaline permanganate solution to condition the film. Experiments are being run to determine whether it is possible to combine these first two solutions. The final step is either ammonium citrate with EDTA, sodium bisulfate, oxalic acid, or phosphoric acid. The ammonium citrate-EDTA mixture is the most

effective but also the most corrosive. Several corrosion inhibitors are being evaluated. The Dowell Company manufactures an inhibited citric acid which will be evaluated. Approximately eight commercial solutions using NaH SO_4 are being evaluated; the results do not show any great advantage of any one formulation. The bisulfate, oxalic acid, and citrate solutions all are effective decontaminants and are non-corrosive to Zircaloy-2, stainless steel, stellite, and uncoupled carbon steel. However, when the carbon steel is galvanically coupled to stainless steel, both crevice corrosion and galvanic corrosion result in excessively high metal loss of the carbon steel, up to one mil per cycle. Studies are continuing to determine specific effects of velocity, temperature, time, and degree of recirculation for all solutions. The effects of general corrosion, crevice corrosion, and galvanic corrosion have been studied in ELMO-12 in the past month. The results indicate that galvanic and general corrosion increase with increasing liquid velocity. The crevice corrosion effect was more pronounced at lower flow rates and accounts for the decrease in corrosion rates as flow rates were increased, for specimens with both a galvanic couple and a crevice area. The single exception is the use of Turco 55-8A, in which case the crevice corrosion rate appears to increase with increasing velocity.

Structural Materials Development

Zircaloy Replacement Process Tubes. Three Zircaloy-2 smooth-bore tubes for C Reactor are on-site and in inspection. They are expected to be placed in C Reactor in December. These are the pilot tubes for a nominal 50-tube order of ribless tubes, being fabricated by Bridgeport Brass Company.

Burst Testing. A Zircaloy-2 tube with 55% cold work was burst at room temperature to evaluate a double ring and groove end-sealing method and to provide an estimate of the pressure required to burst a section of irradiated KER tube (70% cold work). For the 55% cold worked tube, the hoop stress at failure was 124,000 psi (approximately 15,000 psig internal pressure). Extrapolating from this test, it is calculated that about 17,000 psig pressure will be required to burst an irradiated KER tube at room temperature.

Three high pressure sealing methods are being considered for use in room temperature burst testing of irradiated KER tubing. One method employing a welded plug seal backed up with a double groove and ring flange arrangement has been shown to withstand 15,000 psi pressure on a 1.5" OD x 0.125" wall Zircaloy-2 tubing in a 55% cold worked condition. A second method employing epoxy adhesives to cement a plug in the tube ends has been tested. The minimum shear strength developed by the epoxy adhesive was 1500 psi. There appears to be some hope that shear strengths of perhaps 3000 psi can be attained with proper joint design and surface preparation. The third method employs a mechanical gripping method in combination with epoxy adhesives to provide the requisite strength. This method appears to be most attractive for burst testing

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of irradiated tubing since no remote welding is required, mechanical manipulation is relatively simple, and the promise of adequate strength is favorable.

Nonmetallic Materials Development

MTR High Temperature Irradiations. Preliminary graphite irradiation data are now available from GEH-19-2, which was the second experiment in the L-48 position in the MTR. This capsule contained eight samples at four positions to compare CSF and VC (needle coke) graphite. Each set of samples was contained in a graphite cup in order to lessen oxidation and minimize mechanical damage. As tabulated below, the preliminate indications are that VC is a more stable graphite for high temperature use than CSF.

Data Summary - GEH-19-2

Position	Graphite Type	Temp., °C ±50 C	Exposure $\Phi > 1$ mev(Ni) $\times 10^{-20}$	% Length Change ±0.006	Wt. Loss Grams ±0.003
1	CSF	400	Monitor lost	±0.006	±0.0006
	VC	400		+0.027	-0.0002
2	CSF	600	0.571	-0.001	+0.0001
	VC	600		+0.017	-0.0026
3	CSF	800	1.24	-0.050	+0.0060
	VC	800		-0.039	-0.0245
4	CSF	800	1.35	-0.046	-0.0004
	VC	800		-0.024	-0.0059

Because the GEH-19 samples, as well as the graphite samples from some other experiments, have been exposed to water during disassembly of the capsules, a test was conducted to determine the effect of water on the graphite stability. A series of fifteen samples were measured and weighed before and after soaking for one week in cold water. No length change in excess of ±0.01 percent was observed from this test.

MTR Hot Test Capsule. Samples from twenty-one capsules from GEH-14 were measured to evaluate length change during irradiation. Fourteen of the capsules ran in excess of 650 C as evidenced by melting of the aluminum monitor wires. Samples of needle coke graphite irradiated at high temperature consistently showed less contraction than samples of CSF graphite or other non-needle coke graphites. More comprehensive evaluation will be reported after the exposure measurements are received.

GETR Irradiations. The two graphite irradiation capsules in the GETR, H-1 and H-2, have now been exposed through three one-month cycles. The thermocouples in H-2 are now all operating very erratically, and those

in H-1 are beginning to drift. H-2 will be removed at the end of this month.

ETR Irradiations. The first of the GEH-13 capsules to be removed from the reactor, GEH-13-2, was cut up in the hot cell on November 10 and 11. There was some difficulty in removing the samples from the alundum sleeves and in removing the flux monitor wires, and this experience will be helpful in future disassemblies of similar capsules, such as the GETR capsules.

A commitment was obtained for the use of the L-6 and M-6 positions in the 9x9 facility until June when ANP plans to install their loop facility. These two positions should provide higher neutron and gamma fluxes than the four corner positions. Consequently, three of the corner positions will be vacated.

Hot Test Hole Irradiations. Graphite samples were discharged from the Y Test Hole at C Reactor with an accumulated exposure of 7600 MWD/AT at 450 to 600 C. The contraction rates are about the same from 3000 to 5100 as from 5100 to 7600 MWD/AT. However, the contraction rates for the majority of the samples appear to have decreased slightly. Further exposure will be required to verify this observation. KC graphite still shows the lowest contraction rate (perpendicular to the extrusion axis) of any graphite in these tests.

Low Temperature MTR Graphite Irradiations. An indication of a flux intensity dependence of low temperature radiation damage was obtained from capsule irradiations of transverse CSF graphite samples in the MTR.

	Capsule 109	Capsule 110	Ratio $\frac{110}{109}$
Avg. Fast Flux(1 mev) (Ni Activation)	2.38×10^{12} nv	4.08×10^{12} nv	1.71
Total Fast Exposure	1.25×10^{19} nv	2.15×10^{19} nv	1.71
Length Change	0.38%	1.26%	3.3
Δ L per 10^{20} fast nvt	3.04%	5.85%	1.92
C_o Change	2.3%	7.7%	3.4
Δ C_o per 10^{20} fast nvt	18.4%	35.8%	1.94

The temperatures in the two capsules are estimated to have been either approximately equal, or slightly higher in the capsule receiving the higher exposure. Hence, the departure from linearity with exposure in property changes for these irradiations is attributed to a flux intensity effect. In particular, it is seen that the rate of length change and C_o change is approximately directly proportional to the flux levels. There is no a-priori reason to suspect that a flux intensity effect will be observed at high irradiation temperatures.

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Plastics and Elastomers. Tests have been completed to evaluate whether plastics and elastomers change properties more rapidly after being irradiated than during normal (unirradiated) aging.

Measurements made one year after the initial post-irradiation measurements on two materials which are cross-linked and one which is chain cleaved by radiation show no changes in physical properties.

Thermal Hydraulics Studies

Studies Pertaining to Increased Power Levels Resulting From Larger Hydraulic Fittings. The feasibility of increasing the size of outlet hydraulic connectors on old reactor process tubes to permit significant increases in flow and, consequently, in power level, was studied using the full scale experimental heat transfer apparatus. Initial results indicated that the use of such fittings appears feasible although the Panellit protection would be slightly reduced and approach that of the K Reactors.

As the first step in determining the degree of lessening of the reliability of the Panellit protection system arising from the use of larger discharge fittings, steady state boiling curves were experimentally determined. A K Reactor nozzle barrel, slip joint Y fitting, a one-inch tubing pigtail and a 0.650 inch ID rear cross header connector were used. The cross-sectional area of the 0.650 inch cross header connector is slightly less than twice that of the normal connector. Curves were determined at tube powers of 500, 1000, and 1500 kw. The data make evident that increasing the size of the discharge piping significantly reduces the pressurization due to steam formation at low flows. The boiling curves obtained approach those typical of K Reactor geometry. Unstable flow will not occur at tube powers below about 1000 kw. High Panellit trip back up to guard against plugging incidents upstream of the Panellit tap does not exist at tube powers below about 750 kw. A more complete determination of the degree of protection offered by the Panellit system requires further experimentation.

Hydraulic Studies. Hydraulics Laboratory experiments were performed to determine flow rates and front-to-rear flow splits for a reactor process tube assembly during various conditions of nozzle cap removal. The data are useful in analysis of reactor and personnel hazards associated with certain stages of charge-discharge operations during which coolant flow past the fuel elements may be altered or even stopped. The results of the experiments are presented in HW-62798, "Single Tube Flow Rates at Low Header Pressures With Nozzle Caps Removed -- All Reactors."

Laboratory flow tests were conducted for IPD's Plant and Industrial Engineering Operation to determine the flow characteristics of some sample J-type rear pigtail assemblies for use on H Reactor. The off-site vendor of these items was having difficulty meeting the specified tolerances, and it was desirable to determine the relative flow resistance of two sample assemblies which had different tolerances on the

concentricity of the inlet and outlet bores of the pigtail-to-header adapter. The difference in flow characteristics was found to be negligible.

Flow characteristics of process tubes with various increased size outlet fitting assemblies were investigated for possible use on the old reactors. Energy loss profiles were obtained for critical flow conditions as well as over-all energy loss for non-critical flow with high rear header pressure conditions. While still preliminary, the data indicated that normal central tube flow rate increases of eight to 13 percent could be accomplished by replacing the pigtail, nozzle outlet fitting and reaming the rear header Parker fitting.

A paper based on the results of some laboratory critical flow experiments was presented at the Annual Hydraulics Conference at Washington State University on October 30, 1959. In particular, the paper included data on critical discharge from a 1/2 inch pipe and critical flow in a 0.47 x 5.0 inch square-edge entrance nozzle (short tube).

It was found that for upstream subcooling, the critical flow data for the nozzle correlated very well by assuming that the minimum pressure in the nozzle was equal to the saturation pressure and calculating the flow rate necessary for this to occur.

On the other hand, for upstream quality the nozzle critical flow data correlated fairly well with Isbin's data for critical discharge from a pipe.

Contact Heat Transfer Coefficients. The heat transfer coefficients for interfaces between uranium oxide, 2S aluminum, and zirconium-2 for different pressures were calculated from experimental data supplied by the Fuels Development Operation. These data, which consisted of the axial temperature distributions in composite rods, were used both to compute the temperature drops at the interfaces and as a heat meter to determine the heat flow rate through the rod. Data were collected on three types of bars at three different pressures. In addition, data were taken on each sample in a helium atmosphere at the lowest pressure.

The magnitude of the calculated coefficients varied greatly depending on the materials, the type of surface, the atmosphere and the pressure. For interfaces with belt ground surfaces, the values obtained were in the order of 150 for uranium oxide-zirconium-2, 500 for 2S aluminum-uranium oxide, and 1300 for 2S aluminum-zirconium 2. Values in the order of 1700 were obtained for a uranium oxide-2S aluminum lapped interface while interfaces in a helium atmosphere showed values of about 10,000. These values are in Btu/hr-ft^2-F. An increase in pressure from a 91-lb load to a 364-lb load approximately doubled the coefficients.

High Pressure Heat Transfer Apparatus. The inboard mechanical seal on the 250 gpm circulating pump in the high pressure heat transfer apparatus failed and was replaced after 153 hours of operation. It was felt that

a possible reason for the seal failure was the presence of abrasive particles introduced in the circulating water from the test sections. Modifications were made to the pump which would allow clean water to be injected into the seal chamber rather than using the recirculating water passing over the test sections.

Reactor Technology Development

Neutron and Gamma Attenuation. The foils from the as-cured perforated ferrophosphorus concrete test have been counted, the data run through IBM, and the results are being analyzed.

A second irradiation of iron-serpentine concrete (265 lb/ft^3) was made after baking at 100 C. The gamma leakage through 48 inches of iron-serpentine concrete increased by a factor of three as compared with the as-cured test. The foils from the first test are being counted. The lower density iron-serpentine concrete slabs (210 lb/ft^3) are being irradiated for the first time.

Counting of foils from the second loading of the NPR boron steel thermal shield test assembly was completed. IBM computation of results has been completed, and analysis of the results is under way. During the C Reactor shutdown this month part of the third foil loading of the NPR thermal shield test assembly was removed. The third loading could not be completely removed because of high radiation dose rates and limited availability of manpower. For the same reasons, the fourth foil loading could not be placed in the test assembly.

Shielding Instruments. Three gamma ionization chambers with insifnificant response to fast neutrons were calibrated and delivered for final evaluation at the 105-C test facility.

A calibrated double-moderated neutron dosimeter was provided for use in shielding studies at the 105-DR test wells. Two low sensitivity and one high sensitivity BF_3 tubes (manufactured by N. Wood Counter Laboratories) for use with the dosimeter were calibrated against a PuF_4 neutron source (standard source #2), supplied by J. DePangher.

A single channel scanning spectrometer for use in foil activation analysis is being assembled in the instrument shop.

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 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

Basic Studies. Further data on the time-temperature relationships for homogeneous solid solution formation between the isostructural compounds PuO_2-UO_2 has been obtained. Samples of PuO_2 containing 40 percent UO_2 by weight were held for eight hours at temperatures in the interval 1100-1500 C. The angular shift of Bragg reflections on a diffractometer trace then indicates the degree of solid solution formation as a function of temperature. As noted in the x-ray data from samples held for one hour, the individual reflections (h k l) from PuO_2 and UO_2 moved together with increasing temperature. After eight hours at 1400 C, a single broad peak was noted for the planes (111), (200) and (220), but above (311) the two components for each reflection could be resolved. After eight hours at 1500 C, a complete single phase was indicated by the diffraction data. A plot of interplaner spacing of the PuO_2 and UO_2 contribution to the (311) reflection versus temperature gave an intersection at 1500 C with a 'd' of 1.634 Å compared to the theoretical value of 1.635 Å.

The liquidus for the system PuO_2-UO_2 has been obtained from single phase samples of the two compounds. The curve follows the general form for simple systems of this type, and no deviations from uniformity were observed. All the data was obtained in a dried and deoxidized helium atmosphere. The melting point of pure plutonium dioxide appears to be near 2280 C. The lattice parameter of a melted sample of PuO_2 was 5.417 Å compared to 5.396 Å for the as-received powder. This indicates a loss of oxygen on melting; however, no apparent evidence of a sub-oxide was found on the diffraction pattern. A sample of PuO_2 held for one hour at 200 C in a vacuum of 10^{-3} mm of Hg was still predominantly PuO_2, although evidences of both alpha and beta Pu_2O_3 were found. To investigate further the stability of PuO_2 in hydrogen, a sample of PuO_2 and carbon was heated to 1500 C for one hour. No trace of Pu_2O_3 was present, and excellent resolution of the PuO_2 planes was observed. The lattice constant found by high angle extrapolation was 5.3970 ± 0.0003 Å.

High density sintered samples of PuO_2 and UO_2 have been run in a high temperature dilatometer at a heating rate of 25 C/hr to obtain more accurate data on the thermal expansion. Heating and cooling curves were coincident and only slightly curvilinear. The coefficients obtained for PuO_2 are tabulated:

75 - 100 C	alpha = 9.04×10^{-6}/C
75 - 775	alpha = 11.16×10^{-6}/C
775 - 950	alpha = 14.38×10^{-6}/C

These data are in close agreement with that obtained at the 110 C/hr heating rate.

Fuel Evaluation. The three-foot long Zircaloy clad Pu-Al 19-rod prototype cluster has received about 10 operating days at full power and temperature in the ETR. During this time the element has received about ten thermal cycles in the loop due to reactor operation. It has operated at a maximum power generation of about 13 kw/ft of rod and with core temperatures in excess of 400 C which is the maximum expected in the PRTR. Goal exposure is 20 days which is about 50 percent burnup of the Pu atoms.

The prototype 7-rod Pu-Al cluster is also operating in the 3x3 loop facility, and it has received about ten days of operation under full power and temperature conditions. The 7-rod, 1.8 w/o Pu-Al alloy, PRTR prototype cluster with Zircaloy-2 cladding, stainless steel end fixtures, and quick-disconnect end caps is currently under irradiation in KER Loop 1.

The 3-rod Zircaloy-2 clad, 3.1 w/o Pu-Al alloy cluster (GEH-4-46) which has graphite lubricated cores in swage sized tubing is scheduled for insertion into the GEH-4 loop facility on November 23. Another 3-rod cluster (GEH-4-43) containing 3.1 w/o Pu-Al alloy cores which were slipped into as-received Zr-2 tubing is ready for shipment. These rods have diametral gaps between the core and cladding of as much as 0.0061 inch, and they are not lubricated with graphite. Still another 3-rod cluster experiment (GEH-4-48) which contains the corrosion resistant Pu-Ni-Si-Al alloy core material in graphite lubricated and swage sized tubing is under fabrication. This element will also be irradiated in the GEH-4 facility.

The fabrication of a Zircaloy-2 clad Pu-Ni-Si-Al alloy 7-rod cluster (GEH-11-4) using swage sized tubing and a 7-rod Zircaloy-2 clad PuO_2-UO_2 cluster (GEH-11-3) is proceeding for irradiation testing in the ETR 3x3 loop facility.

Three of the six PuO_2 impregnated graphite capsules have completed their irradiation in the MTR. The irradiation of all six will be completed in January, at which time they will be returned to Hanford for radiometallurgical examination.

One of the two, high-density, 0.0259 a/o PuO_2-UO_2, mixed-crystal-oxide capsules (GEH-14-19,20) irradiated in the MTR to an exposure of 4.4 x 10^{20} nvt, was sampled for fission gas release measurements and sectioned for metallographic examination. Photomicrographs of the specimen (GEH-14-19) indicate that the microstructure is very similar to that of irradiated UO_2. No central void was formed. Replication of the sample is currently under way. No data were received yet on fission gas release.

Fuel Fabrication. An evaluation is being made of the quality of the Zircaloy-2 tubing that is to be used in the fabrication of the first Al-Pu elements for the PRTR. Eddy current testing for defects has not proven too effective as it seems to detect only the very bad defects and not even all of these. Ultrasonic testing for defects seems to be more reliable and is being investigated. Metallography of 90 randomly picked samples showed that 38 percent had cracks emanating from the inside that were greater than 0.003 inch, and one 0.020 inch deep crack was observed. The rods used for the fabrication of the elements will be categorized

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according to quality by ultrasonic testing techniques after core assembly.

The Zircaloy tubing to be used for the fuel elements is being swage sized on a steel mandrel to give a constant inside diameter. Swage sizing gives an ID of ±0.0006 inch on an eight-foot length. It is felt that close control of the gap between the core and cladding is required to avoid thermal cycling difficulties.

One hundred and twenty-three billets of the Pu-Ni-Si-Al corrosion resistant alloy have been cast. Sixty of the billets were extruded, and about 50 percent of these successfully passed the corrosion test. Therefore, sixty satisfactory cores have been fabricated during the month.

Fabrication Development. A corrosion-resistant Pu-Al alloy was developed to replace unalloyed Al-Pu as the PRP fuel material. In preliminary tests this alloy, 1.8 w/o Pu-1.3 w/o Ni-1.0 w/o Si-Al, showed good corrosion resistance in 350 C static water at 2500 psi for 200 hours. However, in producing larger quantities of the alloy for the PRP fuel fabrication, non-uniform corrosion results were obtained. Differences in metallurgical structure but not in composition were detected in the extruded fuel rods. Samples of the fuel rods which withstood a 24-hour, 350 C corrosion test had a smaller grain size and a smaller and more uniformly distributed second phase than samples of fuel rods which corroded badly in the same test. Since differences in the solidification rate during casting control the alloy structure, the effect of casting variables on the corrosion resistance of the alloy were investigated. The casting variable which had the most effect on the corrosion resistance was the mold temperature. Billets cast into cold (20 C) molds and warm (100 C) molds yielded a higher ratio of corrosion-resistant fuel rods than billets cast into hot (200 C+) molds. Casting temperature in the range studied was found to have very little effect on corrosion resistance.

The thermal cycling of dummy Zircaloy clad rods fabricated by various techniques is continuing in an effort to better understand and solve the thermal ratcheting problem. All rods were thermal cycled between 100 and 350 C at heating and cooling rates of about 3 C/min. All the rods were about three-feet long. The cycling results on rods fabricated by the various techniques are as follows:

a) Six rods were fabricated by slipping aluminum cores into as-received Zircaloy tubing and then reducing the diameter about 0.003 inch by swaging. After swaging, circumferential depressions were made in the rods about every eight inches which locked the core and cladding together. Only one rod of the original six remained unchanged at the end of 77 thermal cycles. The others had warped and split.

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b) Six rods were fabricated by slipping aluminum cores into Zircaloy tubing which had a layer of ZrO_2 on the inside surface that was formed in an autoclave. The diameter was then reduced slightly by swaging. Five of the six rods successfully withstood 20 cycles and the other rod elongated about 0.6 inch, warped, and the cladding split. At the end of 44 cycles, only one of the original six rods was unchanged.

c) Twelve rods were fabricated by slipping aluminum cores coated with a lubricating layer of graphite into as-received Zircaloy tubes. A slight reduction in the diameters was then made by swaging. All the elements withstood 26 cycles; however, some had warped and elongated as much as 0.50 inch. Only one element was unchanged at the end of 50 cycles; the others were warped and the cladding was split on four.

d) Six rods were fabricated in which both the outside surface of the cores and the inside surface of the Zircaloy cladding was coated with a lubricating layer of graphite. A slight reduction of the diameter was made with the swage. All the rods were virtually unchanged at the end of 25 cycles even though the cores were showing signs of shortening. After 41 cycles, the elements were beginning to elongate and warp, and the cladding was split on one. Two were not affected. Only one of these rods was unchanged at the end of 77 cycles, and all the others were warped and split.

e) Three elements were fabricated by slipping aluminum cores into as-received Zircaloy tubing. No graphite lubricant was used on either the cores or cladding, and the rods were not swage sized. The diametral gap on the rods went from a minimum of 0.0049 to a maximum of 0.0067 inch. No dimensional changes occurred after 77 thermal cycles.

All of the above elements were helically wrapped with a wire under various tensions; all below 25 in-lb. Some other rods with graphite lubricated cores and swage sizing with no wire wrap were also thermal cycled 78 times. In general, those rods which were not wrapped behaved better than similar rods which had the wire wrap. Also, from the results of these experiments it appears that graphite lubricant does improve the thermal cycling behavior to a certain extent and that the minimum diametral gap between the core and cladding is as important or more important than the maximum gap. It is felt that by swage sizing the tubing on a mandrel prior to assembly that the diametral gap can be controlled from a minimum of about 0.0035 to a maximum of about 0.0055 inch which would be satisfactory from a reactor operation standpoint. Additional thermal cycling specimens are being fabricated to test elements of this type.

One injection cast prototype with metallurgical and mechanical bonding between the core and the can has successfully withstood 87 cycles, with a diameter increase of 0.003 inch and a length decrease of 0.070 inch in 42-1/2 inches. It will be returned to the autoclave to be tested to failure. This simulated fuel element has the core cast-bonded to the jacket by the fabrication process, and in addition, the longitudinal expansion of the aluminum core is restrained by mechanical keying obtained by rolling circumferential grooves 0.025 inch deep into the tubing at six-inch intervals before injection casting. This combination of metallurgical and mechanical bonding may prove to be adequate to withstand the severe stresses encountered with thermal ratcheting. Other cycling tests have indicated that the mechanical bond alone or the metallurgical bond alone is not adequate to overcome the problem; however, the combination of the two together could prove to be the answer to the problem.

UO_2 Fuel Development

PRTR Fuel Elements. The densities of swaged PRTR fuel rods have steadily improved since the first rod was fabricated. The average density of the rods has, in general, increased while the variation in density from rod to rod has shown a marked decrease. This is attributable primarily to a tighter control of loading and swaging variables. Rods loaded with sintered and crushed UO_2 have been swaged to an average density of approximately 85.5% of theoretical with a variation from rod to rod of approximately ±1% of the theoretical density. Higher densities are expected with the arc-fused UO_2 which is now being used.

In order to avoid delay in fabrication of swaged fuel rods for PRTR 19-rod cluster fuel elements, the off-site fabricator of Zircaloy-2 end caps has agreed to complete 200 sets of the current order ahead of schedule. This partial delivery will allow rod fabrication to continue without interruption until the remainder of the end cap order is received.

The new PRTR fuel rod end cap design providing a continuous one degree taper on the portion of the end cap that is inserted in the fuel rods has provided excellent welding results. Radiographs of 418 welds this month have shown only two welds with insufficient penetration. These two welds have been repaired by rewelding.

A speed indicating meter has been attached to the rotating chuck used in the vacuum purged welding chamber. The movement of the fuel rod beneath the welding arc is continuously indicated in revolutions per minute, allowing the operator to constantly check the welding speed. The meter provides a fast and positive reference for establishing the correct speed each time the fuel elements are set up for welding.

Cooperation with the Coatings and Corrosion Operation has provided an alteration of their autoclave fixturing to allow an increase from 39 to 65 fuel rods to be autoclaved at one time. The autoclave cycle requires four days. With 65 fuel rods autoclaved at a time, the output is approximately 100 fuel rods per week.

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Detection of defects on the internal surfaces of swaged fuel elements is limited because of the surface roughness produced during the swaging operation. Several specimens giving ultrasonic defect indications were sectioned and examined metallographically. All proved to have indentations, 0.003"-0.005" deep, resulting from the impression of UO_2 particles into the Zircaloy-2 tube surface.

Cost data are being assembled on fabrication of PRTR fuel elements. Although these data are not yet complete, the cost reductions associated with process development are very obvious: the cost per fuel element today is several times lower than the comparable cost nine months ago.

Delivery of six thousand pounds of fused UO_2 from the Spencer Chemical Company was completed essentially on schedule. Use of this oxide for PRTR fuel elements will have the advantages of yielding a higher density, lower unit cost, and probably improved operating characteristics due to better fission gas retention. Analysis of the fused UO_2 shows that it meets the specifications set up for purity, density, and oxygen-to-uranium ratio.

Fabrication Development. Projection welding has been demonstrated as an economical method of fabricating Zircaloy-2. The results obtained in contract DDR-70 (projection welding of the 19-rod cluster fuel element hanger fitting assemblies) indicate that a substantial labor saving can be realized by projection welding. Additional evaluation is being performed on the sample welds.

Dense UO_2 fuel rods can be fabricated by vibrational compaction followed by a one pass swage reduction of ~15 percent. Densities as high as 90 percent of the theoretical UO_2 density can be achieved. Swaging and vibrational compaction used conjunctively should help to insure uniformly high densities. This technique markedly reduces the amount of swaging required, thereby reducing the amount of cold work introduced into the sheath material. The sample which had the highest density after vibration (83% T.D.) also had the highest swaged density (90% T.D.). It contained 60% coarse, 20% medium, and 20% fine, fused UO_2. A sample containing 10% coarse, 10% medium, and 80% fine, fused UO_2 had the lowest density after vibration (67% T.D.), and after swaging (78% T.D.). Results obtained with mixtures of intermediate compositions are anomalous, and systematic investigation of mixtures centering on the composition giving the highest density is needed.

Ten PRTR fuel rods, fabricated by vibrational compaction, are ready for final assembly. The average densities of the rods are 85-86% of the theoretical density, with density variations of ±1% T.D. along most of the length of the rods. The particle size distribution of the sintered and crushed UO_2 was 40% (-6 +20), 25% (-35 +60), and 35% (-200). The swaging characteristics of fused UO_2 from Spencer Chemical Company were evaluated to determine the particle size distribution and tap density associated with the maximum swaged density.

Further studies evaluating the swaging process have revealed that internal surface sheath defects are not propagated during the cold swaging operation. A Zircaloy-2 tube was defected by machining a 0.002 inch deep notch on the internal surface. The tube was filled with UO_2 and swaged. Metallographic examination of cross-sections of the swaged fuel rod showed that the depth of the defect had not been increased. However, the width of the defect was considerably reduced.

Continued development and evaluation of the immersion type ultrasonic tester revealed the capability of the machine to detect internal tubing surface defects missed by other examination methods. Several severe internal surface cracks greater than 0.004 inch deep were detected in Zircaloy-2 tubes which had passed both off-site and on-site internal surface fluorescent penetrant inspection.

Fuel Evaluation. Confidence in the structural and cladding integrity of the swaged UO_2 19-rod cluster PRTR fuel element remains high after sixteen weeks of operation of one such element in an ex-reactor, high temperature, high pressure flow loop. The element, which was thermally cycled through the proposed PRTR pressure and temperature range many times, exhibits no warping, wire wrap loosening, or corrosion. This ex-reactor test will continue.

Arrangements were made to return the purposely defected, irradiated, swaged UO_2 fuel rods to Hanford for sectioning and internal examination to reveal structural changes and potential interaction between high temperature steam and UO_2 core and Zircaloy sheath. A second irradiation test of a purposely defected, swaged Zircaloy clad UO_2 fuel rod was initiated. The second test will involve greater heat generation and in-reactor cycling.

A number of long term irradiations of UO_2 fuel capsules are taking place in various reactors to reveal any progressive changes in the nature of the fuel. Swaged UO_2 capsules have attained an estimated maximum exposure of 12,000 MWD/T during irradiation in ETR-MTR. No failures of these capsules, or of any other swaged fuel elements have occurred.

A four-rod cluster comprising both helium bonded and evacuated, vibratorily packed, arc-fused (Norton) UO_2 fuel rods was examined after MTR irradiation. The test element had generated 11.2 kw/ft, or 310,000 BTU/hr/ft^2 surface heat flux. The evacuated fuel rod without a helium atmosphere developed a central void, with columnar grains and grain growth. The UO_2 core containing helium remained visibly unchanged. The marked difference between the UO_2 rods is understandable in light of the fuel rod gas analysis.

The greater fission gas release from the evacuated fuel rod results directly from the increased fuel temperature which is caused by the absence of a good continuous heat conducting medium, i.e., helium.

The source of hydrogen found in the gases contained within the irradiated fuel rod has not been defined. The dramatic difference between the irradiation behavior of evacuated and of helium-filled UO_2 fuel rods demonstrates once again the importance of insuring a thermally conductive gas phase (e.g., helium) in non-sintered UO_2 fuel elements. The relatively low fission gas release from arc-fused, vibrationally compacted UO_2 fuel elements, operated at average PRTR conditions, is very encouraging. With more recently procured fused UO_2, even better fission gas retention is anticipated.

Basic Studies. A joint HAPO-BMI study revealed, some weeks ago, a ten percent greater thermal conductivity of isostatically pressed and sintered UO_2 by comparison with that of extruded, dried, isostatically pressed, and sintered UO_2. The samples were recovered from BMI, where the conductivity was measured, for microscopic examination to possibly reveal causes for the apparently fabrication dependent variation of conductivity. If the generally accepted Loeb density conductivity relation were solely true, one would expect specimens having similar average pore volumes to exhibit nearly the same thermal conductivity, when correcting to zero porosity. However, the corrected conductivities reveal a greater disparity between such specimens than between specimens having similar grain sizes. The data reveal only grain size as a property which might be responsible for the greater thermal conductivity of the isostatically pressed and sintered specimen.

Equipment was erected which will permit comparative measurements of the thermal conductivity of a variety of UO_2 specimens and adjunctively will provide data on interface and helium gap conductivities. Several standard specimens (stainless steel, aluminum, graphite, fused quartz) were prepared. A transverse specimen was cut from a sample of 100 percent dense dendrite of UO_2. No grain boundaries exist transverse to the direction of the proposed heat flow. Single crystal thermal conductivity will be closely approximated in this specimen. The equipment will also be used to examine the unusually high helium bond conductivity in small gaps disclosed in recent BAPD irradiation tests.

It is interesting to speculate regarding the effect grain size might have on heat removal from UO_2 fuel rods. Results of recent UO_2 irradiation tests are interpreted as demonstrating unexpectedly high thermal conductivities in regions above 1800 C. These regions characteristically consist of long, radially oriented, columnar grains, which should transmit heat more in the manner of single crystals than of polycrystalline material. The relative contribution of radiant transfer through these high temperature regions remains to be resolved.

Corrosion Studies

Corrosion of Zircaloy-4 in 400 C, 1500 psi Steam. Six samples each of Zircaloy-2 and Zircaloy-4 have been corrosion etched in 400 C, 1500 psi steam and show very similar corrosion rates and good black oxide films. The weight gains after ten days are:

Alloy	Weight Gain mg/dm^2 (Avg. for 6 samples each)
Zr-2	27
Zr-4	25

Aluminum Alloy Development. There are now ten alloys using 99.995% base aluminum in test in 360 C water. All but one of these have shown excellent corrosion resistance. The one exception is a 1% Ni, 0.5% Fe alloy made at Alcoa. The same formulation made at HAPO does show a decided improvement. After four months in test, the Alcoa X-8003 alloy (1.4% Ni, 1.5% Fe) shows a penetration of 0.34 mil, compared with 4.3 mils for the X-8001 standards. These alloys are now being tested in the 340 C flow loop and in 290 C refreshed water. The latter test is being conducted to confirm results reported by the Argonne National Laboratory that this type of alloy has a higher corrosion rate at 290 C than at 360 C. No results are available on either of these tests as yet.

Corrosion of Materials in Low pH Water. Preliminary out-of-reactor data indicate the corrosion rate of X-8001 aluminum at 300 C in pH 4.5 water adjusted with HNO_3 is much higher than in pH 4.5 water adjusted with H_3PO_4. After 642 hours of testing, a rate of 0.48 mil/month was observed in the HNO_3 experiment. This contrasts with a rate of 0.06 mil/month obtained from previous H_3PO_4 data. Velocity effects appear to be limited to impingement attack at the higher velocities on the aluminum coupons immediately upstream. No difference in corrosion has been found on other coupons in the test in the range from 21 to 64 fps. The corrosion rate of 304 stainless steel at 300 C and pH 4.5 adjusted with HNO_3 is comparable to that obtained with H_3PO_4, 0.0045 mil/month after 642 hours.

Testing PRTR Fuel Elements. The development of equipment to permit thermal-cycle testing of PRTR Pu-Al type fuel element rods at a linear rate of about 200 F/hr between 325 and 550 F was completed. Two swage-fabricated rods, one with spiral wire wrapping and one without, have been thermal cycled 50 times. The solid aluminum cores substituted for the Pu-Al core were observed to shorten about 0.7 inch. No corkscrew type distortion of the rod around the wire wrapping has been noted.

Structural Materials Development

PRTR Process Tubes. The ultrasonic, fluorescent dye penetrant and radiographic testing of the 97 PRTR tubes prior to pickling and autoclaving is complete. Seventy-eight tubes are considered structurally sound. The ultrasonic flaw detection test will be re-run on 19 pickled and autoclaved tubes which originally gave immerscope indications of possible flaws. No defects at the locations of these indications have been found by visual, fluorescent penetrant, and radiographic tests. Consequently, it is expected that the smoother surface from pickling prior to autoclaving will eliminate most if not all of these indications.

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All 97 tubes have been pickled and autoclaved. Fifty-one have satisfactory autoclave films. Forty-six are being considered for reprocessing because of staining (37) or questionable autoclave film areas (9). A trial run on reprocessing is under way on vendor-reject tubes. Press equipment is nearly ready for straightening the tubes that bowed slightly during autoclaving.

Radiometallurgy Laboratory Studies

Metallographic studies were completed on a high-density sintered UO_2 30-mil Zircaloy-2 clad fuel element which had been irradiated to 300 MWD/T (RM-300). Photographs, diameter and length measurements, and fission-gas collection were completed on a fuel element containing a high density UO_2-PuO_2 mixed-crystal oxide (RM-650). Metallography and fission-gas collection were completed on a fuel element containing high density, centerless ground and sintered UO_2 pellets, after irradiation to 1500 MWD/T (RM-273). Metallographic examination of a swaged UO_2 capsule that had been irradiated according to GEH-3-47 was completed (RM-293). Fission-gas collection and metallography were completed for three rods on an arc-fused UO_2 4-rod cluster. One wafer from a rod which had been sealed in a helium atmosphere appeared unchanged as a result of the irradiation. A wafer from a rod which was sealed while evacuated, exhibited a recrystallization structure and also provided a high fission-gas yield (RM-304).

Metallographic examination of gamma phase annealed, irradiated uranium continued. Very large oriented grains were observed as well as large, rounded, irregularly-shaped fissures (RM-321). Metallographic examination was conducted on a sample of low irradiation exposure uranium that was annealed for ten hours at 800 C (RM-317).

The results and conclusions from this work will be reported in connection with the respective development programs of Ceramic Fuels and Physical Metallurgy Operations.

Thermal Hydraulics Studies

Boiling Burnout Experiments Associated with the PRTR Design. Fourteen additional boiling burnout points were determined using a test section in the high pressure heat transfer apparatus at conditions applicable to the PRTR. These data added further substantiation to the validity of the use of the present design heat fluxes in operation of the PRTR.

The test section used was a single tube, 0.317 inch in diameter and 30 inches long. The magnitude of the boiling burnout heat fluxes were 1,000,000 to 1,800,000 Btu/hr-ft^2 for water qualities ranging from 32% by weight to 28 F subcooled.

A re-evaluation was made of emergency cooling characteristics of the PRTR in consideration of the failure of the flywheels on the PRTR pumps to provide flow for a time as long as had initially been expected. It

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was concluded that the pump decay times as experienced on the prototype pump in the 314 Building were so erratic that it was highly desirable for personnel from the Mechanical Equipment Development Operation to examine the pump further for possible causes of shortened decay times.

PRTR Project Management and Design

Over-all PRTR Contract. The over-all PRTR contract is 54% complete versus 64% scheduled, based on the official General Electric Company schedule.

Phase III PRTR Contract. The Phase III PRTR contract (reactor complex and process piping) is approximately 45% complete. The contractor has requested an extension of time to July 1, 1960, because of the Hanford labor dispute in July, off-site strikes, and added work. However, a completion date of May 20, 1960, has been agreed on pending delivery of government furnished equipment.

The biological shield inner liner is nearly complete and the contractor is preparing for the helium leak test. All buried liquid carrying lines in the biological shield are being radiographed; by the contractor to the amount required by his contract (10%), and the remainder by plant forces. Review of radiographed films indicates a high rate rejection due to lack of fusion, excessive slag, lack of penetration, and occasional cracks.

Heavy aggregate concrete was placed over the transfer pit and approximately 70% of the fuel examination cell wall. It appears that placing of heavy aggregate concrete in the biological shield will be started about the second week in December, pending successful leak test and weld repair of the inner liner. Installation of process cell piping and equipment is progressing slowly pending completion of the reactor shield.

One river pump was placed in the pump well and work on assembly of the second pump is progressing.

All change orders through 41 have been negotiated except Nos. 10, 20, and 40. For change order No. 20, the contractor's price is $86,000, and the AEC-GE fair cost estimate is $72,000. The estimates are currently being reviewed.

Phase II-A PRTR Contract. The Phase II-A PRTR contract (river pump structure) has been completed.

PRTR Stack Addition. Contract work is estimated to be 25% complete. The completion date for the stack is December 27, 1959.

Instrumentation and Control. The electronic portion of the rupture monitor system is being rebid with the three low bidders, since all bids contained unrequired items. It is expected that the order will be placed during early December and will have a four-month delivery. The detailed

design of the mechanical and sample handling portion of this system was begun by CE&UO during the month, with completion of design scheduled for December 19. This part of the system was originally placed for bid on a design and fabricate contract, but no acceptable bids were received. It is expected that procurement of long-lead-time items in this system will be done by General Electric, and such items will be furnished to the system fabricator to shorten delivery time.

A design change is being prepared revising the reactor safety and containment systems to coincidence systems. The safety system relay cabinet has been returned to the vendor for modifications to conform to the new system. The control room panel vendor has been notified to proceed with the safety system control and bypass panel.

Core Components. The calandria and top and bottom shields are essentially completed. Tubing extensions from the calandria down through the bottom shield are now being installed. Although strict specifications were written to insure that the top and bottom shield were dried completely of water after the hydrostatic test, when J. A. Jones' personnel unintentionally drilled a hole through the bottom plate of the bottom shield, a small quantity of water ran out. Another attempt at drying the shields will be made.

Shielding. All of the cast iron thermal shield blocks have been received on-site. The biological shield form has been nearly completed. Some difficulty is being experienced in the quality of the welding on penetrations through the biological shield. Of initial x-rays of these welds, approximately 65% were rejected for not meeting ASME Code quality standards. All liquid carrying penetrations through the biological shield will be 100% radiographed.

Helium Gas System. The high and low pressure helium compressors have been turned over to the contractor for installation. The testing program had not been completed when they were requested by the contractor, so that satisfactory operating life had not been achieved for the check valves on the low pressure compressors and for the check valves and compensating pumps on the high pressure compressors. Steps are being taken to continue testing and development work on the components on devices in the laboratory other than the actual compressors.

One of the high pressure compressors was damaged to an undetermined extent when one of the three suspension points by which the compressor was being lifted broke and allowed the compressor to fall to the floor.

Fuel Handler. Acceptance tests were completed during the month and the manufacturer was instructed to disassemble the machine and prepare it for shipment by November 28. The machine will be accepted with certain deficiencies in operation which will be corrected or brought within acceptable performance standards during testing at Hanford. The vendor will replace the exhaust air hose and resize the shroud. These items will be delivered separately. The air cooling system has considerably

more pressure drop (without the fuel element, shroud, and seat in place) than can be accounted for by calculation. Inspection revealed no obstruction in the line, so the manufacturer was relieved of responsibility for this item. Further testing will be required to determine the cause of this condition and the most desirable corrective action. Vibration in travel of the bridge has become more pronounced at certain positions of the carriage. This matter is the manufacturer's responsibility to correct.

Outlet Nozzle. Some material for re-manufacture of the nozzles has been received by the vendor, and work has begun on new components. Welding on reassembly of four nozzles was not entirely acceptable on the first attempt, and some repair has been made. Nozzles are scheduled to be completed by the end of the year, if no further difficulties are encountered.

Fuel Element Hanger. The fuel element hanger was redesigned to eliminate interchangeability of use with UO_2 and plutonium elements and permit ready visual identification of either type.

Fuel Element Examination Facility. The Mosler Safe Company has encountered more difficulty with cracks in the casting for the cast iron shielding. The cracks occurred in access holes in wall block No. 3 and in one of the top blocks. An attempt will be made to repair the blocks. Due to the cracking problem, Mosler Safe Company will not meet the scheduled shipping date for all blocks. However, to avoid delaying the Phase III contractor, a partial shipment consisting of the filler blocks and bottom two wall blocks will be made. Delivery has been requested by December 15, 1959.

High Pressure Loop (Project CAH-841). Minor revisions and refinements have been made in details of the design criteria. The project proposal is being circulated for approval. Transient analyses of the control system are being made.

Sections of the design criteria concerning the primary pump drives and the emergency tank were revised. The primary pumps will no longer have two-speed drives. Instead, two motors, a 30 hp and 10 hp, will drive each high pressure pump -- the smaller motor being connected by a V-belt drive. The large motor is reduced to 30 hp (from 60 hp) because the flywheel will be separated from the motor by a magnetic clutch. The pump drive changes will place high pressure loop equipment into a portion of the B Cell access area; however, the equipment will stand on the floor and can be covered with a five-foot tall enclosure.

The emergency tank will no longer vent to the PRTR building exhaust after a rupture disk fails. The tank will become pressurized and force water to the holdup tanks outside the containment vessel.

PRP Critical Facility (Project CAH-842). The design criteria was published for comment during the report period. CE&U Operation has been authorized to proceed with preliminary design of the critical facility building. Detailed instructions have been forwarded to them delineating

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the portion of the design which the authorization concerns and which will be included in the PRTR Maintenance and Mockup Addition contract. Expected completion date for detailed design of this portion is January 15, 1960.

Fuel Element Rupture Test Facility (Project CAH-867). The scope description document describing the proposed PRTR rupture loop has been completed. The loop is an "open" type (the primary coolant is reduced to atmospheric pressure prior to leaving the loop) with capabilities for once-through coolant flow or for recirculation. The in-reactor test section consists of a Zircaloy pressure tube with a Zircaloy liner containing the fuel assembly for protection of the main pressure bearing member.

Design Testing

PR-1 - Discharge Operation Mockup. Acceptance testing of the fueling vehicle was completed. The vendor was notified that the vehicle is to be dis-assembled and shipped by the end of the month (vendor was advised that a delivery date of five weeks after shipment of the vehicle for the air system flexible hose and a delivery date of three weeks after vehicle shipment for the shroud was acceptable). The major fabrication problem remaining is the elimination of excessive vibration in the vehicle during bridge travel. The following major components are not functional, and it will be necessary to revise the systems when the vehicle is received:

(1) Bridge position indicating system. The system is being redesigned utilizing a "Selsyn" type drive for the counter.

(2) Air cooling system. Pressure drop in the air cooling system appears to be in excess of the rated capacity of the compressor.

PR-10 - Primary Loop Mockup. The primary process pump has operated for more than 1800 hours. The seal leakage has generally been less than 0.1 gallon per hour. The erratic leakage occurring at 1100 hours was determined to be due to temperature variation in the seal cavity caused by intermittent flow from the seal leak collection tank.

Damage to the low pressure secondary seal is known to be occurring during periods of relatively high leakage (0.5 gph) of the high pressure seal. Helium evolution during these periods is higher than can escape from the seal cavity and causes the seal faces to run without proper water coverage. The high wear rate is evidenced by graphite particles in the secondary leakage.

The oil seal leakage, which started at approximately 900 hours, has increased from 10 ml/hr at that time to a constant 60 ml/hr after 1500 hours. The clearness of the oil leakage suggests hardening and cracking of the O-rings, a condition which the pump vendor has been advised of. Other elastomers should be ready for evaluation in future tests.

The prototype process pump has operated over 700 hours with leakage consistently below 0.1 gph. Flywheel decay tests were performed with the small pump to determine the effects of head variation on flow decay rates.

PR-13 - Injection Pump Test. Packing testing resumed on October 28, using Duramettalic Handy-Pack, Style AB packing rings, consisting of lead foil outer rings and plastic inner rings. The packing failed after 56 hours due to the impact load, causing the lead foil to extrude and bind the plunger. Testing of Raybestos Manhatton Vee-Flex split ring packing, R/M #1204, started on November 16, and is now in progress.

PR-40 - Shim Control Mockup. Modification of the second prototype assembly incorporating changes to agree with those being made by GE-APED is 90 percent complete. All drawings made by GE-APED have been reviewed and approved.

Delivery of the ball bearing lead screws has been delayed until about December 20, due to a vendor fabrication error. Material for new screws was ordered and will be rolled by Saginaw Steering Gear Division of General Motors, who is supplying the lead screws and ball nut assemblies. The thermocouples have been received and are undergoing tests in the laboratory to determine their reliability. It also appears that the AEC will not be able to procure the drive motors by the dates we are required to furnish them to GE-APED. Delay of these items will no doubt delay the delivery of the shim control assemblies.

PR-52 - Process Tube Thermal Cycling and Pressure Testing. The process tube was operated 571 hours during the month with leakage rates from the high pressure closures as follows: nozzle cap - 0.67 ml/hr; nozzle to process tube - 0.18 ml/hr; and process tube inlet - 0.09 ml/hr.

The fuel element was removed and examined by Fuels Development personnel and found to be in good condition.

The process tube was removed and replaced with a new (reject) tube which had been fully pickled, autoclaved, and inspected. The old tube will be inspected by Radiographic Testing personnel to determine if any corrosion was evidenced.

A new style inlet flange incorporating a 27/32" orifice, was installed on the single tube prototype. Pressure drop measurements indicate the following conditions at 480 F and about 110 gallons per minute flow:

Inlet Piping (no inlet valve)	5.0 psi
Process Tube (with fuel element & inlet orifice)	22.0
Outlet Orifice	13.5
Outlet Piping	5.0
Total System (no inlet valve)	45.5

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The hold-down devices are being fabricated by J. A. Jones Construction Co. The Inconel "X" spring has been thermally cycled about 1000 cycles with indications of a small load loss. The Starrett springs withstood over 600 thermal cycles with no difficulty and the SAE 4130 -- 42 cycles.

Materials have been ordered with which to fabricate the springs in case the off-site vendors are unable to supply the springs. A device to mechanically flex the springs while hot has been built and is ready for testing.

PR-64 - Gas Sampling Technique. Testing of several gas separator designs has determined that a separator, three inches high and 2-1/2 inches in diameter, packed with raschig rings, gives satisfactory results. A prototype rotameter has been ordered to better evaluate the problem caused by condensation in the rotameter with the passage of helium saturated with water at 120+ F. Experimental data are being obtained to correlate gas flow rates with varied amounts of helium in solution.

PR-70 - Helium Compressor Test. The test program with the two compressor units was halted October 30, 1959, when the compressors were delivered to the Phase III contractor for reactor installation. A report, HW-62734, has been prepared summarizing the findings of the compressor test program.

Additional work is being planned in the development of the oil compensating pumps for the Hofer high pressure compressor. A test stand is being fabricated and will be ready for operation about December 1, 1959. An aircraft type positive displacement hydraulic pump has been received from Vickers Incorporated for evaluation purposes as a replacement for the existing Hofer designed oil pumps.

The possibility of preparing a test stand simulating compressor gas check valve service is being considered. Duplication or approach of actual compressor conditions will be quite difficult, and a justified installation for further check valve development may not be practical.

Additional test work is being performed with the Beach Sta-Dri oil removal filter in an attempt to evaluate its performance in the 300 to 400 F range.

PR-80 - Air Cooling Duct Test. Design of the small capacity duct is complete. Fabrication is 40 percent complete.

Special Tools - PRTR. Chain driven tools are being fabricated for the outlet and inlet jumper nuts. These tools will be used to start nuts and apply up to 50-foot-pounds of torque. Long end wrenches will be used to apply up to 1000-foot-pounds of final torque.

The tool for removing the shroud tube lower weld was tested and found to operate satisfactorily. A new tool is being designed to remove the portion of the shroud tube that is rolled into the bottom of the calandria.

Silicone Foam Testing. The duct assemblies have been fabricated, and testing will commence immediately with the full size units filled with

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representative quantities of electrical and instrument leads. An initial test showed good sealing characteristics between the silicone and the wires and steel; however, a considerable leak was evidenced through the short (2-foot) wires, especially the multi-conductor cables.

Instrumentation and Control. The selection tests of the PRTR rupture monitor photomultiplier tubes being performed by Nucleonic Instrumentation Operation continued during the month. About 80 tubes have been tested to date. The rejection rate is about 25% of those phototubes tested to date. The last 37 scintillation crystals which were purchased for use in the rupture monitor system arrived, and eight have been found to be defective. Four have leaking seals and four have separations between the crystal and the glass end window. The 17 defective crystals which were received in the second batch of 25 have been returned to the manufacturer for replacement. The additional eight defective crystals are to be returned also. These 25 defective crystals represent nearly 30% rejection of those furnished by the manufacturer. All failures are attributed to poor workmanship or techniques on the part of the manufacturer.

The reactor control and radiation monitoring system were received on November 16. The automatic controller portion of the system is being evaluated on an analog computer simulation of the reactor. Evaluation tests will include operation with ranges of the variables of plutonium concentration, fuel temperature coefficient, and critical moderator level. Tests will consist of frequency response, response to various steps and ramps of reactivity, and a checkout of the period control features. This work is being done by HLO's Systems Research Operation. Completion is scheduled for December 15, 1959.

Process Instrumentation. Testing of the second prototype (100 K ohm) thermistor probe for the Fuel Examination Facility has been continuing in the range of one to six inches from the heat source. Response time to 63% of a 200 F step change in temperature has been found to be 41 seconds for both a positive and negative step. The radiation stabilized glass used in the probe (infrared transmission efficiency approximately two percent) is not satisfactory from the time response standpoint. Arsenic trisulfide glass with a transmission efficiency of 90% has been ordered, and testing will continue as soon as it is received.

An instrument for checking the rate of sudden changes in moderator level in the PRTR calandria has been assembled. Laboratory tests have been completed, and the equipment will be installed in the 189-D calandria mockup for final testing.

Four prototypical cable connectors for use with resistance temperature detectors on the PRTR were examined. These are improved units over the connectors originally specified. Several minor changes have been recommended to be included in the final design. Testing of the resistance temperature detectors with these connectors resulted in some minor changes in the assembly techniques of the RTD itself which should result in a more rugged unit.

Design Analysis

Physics Analysis. A study of the PRP Critical Facility loading worth has been initiated. The variation of fuel types and lattice pitch and the inclusion of a D_2O/H_2O moderator option in the design leads to the consideration of about 32 cell types. Three-group diffusion theory methods will be applied using the F3 program for the IBM-709. Results will be in the form of three-group flux and adjoint flux distributions in specific cells and in various core arrangements. Also determined is the system multiplication. Hitherto unavailable three-group neutron cross sections are being calculated with attention to proper spectral weighting, especially for close-packed, highly enriched, H_2O moderated core schemes.

Formulation of the calculations for generating the PRTR xenon tables has been completed. Flow charting and coding of the problem for the IBM-709 has started. To be generally applicable to all spike loading configurations, the calculation has been designed to provide two sets of tables. The first table will allow direct calculation of local poisoning in terms of tube power, while the second table will provide weighting functions in terms of numbers of tubes, tube power, and reactor power.

Work has started on the design of critical experiments for the Critical Test phase of the PRTR startup. Consideration is being given to calibration of the moderator level and the shim system by uniformly poisoning the moderator with boron. Calculations indicate that a concentration of 20 mg/liter of elemental boron will produce a negative reactivity of 100 mk. A preliminary experiment to determine the feasibility of boron cleanup is now being planned. The design of a special fuel element for determining flux distribution and cadmium ratios is also under way.

Steam Loop Transient Analysis. Calculations to determine a suitable automatic control system are presently in the debug stage. Latest results indicate the Fortran program is satisfactory. A set of coefficients defining the requirements of the control system is being calculated.

Rupture Disk Calculations for PRTR 14" Gate Valve. In order to insure against flow restriction during normal operation and yet prevent flow following a pipe failure, a rupture disk is to be installed in the 14" gate valve. In order to properly size the disk, the maximum differential pressure across the valve following a pipe failure is required. The maximum differential pressure was postulated to occur following a rupture in the 14" inlet header and was calculated to be 20 psi. Since the deadhead of the pump is 130 psi, a rupture pressure differential of 75 psi is recommended to allow for a suitable factor of safety in the calculated result.

Flow Decay Following Power Failure - PRTR Primary Pump. The experimental flow decay curve was determined, and the results are noted to agree well with the calculated curve until the flow had decayed to about 30 percent of normal. At lower flows the calculated rundown times were much greater than observed. The discrepancy appears to be attributable to mechanical

friction in the pump seals. In the previous calculations, mechanical friction had been neglected.

Safeguards Analysis. The PRTR Final Safeguards Analysis was issued. A review of the final safeguards analysis of PRTR was made by the General Electric Reactor Safeguards Council on November 19.

The hazards survey report for the PRTR High Pressure Loop, based on the preliminary scope design, was issued as HW-62111. Preliminary hazards analyses for the PRP Critical Facility were begun.

231-Z Autoclave Failure. Investigation of the autoclave explosion which occurred in 231-Z Building on July 31, 1959, has been completed. It was concluded that the failure was caused by malfunction of the temperature control instrumentation which allowed extreme overheating by the furnaces. Steam-metal corrosion reactions supplied the final increment of energy required to heat the autoclave to 950 C. The autoclave failed by stress-rupture after a short time at 950 C and 1300 psi. No previously unrecognized chemical or physical phenomena contributed to the failure. A report of the investigation of the autoclave failure will be issued early in December.

Plutonium Fabrication Pilot Plant

Phase III Construction. The Phase III equipment installation contract with George A. Grant Company was terminated effective November 15, 1959. The remainder of the equipment installation work is being done by J. A. Jones Construction Company under CPFF contract. Contract completion was estimated at 96% at termination and at 98% at the end of the month. Total project completion is estimated at about 85% at the end of the month.

The change of contractors became desirable because of the large number of change orders ensuing from discrepancies between the installation drawings for the sintering furnaces and the furnaces as received. The sintering furnaces were designed under a DDR contract by Harper Electric Furnace Company. The design of the furnaces themselves appears to be highly competent, with minor modifications to the main electrical switchgear. Changes to the instrumentation to meet HAPO requirements were somewhat more extensive, and the installation drawings (made by Harper to allow issuance of the Phase III bid package on schedule) were unsatisfactory. New installation drawings made by Design Engineering and issued as Design Change #37 were generally satisfactory but allowed George A. Grant Company to claim large sums as contract extras. The furnaces as manufactured by Salem Fabricating and Machine Company were not completed in accordance with the purchase order and the drawings. Thus, additional extra charges would have had to be paid for field completion of the main power wiring and the cooling water and drain piping. Such work, entailing much field direction and many changes, is most economically and expeditiously done under a CPFF arrangement.

The change of contractors was made with little loss of time to the construction schedule. George A. Grant Company craftsmen worked productively until about November 12, and by November 18, J. A. Jones Construction Company had deployed a full crew to the job, and productive work was again under way. The present schedule calls for completion of work on the oxide fuel line December 23.

Group 5 Equipment Installation. All bids for new equipment and all estimates for the cost of installation of new and transferred equipment have been received. Initiation of equipment installation and procurement are awaiting increased project authorization from the AEC.

Procurement. The small parts for the sintering furnaces were delivered November 20. The material needed for the power wiring and cooling water piping is on order. Most will be delivered before December 5, but no firm date is available on the sight flow indicators. The main control panels for the furnaces were shipped November 17. The new motors for the cross-push mechanisms were not delivered to the vendor until November 20, which will probably hold up delivery of these mechanisms to the project until December 15. With this delivery, attainment of the December 23 schedule is still possible, but if the delivery of the motors is delayed, completion of the oxide line will be delayed until December 30.

All other project procurement, including the 20-inch rolling mill, remains essentially on schedule.

A representative of Clearing Machine Company spent most of the month on the site correcting minor deficiencies in the 200-ton hydraulic press. The press was accepted at month's end.

Ventilation Balancing. After a ruling by the AEC Review Board that balancing of the ventilation system in 308 Building is Bacon-Davis work, the Commission issued an order to J. A. Jones Construction Company for this work. The work was completed during the month.

In the course of this work, defects were discovered in several of the CWS filters. Further inspection disclosed that many of the filters furnished by the building contractor were defective, so 123 were removed from Stores stock as replacements. Inspection disclosed that only 24 of this number were free from damage. It was necessary, therefore, to prepare the building for startup with only two of the three main filter banks fitted with filters. The third bank will be fitted with filters when a new shipment is received. The defects observed are those mentioned at an Air Pollution Seminar at Idaho Falls in July, so the filter manufacturers are cognizant of the problem.

PRTR Operations

Pre-Startup Activities. Issuance of the final portions of HW-61900-RD, "PRTR Design Tests," was completed during the month. Twenty-six of the total of 45 tests have been reviewed by the PRTR Start-Up Council and are being revised as necessary. Preliminary shceduling indicates the tests may be performed in 8-1/2 weeks. Procurement of the special equipment required for the tests was started.

A survey of coolant system nomenclature was completed. Standardized definitions are being compiled.

The PRTR Engineering Assistant Training Program continued on schedule. This course, designed to familiarize the Engineering Assistants with all phases of PRTR operation, will be completed December 18, 1959.

The PRTR drawing list was up-dated and reissued. A forecast of cylinder gas requirements was issued to inform Purchasing & Stores Operation of future needs of PRTR operation for various types of gas.

Effort to assemble complete Blue Print Files for all installed equipment continues. BPF information has been assembled for all but a few Phase I and II items. Very little BPF data are available as yet for Phase III equipment.

Assistance has been rendered FPD Maintenance in assembling a complete set of Instrument Specifications. This information is necessary to assist in spare parts procurement and in planning for instrument calibration and design tests.

Operating procedures for the primary and moderator coolant systems were completed. Work was initiated on operating procedures related to physics tests.

A spare parts procurement schedule has been developed. It is planned to have all required spare parts in stock before design tests begin. The majority of this work will be performed by PRTRO personnel. However, FPD Maintenance and other groups have been requested to assist when their specialized knowledge of diesels, generators, and instrumentation may be utilized to advantage.

The first two semi-monthly meetings with HLO Analytical Laboratories Operation personnel were held. During the first meeting the ALO representatives were familiarized with the physical arrangement of proposed PRTR sampling and analytical equipment. The second meeting was devoted to a review of equipment necessary to conduct certain light water analyses in the 309 Building.

Initial contacts were made with the HLO Property Accounting Operation. As a result of this meeting plans were made for establishing property accounting procedures for the PRTR.

Planning for critical tests continued. Instrument Research & Development Operation has been requested to coordinate procurement, installation, and testing of the instrumentation required to perform the tests. Preliminary contacts were made with outside groups to obtain manpower assistance during the performance of these tests.

The complete High Pressure Loop Design Criteria is being reviewed for PRTRO approval at month end. The final rough draft of the PRP Critical Facility is also being reviewed for comment. In cooperation with Experimental Physics personnel, operating procedures for the Critical Facility were prepared.

Vendors' prints of Fuel Examination Facility shielding and primary manipulator details were reviewed. Also, comments were issued on the following subjects: storage and handling D_2O, breathing air supply. overhaul of 2400 volt switchgear, and back-up chargers for switchgear batteries.

Extra Activities. PRTRO personnel conducted nine tours involving 94 persons. The number of tours requested by various HAPO groups has decreased sharply since access to the containment vessel was limited to 12:00 to 12:30 pm and 4:30 to 5:00 pm due to increased construction activity in the vessel.

2. BASIC SWELLING STUDIES

Irradiation Program

Bench tests are continuing on a swelling capsule containing four natural uranium spheres (0.7% U-235) in order to evaluate the capsule components as well as the associated instrumentation. The capsule, complete with a 3 kw heater supply and Minneapolis-Honeywell instruments, consisting of a temperature controller, proportional voltage controller, a magnetic amplifier, a saturable core reactor and a 12-point temperature recorder, is being operated on a continuous basis to simulate in-reactor operation as closely as possible. Original difficulties experienced with the temperature controlling instrumentation, due to component miswiring prior to shipment to Hanford Laboratories Operation, have been corrected, and the units are now operating satisfactorily.

Additional development, however, is necessary in order to improve the reliability of the thermocouples. The gold braze between the 304 stainless steel thermocouple sheath and tantalum tip is subject to failure during capsule assembly and subsequent operation. The tantalum tips were removed from several failed couples and a two-holed 308 stainless steel plug was inserted into the end of the sheath. This plug was then fusion welded to incorporate the thermocouple wires and sheath to form the thermocouple bead. After beading, the thermocouple was flame sprayed with tantalum at expected points of contact with the uranium specimens. Improved reliability and life are expected from these thermocouple modifications as has been reported from other AEC installations who have used this method of thermocouple beading.

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Additional instrumentation for the in-reactor capsules is being assembled and will be laboratory tested with a swelling capsule prior to shipment for the in-reactor tests. A capsule containing four natural uranium (0.7% U-235) spheres and a capsule containing three enriched uranium spheres (3.063% U-235) are being assembled for the in-reactor tests. The Production Test document for the irradiation of these latter two capsules has been submitted for approval.

Mechanisms and Theory

Mechanisms of inert gas agglomeration in uranium during irradiation are being evaluated. Calculations have been carried out to evaluate the concept that parent atoms (e.g., Te and I) may form a second phase which could act to precipitate Xe and Kr pores "in situ" as these atoms decay. During irradiation the concentration of radio-iodine, i.e., iodine that decays to stable Xe, approaches a steady state value of about 3×10^{17} atoms per cc of uranium in less than four days. Assuming that no diffusion takes place, the average distance between unstable iodine atoms is then 40 to 50 atomic spacings. Given these initial conditions, one can then calculate the minimum value of the iodine diffusion coefficient, D, necessary for agglomeration of various size precipitates in the time corresponding to the shortest iodine half-life. For agglomerate sizes of 10^3 atoms and 10^6 atoms, corresponding D values are 10^{-17} and 10^{-16} cm^2/sec. Although the actual D values for iodine are unknown, values greater than 10^{-16} cm^2/sec are highly probable. It is concluded, therefore, that the nucleation of Xe and Kr pores in uranium by parent atom diffusion, precipitation and decay is a realistic possibility.

Pore Size and Distribution

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

The density of a specimen with burnup of 0.41 a/o after annealing at 880 C for 100 hours was remeasured and found to be 14.64. This value is lower than the density values obtained for similar specimens annealed at lower temperatures. The high value of 16.79 reported previously for this specimen was obtained by intentional ultrasonic impregnation of the immersion liquid, water, into the cracks and open porosity present in the specimen, whereas the lower value, 14.64, is closer to the true density of the sample. The ratio of the volume of open porosity to the volume of closed porosity is equal to 1.26. These results illustrate the necessity for exercising extreme caution in interpreting the measured density of small specimens that have external cracks and internal porosity.

A statistical analysis is being initiated on pore volume fractions and pore densities in uranium with a burnup of 0.29 a/o which has been

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annealed at 880 C for 100 hours. It is hoped that with the analysis it will be possible to ascertain the effect of irradiation temperature, 350 C versus 550 C, the effect of etching, and the extent of distortion due to replication on the measured pore diameters and pore distributions in this sample. Replicas of this specimen corresponding to etching times of 0, 10, 20, 40, and 80 minutes duration have been processed; a peripheral area in each replica has been photographed in the optical and in the electron microscope. A minimum of 40 minutes etching time is required to remove the surface layer and reveal the porosity. A similar study of the central core region corresponding to an irradiation temperature of 550 C is in progress.

Fission Product Mobility

A knowledge of the mobilities of rare gas fission products through uranium is important in understanding the mechanisms of pore formation. Rare gases are introduced into uranium by electrical glow discharge (sputtering) and by ion bombardment. The amount deposited under various experimental conditions, as well as the mode of deposition and depth of penetration, is presently being determined. Two, one-half inch diameter, 0.002 inch thick uranium foil disks were sent to C. W. Tucker at GERL. These disks were bombarded with 40 kv krypton ions at an actual ion current of one microamp per cm^2 for approximately five hours. The rate of evolution of krypton from the disks was subsequently determined by heating in a second system connected to a mass spectrometer. Evolution of krypton from the uranium was first detected at 170 C. A peak in the evolution rate versus temperature curve occurred at 400 C in a disk heated at a rate of 400 C/hour. The krypton evolution from a second disk, heated at 200 C/hour, showed no such peak. Instead, the evolution rate gradually increased with increasing temperatures. The raw data from this experiment are still being processed, and absolute amounts of gas deposited and released will be available shortly.

The 0.9 inch diameter x 0.1 inch thick uranium disk, that was outgassed for three days at 620 C and then sputtered at 16 ma/cm^2 in two mm pressure of xenon for four days at this same temperature, was machined into four equal segments. Specimens were submitted for detailed x-ray study, metallographic examination, and vacuum fusion analysis. Of the two specimens submitted for vacuum fusion, one had 0.002 inch removed from the sputtered surface by abrading under oil. Fusion analysis showed that about 1/6 as much xenon was contained in the abraded sample as in the unabraded one. This would indicate that at least a fraction of the deposited xenon diffused into the matrix uranium from the sputtered surface. Electron microscopy, however, could detect nothing in the microstructure that would suggest the presence of the gas. Some large irregular cavities or stringers were observed with the light microscope, which are believed to have been present initially. It is conceivable that these may have acted to trap the gas which would result in misleading analyses. The metallographic specimen will be analyzed by vacuum fusion to determine whether or not this result is reproducible.

3. GAS COOLED POWER REACTOR PROGRAM

Graphite Studies

Pressurized Gas Cooled Loop Facility (Rroject CAH-822). The transient analysis was completed. The results will be combined with the previous work (HW-61393) and issued as a formal document.

The transient analysis covered abnormal reactor startups and shutdowns and normal and reduced CO_2 flow rates. The results of these calculations indicate that the rate of temperature change in the loop piping can be maintained at 900 F per hour except for short periods when reactor power changes rapidly with time. The most rapid rate of temperature change was estimated to be 216 F per minute in the ex-reactor piping.

Calculations for reduced CO_2 flow rates following a reactor scram indicate the minimum shutdown flow can be as low as 2000 lb/hr without excessive CO_2 temperatures at the blower. These calculations showed that if flow is reduced from 15,000 lb/hr to 2000 lb/hr in one minute and thereafter held constant, the loop will experience temperature only slightly greater than at normal operation. The maximum increase in temperature was found to occur at the blower where the CO_2 temperature increased to 935 F. However, the duration of this high temperature will be less than 1.5 minutes. At 1.5 minutes the CO_2 temperature had decayed to 850 F, and after six minutes it was down to 800 F.

Fourteen drawings have been partially approved. All material has been ordered for fabrication of the in-reactor section. A stainless steel nozzle test assembly incorporating a self-energizing seal was completed and is being test evaluated. Welding procedures are available for qualifying welders in welding of Inconel 702, Inconel, and Hastelloy "X", and part of the material required has been received. The fabrication of the reactor sections will be done by plant forces.

Design of a 35 kw heater for testing the gas loop is nearly finished. Two models of a high temperature-high pressure electrical entrance device have proven satisfactory.

Processing of approval drawings and specifications and answering engineering questions from Struthers-Wells continues. The preliminary estimate from Struthers-Wells indicates a net cost for Addendum No. 2 of less than $3000.

It has been determined from Bristol-Siddeley that the main blowers are capable of continuous operatipn on 60-cycle current. Consequently, the emergency motor-generator set will be replaced by two three-phase transformers connected in parallel to the emergency bus, thereby increasing the reliability of the blower back-up system. This change will be issued in Addendum No. 3, together with provision for back-up water to the blower coolant system and a reduction in size of the back-up motors for the shroud coolant blowers.

Final drawings of the main blowers from Bristol-Siddeley have been received and approved. However, word has been received from International General Electric that delivery date will be delayed.

Bid invitations are still open for the top and bottom connectors. Orders for approved assemblies will be placed on the first of December.

All bypass switches have been removed from the loop safety system circuitry, in conformance with the PRTR philosophy that coincident circuits should not have bypass switches unless required for operation of the facility.

Nickel base alloys are being considered for use as in-reactor structural materials for the gas-cooled loop. Samples of the candidate materials will be irradiated in graphite channel in C Reactor. Comparison of mechanical properties of the irradiated specimen with those of unirradiated control pieces will yield valuable data on the behavior of these alloys under anticipated loop operating conditions.

A graphite capsule containing thin washer samples of six nickel base alloys, three low manganese steels, three iron-chromium-aluminum alloys, and type 406 stainless steel will be irradiated in the graphite channel at C Reactor for approximately one month. All of the alloys will be evaluated for stability in the reactor gas coolant environment. The graphite capsule for this irradiation is now being fabricated. Two or three specimens of each of the thirteen alloys to be initially examined have been prepared from strip, polished, and checked for microstructural appearance, hardness, and weight. Duplicate control samples have also been prepared. Only four of the nickel base alloys, Inconel, Hastelloy X, Inconel 702, and Hastelloy R-235 will be studied for radiation induced mechanical property changes. Following evaluation of atmosphere effects, two capsules containing tensile specimen of the selected nickel alloys will be irradiated in the same facility for three months and six months, respectively.

Graphite Oxidation in CO_2. Since needle coke graphites seem to possess more dimensional stability under high temperature irradiation than conventional graphites, tests have been initiated on oxidation testing of these new graphites. At 750 C the average oxidation rate of a needle coke graphite (GL-10) in flowing CO_2 was 1.35×10^{-4} gm/gm-hr, which compares favorably with 1.47×10^{-4} gm/gm-hr for CSF graphite. These samples were oxidized for about one percent total weight loss.

Photographic Studies. When graphite samples are placed within microwave glows established in CO and CO_2, soot deposits form on the graphite and on the quartz components of the apparatus. This soot is probably caused by decomposition of carbon sub-oxides, and therefore it is of interest to study these deposits to shed light on the mechanism of carbon mass transport in gas cooled reactor systems.

Soot deposits have been photographed with the aid of an electron microscope at various magnifications from 5000 to 25,000 X. They reveal a dendritic, fern-like structure built up from ultimate platelets which appear to be a few hundred angstroms thick and a few hundred thousand square angstroms in area. Length to width ratios on individual dendrites were 40 to 50 to one, and large bundles of such dendrites were observed lying parallel to each other. Another form of soot was found which is best described as "lily-pad like". However, it is suspected that the quartz surface on which it was formed may have influenced this growth. Neither form of the carbon had the appearance of ordinary flame soot.

Capsule Experiments. Two N_2-filled capsules containing graphite samples and designed to operate at about 37 psia at 500 C are ready to be charged into a reactor test hole. Six other graphite samples, two with N_2 and two with He at atmospheric pressure, and two in vacuo, will be charged in-reactor simultaneously. All graphite samples have been carefully measured so that, aside from studying gas-graphite reactions, the effect of reactor atmosphere on graphite dimensional stability can be investigated.

Pyrolytic Graphite. Pyrolytic graphite is of interest for reactor application because of its high degree of crystal orientation. This property may cause pyrolytic graphite to exhibit extreme stability under high temperature irradiation and should make the graphite quite resistant to oxidation since a minimum number of crystallite-edge-plane atoms are exposed to attack.

The data from the oxidation of a three-inch long pyrolytic graphite tube in flowing air are compared with CO graphite below. The greater oxidation resistance of pyrolytic graphite is evident. The oxidation activation energy is about 40 kcal/mole which is the same as for coke based graphites.

	Oxidation Rate (gm/gm-hr)	
Temp.	Pyrolytic Graphite	CO (Needle Coke)
450	1.24×10^{-5}	3.5×10^{-4}
500	9.24×10^{-5}	1.8×10^{-3}
550	4.21×10^{-4}	6.0×10^{-3}
600	1.71×10^{-3}	--

One piece of pyrolytic graphite has been charged into a 500 C reactor test facility in order that the oxidation rate can be measured on an irradiated sample.

The mean linear thermal expansion coefficient parallel to the crystal planes was determined for pyrolytic graphite using a quartz differential dialatometer. The extreme anisotropy of this form of graphite is evidenced by a negative coefficient of thermal expansion below 375 C. Hitherto, only natural flake or sketetal graphite has shown this property.

Temp. Range	Thermal Expansion Coefficient x 10^6
25 - 125 C	-0.23
25 - 275	-0.09
25 - 375	0.0
25 - 625	+0.34
25 - 925	+0.59

Graphite Cement. It is possible that cemented graphite joints could be utilized beneficially in certain gas cooled reactor designs. Since no irradiation data are available for graphite cements, samples have been inserted in a hot irradiation test facility for an initial exposure at about 500 C. These samples consist of cemented joints prepared by Allis-Chalmers Manufacturing Company using CS-312 graphite stock and National Carbon Company F-cement. Strength and dimensional change after irradiation will be determined for these samples. Also included in the irradiation is a small sample of graphite bonded with silicon carbide prepared by Minnesota Mining and Manufacturing Company.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

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

Irradiated and control specimens of molybdenum and zirconium were given four, 60-minute isochronal anneals during the month. The annealing temperatures for molybdenum were 175, 200, 225, and 250 C, and for zirconium 200, 225, 250, and 275 C. DPH hardness and electrical resistance measurements were made after each anneal.

The electrical resistance data for molybdenum reveal a recovery process which proceeds at a maximum rate at about 150 C for an exposure of 4.4×10^{18} nvt, and at about 175 C for an exposure of 1.5×10^{20} nvt. Complete recovery in this region has not occurred up to 250 C, and the extent of recovery measured to this temperature is greater for the lower exposure specimen.

Considerable increases in DPH hardness for the molybdenum specimens irradiated to 4.4×10^{18} and 1.5×10^{20} nvt were measured within the annealing range 125 to 250 C. At 250 C the hardness of the 1.5×10^{20} nvt specimen has increased 23 DPH numbers and is still increasing, whereas the hardness of the 4.4×10^{18} nvt specimen has increased eight DPH numbers and appears to be leveling off. This behavior is anomalous to the general trend of radiation damage recovery in metals and is being studied in light of dispersion hardening processes.

The electrical resistance data for zirconium reveal a recovery process which proceeds at a maximum rate at about 225 C for an exposure of 4.7×10^{18} nvt.

Significant recovery for the 1.5 x 10^{20} nvt exposure specimen has occurred at 275 C, but the process has not reached a maximum rate. Completion of recovery in this region has not occurred up to 275 C, and the extent of recovery measured to this temperature is greater for the lower exposure specimen.

Significant change of DPH hardness has not occurred up to 275 C for the zirconium specimen irradiated to 1.5 x 10^{20} nvt; however, a slight decrease in hardness occurred for the specimen irradiated to 4.7 x 10^{18} nvt.

E. CUSTOMER WORK

Radiometallurgical Examinations

PT-IP-190-A Ruptured Doe Elements (RM-402). Examination of these self-supported Doe elements revealed an accelerated corrosion attack in the aluminum can wall resulting in large blisters of accumulated corrosion product. In each case the attack had started in the confined space next to the support spot weld and had progressed outward from this location. An initial accumulation of a heavy oxide layer under the support base apparently caused localized overheating of the can wall, which initiated the accelerated attack. As the accumulated aluminum oxide provided more insulation, the corrosion of the can wall continued to progress rapidly outward.

I & E Hole Failures From 4985 KW and 4259 KE (RM-252). Examination of the slug from 4259 KE, which failed in the internal annulus, was completed this month. The cause of failure was water entry to the uranium through the cap end of the slug. The can was undercut, and the water and/or water vapor progressed along the internal surface of the uranium to within one and one-half inches of the base end of the element where gross reaction between the water and uranium occurred. As the voluminous corrosion products formed, the internal aluminum sheathing was displaced into the annulus and finally parted in tensile failure. The site of the water entry was not found, but examination of the slug showed that its origin was in the cap end. The uranium in the cap end was honeycombed with microcracks which originated from extremely fine grained areas present in the metal. No microcracks or unusual grain size was observed in the rupture area. Both the inner and outer bond layers showed evidence of undercutting in several locations in the cap end of the slug. Two small channels were seen in the inner bond layer in the vicinity of the rupture. The quality of the jacketing and welds which were metallographically examined was good, and no defects were observed in the remainder of the surface, both internal and external, which was examined minutely with the Opton viewer. The probable sequence of events leading to the failure was as follows:

1. Microcracks originated in the fine grained area and spread throughout the uranium in the cap end during initial reactor operation.

2. As the number of microcracks increased, stresses in the sheathing were increased and, with continued operation, the aluminum jacket failed allowing water to enter in the region of the cap end.

3. The water undercut the can and progressed along the spire to the area where the rupture occurred.

Nickel Plated Elements from PT-IP-207-A (RM-306). Three non-plated, internally and externally cooled, Hanford production fuel elements which were used as control pieces in PT-IP-207-A, were examined to determine whether hydrogen gas was being trapped under the plating of nickel plated fuel elements. The gas analyses indicate that hydrogen gas was present, but the limited tests did not provide conclusive evidence as to the origin of the hydrogen. Either a refined test or additional testing to provide enough data for statistical analysis is required for conclusive evaluation of the gas tests.

Examination of a Side Hot Spot Ruptured Natural Uranium I & E Fuel Element From Tube 1165-C (RM-309). Examination work on a hot spot ruptured natural uranium I & E fuel element with 570 MWD/T exposure was continued this month. A metallographic sample taken 1-1/2 inch from the base end and in the hot spot area revealed uranium corrosion-product build-up between the can wall and uranium for 315° around the periphery. Photomicrographs showed that a region around the corrosion-product layer had operated in the uranium beta-phase temperature zone, and that the remaining area toward the spire was in the uranium alpha phase. Another metallographic sample taken about 3-1/2 inches from the cap end did not reveal any beta-phase microstructure. Since the aluminum can wall was cracked in both of the metallographic samples, an aluminum sample was taken from each crack for metallographic work. The sample nearest the cap end showed no intergranular corrosion, but photomicrographs from the base-end sample revealed intergranular corrosion attack which started on the outside and penetrated into the AlSi. This allowed water to enter and form uranium oxide, which in turn enlarged the diameter of the element and caused the can to fail in tension.

Metallography Laboratories

A series of baking tests at 300, 350, and 400 C from 1/2 hour to 12 hours on normal AlSi canned fuel elements was conducted by FPD personnel to determine the effects on the intermetallic compound layer formed during canning. Metallographic examination revealed that a growth of UAl_3 type structure (as shown by its etching characteristics) was diffusing into the uranium. Growth of this diffusion product was most rapid from the UAl_3 structure already produced during canning; however, it also occurred on the uranium side of those layers associated with brittleness. Extended baking produced progressive degrees of brittleness as determined by mechanical tests. Temperatures of 350 and 400 C caused an apparent change in the normal UAl_3 structure. As shown by etching tests, this structure approached the brittle layers in appearance. The change in microscopic appearance was paralleled by a decrease in tensile strength. Short-term baking produced a slight growth of UAl_3-appearing diffusion compound and no detrimental mechanical property effects

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as measured by tensile tests. Long-term baking produced more of the diffusion compound and a change in the appearance of the original intermetallic compounds. These effects were accompanied by progressive losses in tensile strength.

Metallographic examination is nearly completed on recently-procured Zircaloy-2 tubing in sizes of 0.680, 0.505 and 0.502 inch ID from three fabricators, Bridgeport Brass, Superior Tube, and Wolverine Tube. None of the tube sections examined contained cracks, either on the ID or OD. A smooth surface was apparent on all tubes, both OD and ID, with the exception of one order from Wolverine Tube which had a relatively rough or undulated surface in comparison.

Samples Processed During the Month.

Total samples processed: 578

Photographs.

Micrographs	351
Macrographs	113
	464

For Manager, Reactor and Fuels
Research and Development

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

NOVEMBER 1959

FISSIONABLE MATERIALS - 2000 PROGRAM

REACTOR

STUDIES RELATED TO PRESENT PRODUCTION REACTORS

Neutron Temperature Study

Measurements are now being made to gather the data necessary to correlate the neutron temperature calibrations of the lutetium foils and Pu^{239} - U^{235} foil pairs.

Neutron Temperature Coefficients

Debugging of the nuclear data tape code continues. The difficulties encountered thus far have been caused by a Fortran compiler error. An attempt is being made to alter the program in a way that will cause correct compilation.

A subroutine to calculate exponential integrals has been written and tested. Three methods are used to calculate the function in order to give increased accuracy. These methods are: A power series for small arguments, a continued fraction for intermediate arguments, and an asymptotic series for large arguments. The errors found thus far have been less than 1 unit in the seventh significant figure. An average of 60 milliseconds is required for each integral.

A subroutine to calculate complete gamma functions has been written and tested for positive arguments. The errors are less than 1 unit in the seventh significant figure for arguments less than 10 and about 10 times larger for larger arguments.

A calculation of the thermal neutron distribution was made for a hot graphite lattice cell with a thin, room temperature water gap around the fuel rod. Program F_3 modified to include up-scattering was used, with one fast and two thermal groups. Although the results are only qualitative because of uncertainties in the transfer cross-sections, they showed a substantial decrease in the temperature of neutrons in the fuel rod as a result of transmission through the cold water annulus.

It was noted that the calculated fast flux (and hence the thermal slowing down density) fell off considerably at the outer cell boundary. A calculation for a similar lattice cell using age theory indicated that the slowing down density should be almost perfectly flat regardless of the power distribution in the fuel. The discrepancy, which results from describing fast neutrons by a single group, can be avoided, however, either by using a large fictitious fast diffusion coefficient in F_3, or by using ANP program F_N with an external source for the thermal slowing down density.

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Absorbing Rod in a Maxwellian Flux

The effect of an absorbing rod on the thermal neutron flux in a non-absorbing infinite medium has been calculated for a number of cases in which parameters representing temperature, rod radius, and rod material were varied. The digital computer program ARMIE was used in these calculations. Both "reaction weighting" and "flux weighting" criteria were used to determine the constants in the linear approximation to reciprocal blackness. These criteria were described last month and refer to distribution functions used to determine a minimal least squares fit between assumed linear and square-root energy dependences of reciprocal blackness. It was found that the results are relatively insensitive to the weighting function, thus increasing confidence in the reasonableness of the simpler linear approximation.

The data from these cases have been incompletely analyzed. One quantity which has been examined is $(T_{out} - T_{in})/T$ at the surface of the rod. T_{out} and T_{in} are the average temperatures associated with the currents emerging from and entering the rod. Therefore, the ratio which was examined measures the fractional spectral-hardening produced by the rod. This quantity was found to increase with increasing rod size and to decrease with increasing temperatures, a result which was expected from qualitative arguments. Quantitatively, a fractional change of around 1/4 was found at room temperature for a radius about twice the total mean free path in the rod.

The variation of the reciprocal blackness with energy has been examined more closely. It is found that, for the assumption that $1/\beta = C_1 + C_2 E^{\frac{1}{2}}$, the coefficient C_2 has a simple dependence on the absorbing rod radius and material but the dependence of the coefficient C_1 on these quantities is considerably more complex. These conclusions are based on the expression for blackness found by a variational principle by Stuart, Nuc. Sci. and Eng. 2, 617 (1957).

Thermal Neutron Spectrum Near a Temperature Discontinuity

Evaluations of the analytic solutions to the temperature discontinuity problem in a heavy gas moderator in slab and cylindrical geometry are continuing. Temperature ratios of 2 to 1 and 3 to 1 in either direction have been used. It has been found that the results approach closely those of the plane case when $a/\lambda \gtrsim 4$, where a is the slab half width or cylinder radius and λ is the relaxation length. A more thorough analysis is being made at $a/\lambda = 2$, where geometrical effects are evident.

To facilitate the comparison of the exact solution with approximate solutions, an addition has been made to the 709 FORTRAN program SYZYGY. This addition, which is optional, computes at each spatial position a) the temperature in the effective temperature approximation and b) the spatial functions in the multi-maxwellian group approximation. The 1/v reaction rates in these two approximations are also calculated.

Also under way is the extension of the analytical solution to slab and cylindrical geometries for the case of a net current flow perpendicular to the discontinuity.

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Multimaxwellian Group Analysis

Debug runs on FIT-1 were continued. The main program appears to be operating correctly. The modified version of F_3, which is used to calculate two-group fluxes, has been causing trouble. At the month's end, it was discovered that the FORTRAN compiler was not interpreting the program correctly. There does not appear to be a clear-cut remedy for this trouble, so the cut-and-try method is being used.

Neutron Rethermalization Experiments

The graphite fabrication for high temperature experiments in cylindrical geometry has been completed. Preparations for testing the heating characteristics of the assembly are in progress. Five NaI(Tl) counting systems have been calibrated and tested. Two systems are for Pu-U counting, two for Lu, Cu, and Au foil counting, and one for Cu pin counting. Curves for correcting for fission activity decay have been obtained for the appropriate systems.

The Foil Decay Correction program which was originally written for the IBM 650 (HW-57226) has been rewritten for the IBM 709.

Instrumentation and Systems Studies

The write-up of the study on the speed of control of Hanford reactors upon coolant loss has been completed and forwarded to IPD, Reactor Physics, for the addition of several sections.

Study of the basic reactor kinetic equations has gone as far as practical analytically. The conclusions are that the solutions are unstable for all values of amplitude and frequency of a sinusoidal reactivity variation. Practically the oscillations are limited by the presence in a reactor of negative temperature coefficients. Equations for determining the effects of these have been formulated, but it will be necessary to use a computer to get useful results without an inordinate amount of labor.

An attempt was made to obtain the solution of the standard reactor kinetic equations by the use of the DDA. A solution for various values of reactivity and frequency of reactivity perturbations is desired. Some satisfactory runs were completed.

A long section of flexible light pipe material (approximately three feet) made by American Optical Company was tested for possible use as a reactor pigtail radioactivity probe. It was found, using both NaI and anthracene detectors with the light pipe, that excellent gross beta-gamma counting was possible. Further work will be done on this technique.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Exponential Measurements of Large Diameter Fuel Elements

Final material buckling values have been determined for several lattices using tube-in-tube fuel elements and one lattice using a 2.5 x 1.6 I α E fuel element. The material bucklings and other information of interest are given in Table I.

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TABLE I

Fuel Element	Lattice Spacing	B^2 ($10^{-6}cm^{-2}$)	λ(side) (in)	Volume Ratios Al/U	H_2O/U	C/U
2.5 x 2.0 with 1.66x1.1	7 3/16 wet	-123	1.4	.493	1.102	14.85
2.5 x 2.0 with 1.66x1.1	8 3/8 wet	-61	1.3	.493	1.102	21.12
2.5 x 2.0 with 1.66x1.1	10 3/8 wet	-45	1.4	.493	1.102	33.86
2.5 x 1.6 I α E	14 9/16 wet	-129	2.1	.373	1.291	70.44

λ is the measured side-to-side extrapolation length. A front-rear λ of 1.03 inches was used in all cases.

Preliminary buckling values have been determined for one lattice using tube-in-tube fuel elements and one lattice using the 2.5 x 1.6 I α E fuel elements. The results are shown in Table II.

TABLE II

Fuel Element	Lattice Spacing	Buckling ($10^{-6}cm^{-2}$)	Volume Ratios Al/U	H_2O/U	C/U
2.5 x 2.0 with 1.66x1.1	7 3/16 dry	-292*	.493	-	14.85
2.5 x 1.6 I α E	8 3/8 wet	-70	.373	1.291	21.47

* To be remeasured because of poor fit.

The preliminary buckling values are based on an estimated side extrapolation length of 1.66 inches. Final bucklings will be reported after analysis of horizontal traverse data.

Horizontal Traverses have been taken using the shutter method with a bare counter and a cadmium covered counter. The results of these traverses are shown in Table III.

TABLE III

Fuel Element	Lattice Spacing	λ(side) (in)	Counter
1.92 solid	10 3/8 dry	1.7 ± 0.1	Cadmium covered
1.92 solid	10 3/8 dry	1.5 ± 0.1	Bare

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PCTR Measurements of Lattice Parameters of Large Diameter Fuel Elements

The preparation of equipment for the 2.5 x 2.0, 1.66 x 1.12 tube-in-tube experiment is essentially completed. The foils for the water annuli remain to be made.

Two of the foil holders for the p measurement must be cadmium covered. Two "doughnuts" of cadmium and two flat strips are necessary to cover each foil holder. Preliminary tests indicate that this method will be satisfactory.

Automatic Counter - Sample Changer

The final design drawings of the details of the components of the Automatic Counter are 50% complete. Preliminary estimates of the cost of fabrication and assembly have been set at $20,000 with an additional $1,000 for final design. These estimates are based upon a project cost estimate.

Tentative arrangements for the start of fabrication have been made with Mr. Lucas of the HLO Technical Shops. The schedule is as follows:

a) Technical Shops will estimate the costs of fabrication and assembly by December 15, 1959.

b) A revised appropriate request will be prepared, based upon their estimate. Approval is expected about January 1, 1960.

c) Fabrication will be started after January 1, 1960.

d) Completion is expected by June 30, 1960.

Automatic PCTR Data Recording System

A call for bids on the proposed system has gone out to prospective vendors. The bids will be opened December 7, 1959.

Instrumentation and Systems Studies

All design-development work is completed for a prototype, linear, four-decade, scintillation beta-gamma area monitor. All materials have been ordered and fabrication will start when the materials are received. Fabrication is continuing on a prototype, logarithmic, three-decade, scintillation beta-gamma area monitor. A scintillation detector light-pipe combination was developed for use with the prototype transistorized beta-gamma air monitor for the 105-N Building. The new detector head features excellent shielding, sensitivity, and replaceability.

The detailed fast and slow-scan mechanical design for the NPR Fuel Element Rupture Monitor prototype is about five percent completed. Specifications and drawings are completed for a slip-ring assembly to be used for prototype test work. Fabrication is almost complete for a simulator for a chopped gamma signal source. Testing of the preliminary circuits will proceed when the source is completed.

Some survey work was done on the detailed simulation of the dynamics of the NPR heat exchangers. It appears that the amount of non-linear equipment (function generators and multipliers) now available on the GEDA will be insufficient

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to handle the problem in its present form. Further work is required in order to determine whether the problem can be handled prior to the arrival of additional computer equipment.

Mechanism of Graphite Damage

A liquid helium cryostat for electron irradiation of graphite was obtained from the Physical Metallurgy Operation. It was originally built for use with uranium but can be adapted for graphite at a considerable saving.

STUDIES RELATED TO THE SEPARATIONS PLANTS

Plutonium Critical Mass Facility

The construction phase of the Plutonium Critical Mass Facility is proceeding almost on schedule (perhaps a few percent behind). The interior construction of the control building is now near completion; there is some indication, however, that a delay of several months may be encountered in the delivery of the control panel and associated instrumentation.

Service equipment is being installed in the service room of the service building. This includes the air conditioning and heating system, chilled water refrigeration, air compressors and necessary plumbing.

On November 24 the remaining two concrete walls of the reactor room were poured, leaving the ceiling slab and emplacement of the large shielding door to the reactor room to be completed.

In order to verify the suitability of the proposed design of the safety rod system for the initial reactor assemblies, a study was made of the safety rod support electromagnet mockup; the preliminary results indicate that no difficulty will be encountered in using the 400 series stainless steels for electromagnet frames. The 400 series stainless steels are highly magnetic and present no problem in obtaining sufficient holding force. The chief noticeable difference over soft steel, which would ordinarily be used, is a quite high hysteresis behavior.

Measurements of the release time between current cutoff and rod release indicate that there should be no great problem with respect to the speed of scram action. The release time is very dependent on the supported weight, air gap between pole faces and armature (head of safety rod), and current excess over the minimum holding current. However, for an intermediate air gap ($\sim$0.005 inch) and currents of about 30 percent over the very minimum holding current, the preliminary measurements give release times of the order of 20 milliseconds. The accumulated delays due to other causes (relay actuating time, rod travel time, etc.) are expected to be somewhat longer than this.

Measurements are continuing in an effort to establish the optimum operating conditions for reliable and fast safety rod action.

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Critical Hazards Specifications

NPF Fuels Processing

Discussions were held with relevant personnel from CPD and HLO who are concerned with the design of process equipment for the reprocessing of power reactor fuels. This included personnel from CPD, Research and Engineering Operation, and Facilities Engineering Operation, and in HLO, Chemical Development Operation.

The criticality aspects of some proposed designs were discussed in general, and the problems of designing equipment which is both "nuclearly safe" and at the same time economically and operationally feasible were discussed.

Calculations are proceeding for comparing theoretic bucklings and critical masses with experiments for enrichments in the range of 3 percent in an effort to evaluate safe dimensions of dissolver and process equipment for heterogeneous systems of metal and/or UO_2 rods with enrichments up to 5 percent.

NPR Fuels Handling

On November 25, a meeting was attended to discuss the approval of scoped NPR casks and cask cars. Tentative CPD approval has been given to the scoped NPR cask and cask car, subject to criticality tests using NPR type fuel elements. Critical Mass Physics will conduct exponential and/or critical approach experiments when a sufficient number of these fuel elements are available.

Criticality Studies in Support of Processing Power Reactor Fuels

Critical mass studies were continued with the 3 percent enriched uranium relevant to the reprocessing of power reactor fuels. The measurements included critical approach experiments with heterogeneous systems and exponential experiments with homogeneous systems.

Experiments with Heterogeneous Systems

The experiments with the heterogeneous systems yielded information on the critical mass, material buckling, extrapolation length, and shape factors for the water moderated and reflected assemblies. Critical approach experiments were made with one circular cylinder, three elliptic cylinders, and two rectangular parallelopipeds. The purposes of the experiments were: 1) To determine the effect of an irregular outer boundary variation on the measured critical mass, 2) to obtain data on "shape factors" for the interconversion of critical cylinders to other geometries, 3) to obtain information on the effect of geometry on the extrapolation distance, 4) to examine the feasibility of more accurately determining the "effective" radius of the extrapolated critical cylinder by introducing a shape deformation which is then successively decreased and put to zero, 5) to compare theoretical buckling formulations with experiments.

The uranium rods which were used in these experiments were 23.5 inches in length and 0.175 inch in diameter; the uranium enrichment was 3.063 percent. These rods were encased in 0.025-inch wall lucite tubes and were arranged in a 0.5

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inch trinagular lattice; the resulting H_2O/U volume ratio was 8.0. The reactor assemblies were both water moderated and fully water reflected.

The results of these measurements are shown in the following table:

CRITICAL MASS AND BUCKLING

For 3.063 Percent U-235; 0.175-inch Diameter Rods Positioned in 0.5-inch Triangular Lattice

Elliptic Cylinders

Eccentricity of Ellipse	Critical Dimensions of Semi-Major and Semi-Minor Axis		Critical No. of 23.5-inch Rods in Elliptic Cylinder	Critical Mass of Uranium (lbs)	Material Buckling ($10^{-6}cm^{-2}$)
	a	b			
0 (circular cylinder)	R = 15.88 cm		567.3 ± 1	219.0 ± 0.4	13,412
0.212	16.07 cm	15.71 cm	568.2 ± 1.5	219.3 ± 0.6	13,315
0.465	16.92 cm	14.98 cm	570.3 ± 2.5	220.1 ± 1.0	13,041
0.647	18.34 cm	13.99 cm	577.2 ± 1.5	222.8 ± 0.6	12,941

Rectangular Parallelopipeds

Critical Dimensions of Rectangle (cm)		Critical No. of 23.5-inch Rods in Rectangular Parallelopiped	Critical Mass of Uranium (lbs)	Material Buckling* ($10^{-6}cm^{-2}$)
a	b			
28.09	29.22	587.7 ± 0.6	226.9 ± 0.2	13,250
25.30	33.00	597.7 ± 1.5	230.7 ± 0.6	13,262

* The extrapolation length was taken to be 6.5 cm for these calculations.

These measurements may be the first of their kind in elliptic cylinders. The variation in the critical mass with reactor shape for the above-reflected systems is small, giving "shape factors" near unity (the ratio of the critical mass of the circular cylinder to that in the other geometries is ≃ about 0.95 in the above cases).

The buckling which was previously determined for the cylindrical case was 13,382 μB. Because a different loading technique was used in these measurements, the cylinder was rerun using the new technique. The difference in buckling of the two rectangular cases is seen to be smaller than that between the two cylindrical cases.

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The calculated bucklings from the elliptic cylinders show a decrease with increasing eccentricity of the ellipse. Since the material buckling of each loading must be very nearly a constant, these differences can be attributed to a change in the extrapolation length; this change could be caused by the differences in reactor curvature, shape, etc. The variation in λ which is required to give bucklings from the elliptic cylinders equal to that of the circular cylinder is shown below:

Eccentricity	λ
0	6.5 cm (assuming this value for the cylinder)
0.212	6.4 cm
0.465	6.14 cm
0.647	5.9 cm

It is doubtful, however, that such fine distinctions can be drawn and further analysis of the results is planned.

Experiments with Homogeneous Systems

Exponential experiments were continued with the 3 percent enriched UO_3-polyethylene systems. These experiments were conducted with homogeneous mixtures of 3 percent enriched UO_3 and polyethylene contained in a lucite tank twelve inches in diameter and 32 inches in height. Measurements have now been completed at nominal H/U atomic ratios of 6, 12, 18, and 26. The results of these measurements are shown in the following table:

BUCKLING OF 3 PERCENT ENRICHED
UO_3-POLYETHYLENE MODERATED SYSTEMS

H/U (atomic ratio)	Total Density (gm/cm^3)	UO_3 Density (gm/cm^3)	λ (cm)	Buckling ($10^{-6}cm^{-2}$)
6.1	1.54	1.33	9.5 ± 1.0	5640
11.9	1.46	1.12	"	4518
18.2	1.28	0.89	"	3876*
26.5	1.20	0.73	"	2675

* This value was measured in the previous month.

These values are preliminary in that the extrapolation length (9.5 ± 1.0 cm) is a preliminary value measured at an H/U atomic ratio of 18. A horizontal traverse measurement has been made for determining the extrapolation length at an H/U atomic ratio of 12, and these data are now being analyzed.

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Since the maximum buckling has not been obtained (the buckling is still increasing at an H/U ratio of 6) a further measurement of the buckling is planned for an H/U ratio of 4.

Theoretical Critical Mass Studies

The reactor kinetics program and its associated subroutines are still being debugged. A test case possessing an analytical solution is being prepared for a check of the entire program.

Two simple subroutines have been written to calculate material and geometrical parameters for small, bare, homogeneous reactors. The material parameter subroutine calculates f, k_∞, and τ_{eff} for a solution of specified fuel-to-moderator ratio and critical buckling. The geometrical parameter subroutine calculates k_{eff} and geometrical buckling for a material with given parameters in a specified geometry. These subroutines may be used independently or in association with other programs. For example, they are being combined with a covering program to calculate the leakage of fast and thermal neutrons from a bare, homogeneous subcritical system. This program will be used to check hand calculations done some months ago.

Relative to critical mass calculations for Pu systems, a test problem for the C_3 code has been run on the 709 Computer using the data tape compiled this month. The exact worth of the results has not been fully determined, but some changes will be required in the code for better utilization.

Mass Spectrometry

No customer service was requested for isotopic analysis with this mass spectrometer during the month. The instrumentation of this spectrometer was used to study and improve the reliability of the ion pulse counting systems of the mass spectrometers. The electrometer-Brown recorder components of the ion current measuring system were calibrated for linearity of response to input DC current.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Scattering Cross Sections

Growth of Single Metal Crystals

One additional aluminum crystal was grown bringing the total to seven crystal ingots of the size previously reported. The furnace was modified and used to grow a lead crystal two inches in diameter by eight inches long. A single melt produced an ingot with a large amount of lineage structure. A second melt with a larger temperature gradient and slower growth rate yielded an ingot with a great reduction in lineage structure as determined optically.

Studies of Monochromating Crystals

Crystal reflectivity measurements were carried out on three uncut aluminum ingots for neutrons of energy 0.084 ev. A comprehensive set of measurements was made on the first crystal and survey measurements on the other two as indicated by the more complete studies. None of the three crystals investigated

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are particularly useful as neutron monochromators in their present ingot form. The possibility of improved reflection characteristics because of altered geometrical form or induced perturbations of the crystal structure remains to be investigated.

Slow Neutron Fission Cross Sections

A very light deposit of the 96 percent Pu^{241} sample was prepared by electro-deposition by Analytical Laboratories in hopes of obtaining a more uniform areal density for absolute fission cross section measurements. A fission scan was made of the areal density of the foil using a 1/8 inch diameter neutron beam. The observed extreme variation in density across the deposited surface was a factor of our which precludes the use of this sample for absolute measurements.

Fast Neutron Spectra

Measurements were made on the time-of-flight spectrum of Be(d,n) neutrons using the positive ion Van de Graaff accelerator. Ten working days were spent on the Van De Graaff, seven of which were spent on mechanical realignment of the Van de Grafff and focusing adjustments of the ion beam. In order to facilitate future alignment the accelerator and magnet were placed on a definite baseline established by the fiducial marks found on the building walls. This required a gross movement of the rear supports of the accelerator and a 1/2 inch movement and 1/2 degree rotation of the analyzing magnet. The + 25 degree beam tube was straightened and the magnet shims readjusted to obtain the best focus.

The smallest vertical beam width obtained was about 2 mm or about twice that which should reasonably be expected. The voltage regulation system of the Van de Graaff was determined to be faulty causing the beam to continuously impinge upon one of the regulating electrodes rather than pass through the middle of the regulation slit. The regulator was also unable to suppress the energy variations of the accelerator which caused a horizontal sweeping of the beam with an amplitude of several millimeters at a frequency of several cycles per second. The ion beam also flashed completely out of focus every few seconds.

The mechanical alignment that was achieved was judged to be satisfactory since the position and focus of the beam were the same for protons, molecular hydrogen, and deuterons.

The best working resolution obtained was about 2.2×10^{-9} seconds compared with previous work at 1.5×10^{-9} seconds. A fairly detailed study was made of the Be(d,n) neutron spectra at an angle of 20 degrees for 1.85 Mev deuterons. A crude angular distribution was also obtained. At angles greater than 40 degrees a large synchronous background was observed which could be identified as originating from the horizontal steering plates which were irradiated because of the horizontal spread of the beam. It was also discovered that the resolution could not be improved by using a higher beam sweeping voltage because the slits were not properly shaped to stop the beam and the resulting deuterons striking the tube wall produced a large background.

Several new pieces of beam tube and components are being fabricated to attempt to reduce some of the deleterious effects discovered in these measurements.

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REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Lattice Parameters for Low Exposure Plutonium

PCTR experiments on the 1.8 w/o Pu-Al 19-rod clusters in a 10 1/2 inch square graphite lattice with air coolant were completed on November 24. Approximately five shift-weeks were required to gather the data. Analysis of the data is underway.

Difficulty arose in making reactivity measurements due to the presence of self-generated neutrons in the Pu-Al fuel. These neutrons were the result of an (α,n) reaction in the aluminum matrix ($\sim$90%), and spontaneous fission in the plutonium ($\sim$10%). The total source from these reactions has been calculated to be $\sim 6 \times 10^5$ n/secs from the nine cluster array ($\sim$900 gms Pu). The difficulty was overcome by going to a higher power level while measuring rising pile periods (27 watts peak).

An approach-to-critical was made when the nine clusters in the core were unpoisoned. Two enriched BF_3 tubes, located on either side of the central cluster, and the PCTR channel 1 fission chamber were used to monitor subcritical multiplication. The reactor was made critical with twelve drivers, located symmetrically on a 60 cm radius from the core axis.

No contamination problems from the plutonium fuel were encountered during the experiments.

Lattice Parameters for High Exposure Plutonium

Word has been received that the 20% Pu-240 material from Oak Ridge will not be available. The Division of Military Applications has exercised a prior claim and taken over the 1.2 kilogram lot that was being shipped to Hanford for PCTR experiments. This action has forced suspension of preparatory work by Plutonium Metallurgy. It may be possible to use some lower exposure material that is available on plant. This alternative is being actively explored.

Irradiation of the MTR Pu-Al elements is continuing in the ETR toward the 40% Pu-240 goal.

Reactor Theory

The inhomogeneous linear equations arising in reactor physics can be written in the form

$$\phi = K\phi + f$$

where f is the external source and $K(x,x')$, the kernel of the integral operator K which describes the system, can be interpreted as the probability of finding the system at x after an interaction at x'. By defining the moments of the adjoint kernel by

$$\mu_n^+(x) = \int dx' \, K(x,x') \, (x'-x)^n,$$

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the integral equation can be written as the infinite-order differential equation

$$\phi(x) = \sum_{n=0}^{\infty} \frac{\mu_n^+(x)}{n!} \frac{d^n}{dx^n} \phi(x) + f(x) .$$

Terminating the summation at some finite index N leads to a class of moment approximations. Since the kernel of the integral equation, which depends on two independent variables, has been replaced by a small number of moments depending on a single variable, the amount of information in the system equation, and therefore its computational complexity, has been substantially reduced. Since the first two moments describe the average distance in phase space which the system has traversed since its last interaction and the dispersion about that distance, a second order differential equation should give a reasonably accurate description of most systems.

These considerations were applied to the diffusion of monoenergetic neutrons, assuming isotropic scattering. The second moment approximation to the Milne equation leads to diffusion theory; however, there is a small correction to the diffusion length when absorption is large, and external neutron sources are replaced by their first collision distributions. For the case of neutron moderation by elastic scattering in an infinite medium, the first and second moment approximations to the integral balance equation result in age theory and the Greuling-Goertzel equation, respectively. In view of the physical significance of the second moment, the Greuling-Goertzel theory should describe the slowing down of neutrons through strong resonances much more accurately than age theory; this is consistent with some unpublished numerical results obtained at ANP.

PRTR Startup Experiments

Meetings with the Physics Startup Committee have continued through the month. A general outline of all the experiments and the time necessary for their completion were discussed.

In addition planning for the subcritical experiments was begun. These experiments can be divided into five types which utilize a total of seven different loadings. The five types comprise an all UO_2 exponential loading, a two-zone, two three-zone, a quasi-uniform, and two all Pu-Al approach-to-critical loadings.

The two zone loading will have a core of approximately 61 UO_2 elements surrounded by Pu-Al elements. For the three zone experiments 18 Pu-Al elements will be loaded in the form of a ring. This ring will surround, as well as be surrounded by, UO_2 elements. For one loading the ring will have a smaller radius of 20 inches and a larger radius of 26 inches. The second three zone loading will contain a ring which has a smaller radius of 26 inches and a larger radius of 31 inches. It is being planned that in the quasi-uniform loading every other fuel element will be a Pu-Al element. The all Pu-Al loading will be made with both an 8- and a 16-inch lattice spacing.

For all the loadings, measurements will be made for the reactor full of moderator. In addition measurements will be made with the height of the moderator at 1/2 and 3/4 of the full height for all the loadings except the all UO_2 and all Pu-Al ones.

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The Critical Facility of the PRP

A typical procedure to be followed in the use of the Critical Facility was outlined for the purpose of indicating the degree of operability desired. This operating procedure was incorporated in the Design Criteria document. A rough draft of the Design Criteria has been prepared and distributed for comments.

Instrumentation and Systems Studies

Acceptance tests were completed on 100 of 150 total photomultipliers for the PRTR Fuel Element Rupture Monitor. The rejection rate is running about 20 to 25 percent. Simultaneous acceptance work for the detector crystals (NaI) has shown a rather large rejection rate due to internal moisture and glass-crystal separation.

Further investigation continued on neutron/gamma discrimination by scintillation pulse shape. For a stilbene phosphor, the total area under the decay curve for a neutron-induced scintillation is roughly ten percent greater than for a gamma-induced scintillation of the same initial height. The difference is due to at least two additional or enhanced longer phosphorescent decay components with decay times of about 0.3 and 5 microseconds. It has been shown that the circuits built by earlier investigators to utilize this phenomenon give misleading results. This is due to the use of crystal diodes to stretch the unamplified pulses directly from the photomultiplier. As a result small pulses from low energy gammas or low energy neutron events would be cut off while the upper part of high-energy neutron pulses would be passed. The result is that the pulse shape discrimination appears nearly perfect; however, the effective energy bias is several Mev different than intended or than was reported by earlier investigators. Fresh attempts are being made to design a proper and useable circuit.

A supplemental work order was received which permitted work to begin on the fabrication of the profilometer. Most of the work is being done in offsite shops. This unit is designed to provide diameter and warp measurements of PRTR fuel elements as well as permit surface examination at 5X magnification. All optical components have been received. Some work remains to be done in specifying control cables and mounting of some small motors.

Lenses for the Wide Angle Viewer have not been received. The Simpson Optical Company was to have completed fabrication of these several weeks ago but has been on strike since October 10.

The PRTR controller was received in the analog lab on 11/19/59 and is being wired to the computer. Simulation of the PRTR is being programmed on the GEDA computer.

GAS COOLED REACTOR PROGRAM

Lattice Parameter Measurements

Preliminary results have now been obtained for the control rod experiment. A four by four array of seven rod cluster fuel channels with a parallel boron carbide control rod in the center of the entire assembly has a k_∞ of 0.9945. This

number was calculated from poisoned and unpoisoned thermal utilizations for the super cell. Now $k_\infty = 1.1468$ without the control rod in place; so the control rod worth in the four by four matrix is $\Delta k_\infty = -0.1523$.

The k_∞ for the four by four array with the control rod has been extrapolated to a value of k_∞ for a three by three array, also with control rod, by two different calculational schemes described below.

In the first method, one assumes that the perturbation caused by the control rod has diminished sufficiently in the exterior region enclosing the three by three that $k_\infty = 1.1468$ for the exterior region. One then obtains $k_\infty = 0.8766$ for the interior by a volume weighted calculation, so that $\Delta k_\infty = -0.270$.

The second calculation utilizes only the absorptions occurring within the three by three matrix, and assumes that the worth of copper poison within the interior three by three region is identical to the worth in the exterior region. The result for this case is $k_\infty = 0.8755$, which agrees well with the result from the first method. The control rod worth as calculated here is -0.271.

An error analysis of the experiment has not yet been performed.

Estimates have been made on the shop work needed to fabricate some special core blocks for the additional measurements for the EGCR. A work order has been written to cover these costs.

Variation of the Doppler Coefficient with S/M Ratio

The IBM-709 program for computing surface and volume average temperatures for a finite cylinder has been tested and run successfully. It is now considered ready for use.

Rod Replacement Analysis

The calculation of the change in k_∞ upon insertion of one control rod per nine fuel elements in the GCR lattice has been made. This calculation was based on a two-group, small source theory formulation in which non-uniformity of the slowing down density into the epithermal group was neglected and the U-238 resonances were lumped into a single equivalent resonance. The results are $\frac{\Delta f}{f} = -31.3\%$ and $\frac{\Delta p}{p} = +7.7\ \%$ which combine to give a $\frac{\Delta k_\infty}{k_\infty} = 26\%$.

NONDESTRUCTIVE TESTING RESEARCH

The basic design of the broadband eddy current instrument for use in measuring zirconium jacket thickness and air gap thickness in an unbonded fuel element is about 75 percent complete. The instrument will consists of (1) a sawtooth generator to supply excitation to (2) a small test probe, (3) an adjustable broadband balance circuit, (4) a main amplifier furnishing broadband signals to (5) a zirconium thickness channel and (6) an air gap thickness channel, and (7) an automatic gain control circuit for minimizing the effects of changes in coupling between probe and fuel element surface.

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Operation of an assemblage of laboratory equipment is giving promising results although the tests regarding interaction between the jacket thickness and air gap thickness readings are not complete. The amount of compensation required, if any, between these channels in addition to that already designed into the readout channels has not been determined. Air gap channel sensitivity has been obtained which gives one-fifth full scale output meter deflection for a one mil change in air gap thickness at normal jacket thickness. Additional measurements are now to be made to determine circuit stability and whether additional inter-channel compensation is required. Additional compensation is believed to be necessary and the method of handling it is of the essence in the solution of the general broadband readout problem.

The instrument design being evolved will be applicable to a wide range of eddy current test problems. Plug-in type construction can be used and additional channels can be added readily. Maximum use is made of resistance-capacitance filters, eliminating the need for specially designed, bulky inductance-capacitance filters.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month. There were eight unscheduled shutdowns; five were due to electronic failure and three were due to faulty bypassing technique.

The PRP low 240, 19 rod clusters, 10-1/2 inch lattice, k_∞ and f determination experiment was completed during the month.

A one and one-half inch hole was drilled through the north face of the reactor to permit extension of neutron traverse measurements through the reflector.

Mechanical stops were installed to limit the face motion and thus provide a more reproducible reactor face closed position. The moving face tracks were also realigned. Preliminary tests indicate that reactivity measurement reproducibility has been improved.

The speed of the control rods was approximately doubled. This improves reactor control by decreasing the time of setting control rods prior to period measurement. The maximum rate of reactivity addition is still less than half that allowed by the operating standards.

Critical Mass and Neutron Temperature experiments shared the TTR reactor time about equally.

There were no unscheduled shutdowns during the month.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

A planning conference, for the delineation of tasks and establishment of format and content of the general report on the past summer's dispersion experiment, was held with AF CRC personnel on November 3-5, 1959. A three-volume Geophysics

Research paper, published by the Air Force, but with credit lines for General Electric Company and the U. S. Atomic Energy Commission, was agreed upon. Assignments for chapter authorships were agreed to. These were made on the basis of responsibility for various phases of the work.

Reduction of the dispersion data was greatly facilitated by the development of a new rapid assay technique by Analytical Chemistry Operation. This system involves the use of the phosphorescent property of ZnS and is capable of precise calibration. The method also permits correction for dust loads on the sampling filters, a prime requisite in the analysis of Project Green Glow data.

A first approximation of the dispersion data for each sampling point was obtained by combined use of the chemical method and the assay made using the counter developed by Instrument Research and Development. These results, using an eight-class dust correction determined by a visual assessment of the dust loading, were precise to within about ±20% of the correct value for ZnS loading. More precise analyses are required and are being sought through the chemical system. This first approximation was required by December 11, 1959, by the Air Force for an operational problem, a deadline which was imposed on November 5. The results of this first analysis were delivered to the Air Force on December 7. (This deadline could not have been met without the wholehearted cooperation of Analytical Chemistry personnel.)

DOSIMETRY

It was found that Zn^{65} in oysters may possibly have been responsible for many of the higher body burdens that have been found in people. A subject who had previously been observed to have a Zn^{65} body burden higher than average was counted again and found to have an increased burden. Conversation revealed that he had had a meal of oyster stew a day before the last measurement. In a recent paper on Zn^{65} (Science 130 1255-1256 (1959)) oysters (Atlantic Coast) were reported to contain much more Zn^{65} than other foods. Fortunately the subject still had two cans of the oysters he had eaten. These were counted and found to contain 2×10^{-2} μc of Zn^{65}. The average specific activity of the oysters was 4×10^{-5} μc/gm or about 200 times that of the oysters in the above reference. The oysters were bought at a Richland store, but their source was not identified other than that they were labeled as Pacific oysters. As a result of these findings Analytical Chemistry Operation examined a variety of sea foods from local stores. They confirmed the activity of the oysters found above. Another brand of Pacific oysters had about one-fourth as great a specific activity. About one-half the foods had a specific activity similar to those found on the Atlantic Coast. A brief attempt to measure the Zn^{65} retention of a subject who ate contaminated oysters was unsuccessful because in the test period the subject eliminated more Zn^{65} than he acquired from the oysters.

Enough data has now accumulated on Zn^{65} for employees working in the 100 Areas to indicate significantly different burdens than in the rest of the people studied. On the average 100 Area employees contain 70% more Zn^{65} than the others.

Data obtained at Argonne were used to show that there is an uncertainty of about 0.2 mμc in our Zn^{65} measurements due to individual variations in the corrections that must be made for K^{40}.

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About one-half of the difference between our potassium results and those of Los Alamos was eliminated by omitting data obtained with the plastic phantom in our potassium calibrations. The evidence indicates that the potassium in the body is less uniformly distributed than the potassium in the phantom.

X-ray calibrations were completed for the subject examined for americium and plutonium last month. The result was about twice as much plutonium as estimated last month from the amount of americium.

The discrepancy reported two months ago in Na^{24} measurements in connection with neutron exposures of the plastic phantom was eliminated by obtaining a calibrated point source of Na^{24} and measuring it both as the point source and when dissolved in a gallon of water. Basically, however, a discrepancy still remains. Measurements of the activity of the point source were 50% off from the calibration value.

On November 16, the Shielded Personnel Monitoring Station was closed to permit installation of a 1/8-inch lead lining on the interior walls of the iron room. Work is still in progress.

The positive ion Van de Graaff operated satisfactorily during the month. The accelerator was realigned using a new optical system. Alterations to the circular track system were completed to permit use of quite heavy counters. Equipment was installed that permits automatic background subtraction when using accelerator neutrons. Fabrication was completed of a new beam current integrator and automatic controller. A lucite-zinc sulphite scintillator was used successfully as a monitor in the time-of-flight system.

Solutions to practical problems in neutron dosimetry are being sought through cooperative work on several problems both under laboratory and under field conditions. The performance of the double moderator neutron dosimeter was evaluated in a particular location in a reactor area.

Development of the precision long counter proceeded with measurement of the effects of placement of the counter and the calibration source on reproducibility of counting. Neutron film exposed to our plutonium fluoride neutron source for the United States Naval Radiological Defense Laboratory were evaluated and the results communicated to us. The average neutron energy determined from these films is in fair agreement with our experimental value determined with the double moderator.

A standard Co^{60} source was received on loan from the National Bureau of Standards. It is planned to compare this source (with our own Co^{60} source) and also with the absolute calibration of our gamma ray calorimeter.

INSTRUMENTATION

After nine months of continuous satisfactory use in the 329 Building, the scintillation transistorized, combined alpha-beta-gamma hand and shoe counter has been assigned to the Calibrations Operation so that complete plant as-built drawings can be prepared.

Complete transistorized circuitry is being developed and fabricated for an experimental alpha air monitor using coincidence counting techniques to eliminate radon-thoron background counting effects. Previous tests with the same scintillation detector and vacuum-tube circuitry showed that the instrument will alarm on 10 MPC of Pu^{239} in 25 minutes with no false alarms due to background fluctuations.

Further work was completed on miniature scintillation detector light-pipe combinations for Biology research. The probes (one-eighth inch diameter by four inches long) were used with various single radioisotope solutions such as Cs^{137}, I^{131}, Sr^{90}-Y^{90}, Sr^{85}, P^{32}, Ca^{45}, Ce^{144}-Pr^{144}, Na^{24}, Zn^{65}, and Ru^{106}-Rh^{106}. Relationships between count rate and dose rate were established for liquid solutions of the above isotopes. Anthracene was used as the detector.

Another experimental detector light pipe of one-eighth-inch diameter by four inches long was used for low-level Pu^{239} detection in solution (two normal HNO_3). A relationship was established between count rate and relative concentration of Pu^{239} in millimicrocuries per milliliter. The background count rate was only 0.05 c/m. With the probe inserted in a two milliliter solution of 1.28 millimicrocuries of Pu^{239} per ml, a count rate of 1.3 c/m was obtained. Using a scaler, one millimicrocurie of Pu^{239} per milliliter of solution can be easily detected. The counting efficiency can be improved by using a thinner mylar outer cover (for decontamination ease) over the probe tip. The present probe uses 0.25 mil clear mylar over the standard light shield of 0.9 mg/cm^2 double-aluminum-coated mylar.

Experimental work continued on alarm circuits and devices for the personally-carried personnel alarming dosimeters. Work centered about the use of a quartz fiber electrostatic relay for the alarm activator.

Fabrication work continues on several experimental alpha-detecting scintillation probes with effective areas of two by four inches. Work has started on the design of a similar probe of a two by seven inch size. None of the probes has any increase in background counting in a five r/hr Ra gamma field. Pu^{239} detecting geometry is better than 10 percent and is uniform over the complete probe face.

A method of eliminating a battery supply for a transitorized emitter follower was investigated and proved satisfactory. The emitter-follower impedance matching circuit is used with a phototube scintillation detector and can drive 1,000 feet of shield cable with ease. No battery supply with--or power cable to--the detector head are necessary. The emitter follower drives power for operation from the high voltage applied to the phototube via the single long cable. Either positive or negative high voltage can be used as desired. The output pulse signal is transmitted over the same cable as used for high voltage input to the detector. Such a detecting unit should be able to operate for long periods with no maintenance. Pulse-height analysis results, using the system, were quite satisfactory.

A slip-ring assembly was designed to be used with the long, cable-supported G-M instrument. Several hundred feet of cable are used between the portable G-M instrument and the G-M tube. The slip-rings are used to prevent cable tangling. The unit will be used for gross gamma count work in 200-Area wells.

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A holding-support mechanism was designed for the large NaI crystal and multiple phototube assembly for the Biology Operation total-body monitor.

A five microcurie Ba^{133} source was given to Biology to permit setup of the I^{131} Hog Thyroid Monitor. The use of this relatively long-lived (in relation to the previously used I^{131} check sources) isotope will permit ease of setup and adjustment of the monitor. The photopeak energies and, consequently, pulse heights for Ba^{133} and I^{131} are close enough for the accuracies required.

The experimental, completely transistorized Aural Scintillation Transistorized Alpha-Beta-Gamma Monitor was completed. The unit, operating from 110 VAC mains, uses a single combination scintillation probe and has both a count-rate meter and loudspeaker indication. Some investigative work was done to develop a scintillation detector to have a better C^{14} response. Various solutions using zinc sulfide, terphenyl, anthracene, toluene, and polystyrene adhesive were tried. The solution can be painted onto the phototube face or on a light pipe. After a short drying time, the detecting material adheres very well to the tube face or pipe. Further tests will be conducted.

The text of the Radio Telemetering Network data station instrument manual was completed and will be forwarded to duplicating along with the finished circuit diagrams. The changing of fifteen data stations to different locations was also completed.

Further investigation into the robot monitor odometer indicates the desirability of placing the motion computing elements at the stationary location and of telemetering the turning and speed data directly from the moving robot.

WASHINGTON DESIGNATED PROGRAM

The mass spectrometer was operated for 16 of the 19 working days of November providing isotopic analyses for this program with a high operating efficiency.

Two operating days were lost because of the maintenance required following an outage of the building water system.

The electrometer-Brown recorder components of the ion current measuring system of the mass spectrometer were checked for linearity of response to changes in DC input current. The systems were found to be linear to within about 0.2 percent for all but the two lowest ranges where the precision of measurement was limited to about one percent. The accuracy of isotopic ratio measurements is therefore not significantly limited by nonlinearity in these components.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	84.8
24-Hour General	60	82.3
Special	115	90.4

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November temperatures averaged 3.5 degrees below normal. A notable feature of the temperatures was the extremely high variation from a low of 6 on the 13th to a high of 70 on the 23rd. Daily departures varied from 23 degrees below normal to 24 degrees above. On 15 days, the departure was 10 degrees or more and, on 11 of these days, the departure was negative.

Precipitation totaled 0.41 inch, which was less than half the normal amount for November.

Instrumentation

Specifications for the mechanical conveyor portion of the Laundry Monitor were drawn and written and are being sent out for bids.

Fabrication was completed on an instrument for the Biology Operation for measuring respiratory activity of animals. The unit measures the rate of air displacement and the air volume displaced. Volume changes as low as 0.03 cc can be detected. The unit will be delivered when the recorder is obtained.

The following fabrication work is being done, presently, in the 328 Building Electronics Fabrication Shop:

1. Work is nearing completion on 12 scintillation, gamma, criticality or incident alarm units. All operate from 110 VAC mains and will be installed in various 300-Area buildings.

2. Fabrication was completed on one G-M tube detector, transistorized circuitry, alarming monitor of 110 VAC-operation type. The unit, plus two more, will be used at Redox. Alarm levels (gamma) of about 0.1 to 5.0 mr/hr will be available. Calibration and debugging tests are proceeding.

3. Two final model, portable, scintillation, transistorized gamma-energy analysers were completed and will be debugged and calibrated. The Calibrations Operation ordered these two units.

4. Fabrication continued on three experimental, non-beta-gamma sensitive, scintillation alpha probes of the latest type. Effective probe area is eight square inches (two inches by four inches).

Advice was rendered to electronic maintenance personnel at Redox concerning the Redox Gas Effluent Stack Monitor. The instrument has been turned over to the Redox personnel for general maintenance after about one year of completely satisfactory service.

Advice was rendered to the 300-Area Portable Radiological Instrument Maintenance Shop concerning conversion of 15 obsolete, vacuum-tube, BF_3 tube portable instruments to proven-circuitry, completely transistorized models using the standardized transistor amplifier count-rate meter and high-voltage supply circuits. Two prototype transistorized models have proved to be improvements in all plant field tests to date.

The circuit tester for functional testing of all the IRDO transistorized, standardized, printed, modular circuit boards has been rebuilt and a report will be issued shortly. The report will enable any interested plant maintenance group to

fabricate the device for testing of the plug-in boards. Only a simple voltmeter and a good quality triggered oscilloscope will be required in addition to the tester for complete maintenance and test work.

Field tests were completed on the prototype, first model, transistorized, loud-speaker G-M instruments. Satisfactory field operation was obtained except for some needed mechanical modifications. As-built plant drawings of the instrument will be made while incorporating the minor mechanical changes.

Acceptance tests were completed on four (of 12 total) portable, battery-operated, scintillation, poppy instruments.

Acceptance procedures for 0-200 mr self-reading pencil dosimeters were revised. Acceptance tests were started on 50 Bendix dosimeters.

Performance of the sensitive, gamma, Scintillation-Transistorized Monitor was checked in an airplane flight over the plant area. The unit performed satisfactorily with the conclusion, as known since the instrument was originally designed, that sensitivity can be increased by using a large NaI crystal in place of the 5 x 5-inch terphenyl-in-polyvinyltoluene detector presently used. The NaI substitution can be made directly at any time with no circuit changes. The only problem is that of cost of the NaI crystal.

Recommendations were made to the Critical Mass Physics Operation for specific instruments and an instrumentation philosophy different from those for production reactors, but suited to the needs of experimental critical assembly facilities.

Analog Computer

Consultation and aid in programming a chemical dissolver problem for the DDA was provided CRDO - HLO.

No customer work was completed on the Goodyear (GEDA) computer during November due to difficulties precipitated by moving the computer. It is now operable and a limited customer work schedule is possible.

Optics

Internal Diameter Micrometer for 105-C FEF - Design drawings are in the hands of Tech Shop estimators.

Scratch Depth Illuminator for 105-C FEF - Design drawings are being checked.

Infrared Radiation Ratio Pyrometer - A mounting was designed to support the pyrometer over the metallograph. A work order has been issued to Tech Shops for fabrication. Some electronic components have not yet been received. Installation of this unit will probably be delayed until early January.

Cave Periscope for Purex - Design drawings are in the hands of Tech Shops estimators.

Zyglo Detector - A work order has been received from E. H. O'Clair to demonstrate the feasibility of photoelectrically detecting defects in the internal bore of PRTR fuel elements.

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Chemical Research and Development

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATIONS PROCESSES

Decontamination of Reactor Components

Variations in decontamination and corrosion of stainless and carbon steel as a function of concentration of Wyandotte 75 and Wyandotte 1112, typical proprietary bisulfate-based cleaners, were studied. Using coupons contaminated with activated corrosion products and using the standard caustic-permanganate pretreatment, the cleaner concentration could be reduced from a normal value of 90 g/l to about 9 g/l without impairing decontamination of carbon steel. Carbon steel corrosion rates, however, remained undesirably high. Decontamination of stainless steel was adversely affected when the cleaner concentration was decreased below 20 g/l because of the failure of the cleaner to descale at the lower concentrations.

Corrosion tests of type A-246 carbon steel in Wyandotte 1112 indicate that the increase in corrosion due to dissolved iron will be negligible at the expected (0.005 molar or less) concentrations.

Uranium Oxidation and Fission Product Volatility

The 292-T Facility project was closed with some exceptions which were necessary to permit shakedown testing. Several problems which developed in the induction heater and lead configuration were resolved. Other items including disposal casks and dissolving equipment were made available.

First beneficial use was obtained on November 10 when a meltdown test was performed on an unirradiated, 4-inch long normal Hanford fuel element. The meltdown was conducted in the presence of a Zircaloy process tube. This test was made to determine the extent of zirconium-uranium reaction and mode of melting in a full scale piece. Motion pictures were made. Metallographic results are not yet available.

Fission product release tests will begin in the new facility in December after preliminary oxidation tests using unirradiated metal have been made.

Effluent Decontamination

Initial experiments with NPR decontamination wastes indicated that the reduction of potassium permanganate was accompanied by precipitation and that Sr and Co ions were effectively removed from solution, presumably by a scavenging action. Alkaline permanganate is almost certain to be used in the second step of the NPR decontamination process. Mixing the permanganate waste with solutions from the other two steps resulted in scavenging decontamination factors between 1×10^2 and 5×10^3 for Co. The possible utilization of this favorable scavenging reaction has led to plans for related experiments with other radionuclides and a postponement of experiments on soil reactions with waste solutions.

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Analytical Services

Iodine-131 and Xe^{133} comparative analyses in helium samples from the 100-DR gas loop were made by gamma ray spectrometry to check for slug ruptures. Gas samples were accurately bled through caustic solution for collecting iodine, or activated charcoal for collecting xenon.

A modified gravimetric procedure was used to determine 11.0 per cent silicon in an ingot of AlSi to confirm a control analysis that a recently arrived shipment was out of specification. Preliminary caustic dissolution resulted in the methods having about a 2 per cent error.

The first mass spectrographic isotopic data were obtained since calibration with the Th^{230} standard. Those data agreed with alpha and total thorium data previously used to estimate the Th^{230}/Th^{232} ratio. Also, further studies of lanthanum fluoride carrying and ion exchange behavior of thorium were made. Thorium was quantitatively precipitated and carried, with lanthanum fluoride, from typical samples. Oxidants, potassium dichromate and potassium chlorate, caused no complication. Oxidants were used to take uranium to the hexavalent oxidation state and hold it there. Many of the solid samples were treated with nitric-hydrofluoric acid mixture to extract thorium. The extract was then treated with boric acid to tie up the fluoride. Thorium was recovered from that solution with Dowex-1 in 95 per cent yield without prior removal of boron or fluoride compounds.

SEPARATION PROCESSES

HA Column Studies

The flooding capacity of a 3-inch-diameter HA extraction column containing stainless steel nozzle plates (3/16-inch holes) was determined using a 27 C, 0.05 M HNO_3 aqueous solution and 30 per cent TBP organic. With a pulse amplitude of 1.1 inches and an L/V of 0.17, the column flooded at a pulse frequency of 95 to 100 cycles per minute at a total throughput of 1450 gal/hr/sq ft.

Analysis of Purex Samples

Continued slightly sub-standard decontamination performance in the Purex plant has prompted additional analyses of Purex plant streams. The analytical data are not yet completed, but the data thus far obtained indicate decontamination factors over the final uranium cycle of 86, 400, and 480 for ruthenium, zirconium, and niobium, respectively. The low ruthenium decontamination factor is to be expected under the low acid conditions employed in the final uranium cycle.

The fission product activity in the uranium product (sampled November 17) was 43 per cent ruthenium, 49 per cent zirconium, and 8 per cent niobium.

Analyses of streams around the partition columns confirm the conclusion reached when similar analyses were performed in August. By comparison with past experience a major portion of the difficulty in securing adequate decontamination of uranium arises from the fact that zirconium is tending to follow uranium to a much greater

extent than formerly. Adjustments which have been made to force neptunium to follow uranium in the partition columns are in part responsible for this. However, the presence of organic-favoring solids is also suspected.

Processing of Irradiated Neptunium

Preliminary studies of radiolysis effects in plutonium-238 bearing systems indicate no severe problems in processing irradiated neptunium by TBP solvent extraction methods in the Hot Semiworks.

Dealkylation of TBP results in formation of "non-strippable" plutonium at a rate of 0.8 to 1.0 per cent per hour. This corresponds to formation of DBP at a rate of about 0.018 grams $hour^{-1}$ $liter^{-1}$ in 30 per cent TBP containing 1 g/l plutonium-238.

In a system containing 1 g/l plutonium-238, 2 M HNO_3, 0.1 M ferrous sulfamate, and 30 per cent TBP in Shell E 2342, ferrous ion was oxidized at a rate of about 2.7×10^{-3} moles $hour^{-1}$ $liter^{-1}$. In the same system sulfamic acid was hydrolyzed at a rate of about 1.7×10^{-3} moles $hour^{-1}$ $liter^{-1}$. The plutonium distribution coefficient (organic/aqueous) increased from 0.06 to 0.125 in a period of 6 hours but had attained a value of 22 at the end of 12.5 hours.

"G values" (molecules per 100 ev absorbed) computed from these data are as follows:

For Conversion of TBP to DBP	- 0.3 to 0.35
For Conversion of Fe(II) to Fe(III)	- 12.0
For Hydrolysis of Sulfamic Acid	- 7.5

One precaution pinpointed by these studies is the desirability of using a fairly high acid reducing strip to recover difficultly stripped plutonium-238. Current proposals for processing irradiated neptunium envision that the conventional low acid stripping column will be backed up by a second strip column in which a reducing strip will be used to recover "non-strippable" plutonium-238. In testing such a supplementary stripping operation it was found that plutonium stripping is more efficient at 0.85 and 3 M HNO_3 than at 0.1 M HNO_3. Plutonium-238 distribution ratios out of 0.1 molar ferrous sulfamate into radiation-damaged 30 per cent TBP were 0.3 to 0.9 at 0.1 M HNO_3 but only 0.025 at 0.85 M HNO_3, and 0.03 at 3 M HNO_3. Thus it is probable that the back up strip column (the 1F column) would have to employ 1 to 3 M HNO_3 in order to function efficiently.

Analytical Services

Forty-four samples of filter paper through which air had been drawn were submitted by Atmospheric Physics for the analysis of Zn as ZnS down to 10^{-8}g. Activation analysis was used for the measurements. The 1.12 Mev photopeak of 245-day Zn^{65} was used to determine quantities present.

Controlled potential coulometry was extended to the determination of uranium in the 0.025 to 0.1 g/l concentration to provide greater precision (± 3 per cent) than other conventional applicable methods. Segregation of cells for high and

low level U solutions and use of a cell with a bottom drain and top mounted stirrer having blades partially submerged in the mercury electrode gave the stability, reproducibility and cleaning efficiency required for titration in the above U concentration range. Research personnel are starting investigations to circumvent the lengthy (30 minutes) titration period.

WASTE TREATMENT

Semiworks Waste Calciner Prototype

Operation of the fluid-bed calciner was continued using simulated ICPP waste. Seven runs were completed during the month. In general, equipment performance was satisfactory. Nozzle pluggage and particle agglomeration were negligible. The major problems encountered were excessive attrition with resulting excessive fines carryover and a gradual reduction of bed volume during the course of a run. A modified fluidizing gas distributor (four 0.0312-inch holes in each bubble cap compared to four 0.0760-inch holes in each cap of the previous distributor) was installed and improved fluidization with less slugging. However, for comparable fluidizing gas flows, the attrition rates were somewhat increased.

Batch Waste Calcination

Four laboratory-scale runs were completed calcining Purex high-level wastes in a heated, unagitated, 3-inch-diameter pot at a feed rate sufficient to maintain some concentrated solution in the pot. The pot was subsequently fired to a final internal temperature of 800 to 900 C. The simulated wastes used in the studies contained iron, chromium, nickel aluminum, sodium, and varying amounts of acid, sulfate, and nitrate.

The behavior during calcination and the final appearance of the solids is apparently dependent upon the relative acid, nitrate, and sulfate concentrations. At sulfate to salt nitrate (total nitrate concentration minus acid concentration) ratios of 1.5, a melt formed at about 750 C; although some difficulty was encountered from solids coating the pot wall and reducing the effective pot diameter. With ratios of 0.5 and -1.5, no melts were formed at temperatures up to 940 C. At negative values of the ratio, the solids remained mobile, however, a slurry temperature above 150 C was required to prevent excessive foaming. Also, only SO_3 fumes were evolved during firing, and the solids pulled away from the pot wall upon cooling.

Pot corrosion was negligible in all of the studies. Thermal conductivity measurements of the various solids are planned.

Waste Solidification

Because of current interest in possible neutralized interim storage of Purex waste, which implies calcination of a neutralized slurry, additional measurements have been made of the extent of leaching of cesium and strontium from such a calcine. Earlier experiments (HW-57686) had shown that the short-lived beta and gamma activities (primarily ruthenium and rare earths) are leached to only a very slight degree (few tenths per cent maximum); however, the analytical methods

used were not sufficiently sensitive to define the behavior of the long-lived, but biologically significant, strontium and cesium. Measurements with cesium-only or strontium-only spikes were therefore made. Only 0.5 per cent of the strontium was leached from neutralized material calcined at 500 or 900 C. Cesium was much more soluble, 85 per cent leaching at 500 and 36 per cent at 900 C. (Per cent values have relative significance only.)

Observation Wells

Analyses of ground water samples from well 699-50-53, located 0.6 mile north of 200 East Area, showed beta-emitter concentrations of 1.8×10^{-4} uc/cc. This is about 10 per cent of the concentration now detected in wells at the 216-BY cribsite, the probable source of this contamination. The significant movement of waste to the north is probably due to the ground water overflowing low spots in the sub-surface basalt ridge north of 200 East Area. Movement of contaminants from this site toward the river should be deterred by the ground water mounds below B-Swamp and Gable Mountain Swamp.

Efforts to identify the source of contaminants in three wells located from 2 to 5 miles southeast of 200 East Area have not been successful. Probable sources are wastes that migrated to this locale from the 216-BY scavenged waste cribs in early 1956 or wastes discharged to the Purex 216-A-5, 8 and 24 cribs. Failure to find positive Ru^{103} concentrations in well water samples rich in Ru^{106} places the minimum age of the waste in this particular instance at about 1-1/2 years. Several wells scheduled to be drilled within the next year are expected to assist in determining the source of this ground water contamination.

Disposal to Ground

Soil column tests were completed on the D-2 waste going to the 216-S-7 crib. The average limiting Sr breakthrough for three columns, as found by extrapolation on logarithmic probability plots, was found to be 50 column volumes. Limiting breakthrough for Cs^{137} was found to be 123 column volumes. The waste to this crib to date has been about 7 column volumes and averages about 1 column volume per year. The long life expectancy of this crib can be attributed to the low salt content of the waste, caustic neutralization, and the high exchange capacity of the soil in this area.

Data relating to concentrations of cyanide ion in ground water at the 216-BY cribsite were communicated to Industrial Hygiene for possible toxicological evaluation. Only one well, E-299-E33-12, showed a free cyanide ion concentration greater than the analytical detection limit of 0.4 ppm. The CN^- concentration in this instance was 2.2 ppm. Several nearby wells contained combined cyanide, probably as the ferrocyanide ion; the maximum concentration being 6.0 ppm.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Fission Product Isolation and Packaging Prototype

The equipment necessary to determine the effects of operating variables on the entrainment and volatilization of cesium from the hydrolyzer was installed. The

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variables which are expected to affect the performance of the hydrolyzer are (1) evaporation rate, (2) rotor wall temperature, (3) gas velocity, (4) reaction zone temperature, (5) rotating speed and,(6) mode of feed injection.

One exploratory run at about 40 per cent of the design evaporation capacity was made in the hydrolyzer. The solids yield, i.e., solids discharged from the product end of the hydrolyzer, was greater than 90 per cent. The condensate showed a trace of white solids while the noncondensible off-gas yielded about 0.05 per cent cesium. A material balance will be completed when the cesium analyses of the condensate are available. Although additional efforts will be made to further reduce entrainment, the solid yield obtained in the above run is considered adequate since a large fraction of the entrained solids would be scrubbed from the off-gas stream and returned to the hydrolyzer as recycle.

Strontium Recovery

Further studies have been made aimed at recovery of strontium from 1WW via sulfate precipitation in the Purex head-end equipment. It was reported last month that precipitation of 80 per cent of the strontium can be achieved in the rare earth double-sulfate strike by increasing the sulfate concentration to three molar. It has been subsequently found, however, that some of the iron is also precipitated (as ferric sulfate) and that gross amounts form on prolonged digestion or on standing. This iron precipitate is a hard crystalline material which would overload the centrifuge, plug pipes, and render the process inoperable. Two ways have been found to avoid this difficulty. One involves the use of tartrate to complex the iron and hold it in solution, the other utilizes carrier to give good strontium recovery at low (one molar) sulfate concentrations.

An integrated test was made to determine the effect of the tartrate addition on cerium and promethium recovery. This was followed by a peroxy-acetate strike to define the path of strontium in the latter operation. The 1WW (0.5 M Fe) was made 0.25 molar in tartaric acid, adjusted to three molar in total sulfate, neutralized to pH 0.5, and digested at ca. 90 C. Ninety-seven per cent of the cerium and promethium and at least 75 per cent of the strontium were precipitated. In the subsequent peroxy-acetate step, all of the strontium followed the trivalent rare earths. This split of strontium with the trivalent rare earths is further corroborated by analytical results of the October plant test.

In other experiments, it was found that 0.02 molar lead, barium, cerium, neodymium, lanthanum, or didymium carrier precipitated about 80 per cent of the strontium from 1WW at one molar sulfate and pH 0. These solutions are stable with respect to iron precipitation and do not require tartrate addition. Calcium was ineffective as a carrier, and added strontium decreased the fraction precipitated. From the results to date, it is apparent that strontium can be recovered from current Purex 1WW by several schemes which do not involve precipitating the iron. The choice between these is largely dependent on the product mix which is desired and on complications which certain carriers may cause in subsequent processing.

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ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Scintillating Glasses

Studies of the gamma scintillation properties of special glasses have been made elsewhere (Dr. H. P. Hood of Corning Glass Works and Dr. R. J. Ginther of the U. S. Naval Research Laboratory). Samples of the most promising glasses have been obtained from these two scientists for testing at Hanford in alpha counting applications. Of particular interest are a cerium activated Vycor and a low-silica, cerium activated magnesium, aluminum, lithium-silicate glass. The alpha and beta responses of these glasses have been tested and the alpha pulse efficiencies are 1.7 and 5.0 per cent, respectively, relative to ZnS(Ag). Both glasses yielded about a 25 per cent alpha to beta response relative to ZnS(Ag). Despite this inferiority to ZnS(Ag) the alpha response will be suitable for some applications. Since the glasses can be expected to have relatively good chemical resistivity in solutions they will be tested for their applicability to solution contact alpha counting, especially for in-line analysis applications.

Automatic Controlled Potential Coulometer

The original controlled potential coulometer developed at Idaho Falls with simplifications suggested by ORNL personnel has been modified to reduce instability in the low ranges. In addition, the complete sequence of operations for plutonium or uranium titrations has been programmed to permit automatic operation. The full-scale range of the instrument is adjustable (switching) from 5×10^{-5} to 1×10^{-6} moles, and the accuracy and precision obtained by the earlier Hanford models (± 0.05 per cent σ at high levels to ± 0.3 per cent σ at low levels) has been retained. One instrument is in continuous use at present and two more are being built.

EQUIPMENT AND MATERIALS

"Triple-Threat" Deepwell Turbine Pump

The Johnston deepwell turbine pump which had been previously modified (i.e., holes drilled in the impeller housings) to permit its use as a combination pump-agitator has been further modified to permit it to supply a small side stream for a sampler or in-line monitor. A 1/4-inch sampling line was connected to a hole drilled in the impellor housing. With the pump installation employed, a side stream flow of 2100 ml/min was delivered at a discharge pressure of 9 p.s.i.g.

Hollow Shaft Agitator

Testing has continued on the 10 hp, 300 rpm, hollow-shaft motor, agitator assembly designed for use in either the Redox or Purex plants. Testing has been successfully completed on 3 shaft lengths of interest -- 9 feet 2 inches, 10 feet 2 inches, and 15 feet 5-1/2 inches. Agitation with the various shaft lengths and various paddle immersion depths has been smooth and steady, and no critical speed difficulties have been encountered.

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Non-Metallic Materials Testing

A glove port ring from the Purex plant was tested by static immersion at room temperature in the solutions normally used for transparent sheet glove box materials. The ring is reported by the vendor to be made from Tennite II, a cellulose acetate butyrate polymer produced by the Tennessee Eastman Company. This plastic failed after 28 days in 20 per cent nitric acid, after 7 days in 30 per cent nitric acid, and after 7 days in the vapor above 48 per cent HF. Failure occurred after 24 hours in trichlorethylene. The material was noted to darken or yellow in 10 per cent nitric acid, a saturated solution of oxalic acid, and potassium permanganate. Swelling of 10 per cent in perchlorethylene and 20 per cent in both carbon tetrachloride and Recuplex CAX was observed. Lucite, or Plexiglas, for which this material is a substitute, is unaffected by 28 days in 30 per cent nitric acid, swells 20 per cent in trichlorethylene, and 5 to 8 per cent in the vapor above 48 per cent HF. Lucite is substantially unaffected by the other solutions reported in the Tennite II test.

A transparent laminate of Lucite and Teslar which was prepared by the duPont Company Development Laboratory was tested for use as a hood panel material. In only 3 solutions were any effects noted. Recuplex CAX softened the Lucite, trichlorethylene dissolved the Lucite but both solutions left the Teslar unchanged. Potassium permanganate stained both plastics and caused a slight delamination around the edges of the sample. This effect extended in about 1/32-inch from the edge.

Effect of Air Sparging on Corrosivity of Redox H-4 Oxidizer Solution

Samples of 304-L stainless steel were exposed to synthetic Redox H-4 oxidizer solution (1.5 M UNH-0.1 M HNO_3-0.1 M $Na_2Cr_2O_7$) at its atmospheric boiling point. One sample was exposed in the bubble stream from an air sparger, one was exposed in the bulk solution being air sparged, and two were exposed in unsparged solution. No significant differences in corrosion rate have been observed throughout a total exposure of about 670 hours. It appears that the corrosivity of this solution is not affected by air sparging.

Corrosivity of Purex EH-4 Back Cycle Concentrator Solutions

Samples of 304-L stainless steel exposed to boiling synthetic EH-4 solutions (5-10 M HNO_3-0.4 M UNH-0.15 M H_2SO_4-0.22 M $Fe_2(SO_4)_3$-0.16 M Cr(VI) - 0.003 M Ni-0.003 M Si) exhibited corrosion rates ranging from 12 to 18 mils/month. Corrosion rates of 304-L stainless steel in these solutions at 5 and 10 M HNO_3 were not significantly altered by decreases in the iron(III) sulfate concentration from 0.22 to 0.005 molar. It is believed that Cr(VI) is the principal contributor to the high corrosion rates observed in these solutions.

PROCESS CONTROL DEVELOPMENT

Purex HSP Photometer

Shortly after the light photometer was installed on the Purex HSP sample stream, aqueous flush solutions of extremely high radiation intensity were inadvertently

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passed through the HSP sampling system. Following this incident the photometer functioned as if the sample cell was opaque to the source light, perhaps due to some foreign material lodged in the sample cell. Therefore, the filter shifting mechanism was removed from the sample cell and the cell and filter assembly visually examined. The viewing windows, while made of radiation resistant glass, had every appearance of being discolored by the radiation. The windows were dark amber in color, probably accounting for the apparent opaqueness of the optical system. The light filters, which are approximately 1-inch from the sample solution were darkened slightly but otherwise unaffected. A replacement sample cell with new filters is being assembled and will be installed as soon as scheduling permits.

Purex 2BP Alpha Detector

A Teflon coated zinc sulfide phosphor used in the Purex 2BP stream performed satisfactorily for 22 months. Failure after this length of service was due to ruptures in the 1/4 mil Teflon protective film. A new phosphor of similar design was installed and is operating satisfactorily.

Ultra Sonic - Resin Level Detector

An uncanned zirconate crystal operating at a frequency of 2.25 megacycles has performed satisfactorily in measuring resin level in a laboratory column. This crystal is not subject to ringing at distances greater than 3-inches. The instrument has been calibrated for 2 ranges, 0 to 2 feet and 0 to 10 feet.

UO_3 Plant Calciner Automation

The intermediate step in power level incorporated in the shutdown cycle of the calciner programmer did not give a satisfactory rate of shell temperature decrease. Thus, the programmer was again modified so that the shutdown cycle is now approximately a mirror image in time of the startup cycle. The feed however, is cut off on shutdown immediately after the power decreases to 50 per cent of full load, whereas on startup the feed comes on at 15 per cent of full power level.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Head-End Studies

Hacksaw Testing. Hacksaw testing to demonstrate fuels hardware cutoff continued with the operation of 2 types of saws: the "dual-feed" Marvel* saw and the simpler, less costly Peerless** saw. Thin-wall tubes and rod bundles with springs were sawed in the tests, to simulate hardware removal operations for the City of Piqua and Dresden fuels, respectively. Test highlights include the following:

*Armstrong-Blum Company, Chicago, Illinois
**Peerless Machine Company, Racine, Wisconsin

1. Using either saw one rugged "weld-edge" (two piece) blade may be expected to remove the end hardware from fuel elements containing at least a ton of uranium. This estimate assumes that rod bundles will be sawed through at massive end plate sections rather than through unsupported rod sections. Blade cost is approximately $3.

2. Since "weld-edge" blade life is equal for either saw, the Peerless saw (or equal) can be used to reduce equipment costs in the cell. Furthermore, preliminary results show that both median cutting speeds (100 strokes/min) and feed pressures (100 to 200 pounds) are suitable for hardware cutoff. Hence, control accessories for the NPF saw may be reduced to the bare minimum: on-off pushbutton and blade tension devices.

3. "Weld-edge" blade imperfections in "as-received" blades (indicated by porosity, cracks, and poor weld bonds revealed in radiographic and dye penetrant tests) have negligible effect on blade life.

4. Blade life and cladding-wall integrity cannot be guaranteed when cutting unsupported rods. Hence, cutting through end plates on both Yankee and Dresden (or similar) fuels is recommended. Potting techniques or shims are required for successful rod bundle cuts.

In future hacksaw tests, a third type of saw, the Racine hydraulic-feed hacksaw, will be compared with the two types previously tested.

Yankee Fuel Element Disassembly. Knife and sabre-saw cutting of thin stainless steel bands, such as those used to hold the subassemblies of the Yankee fuel together, was attempted in scouting studies of Yankee bundle disassembly methods. Some knife jamming occurred because of band movement during the cutting operation. A "weld-edge" sabre-saw was successful in band cutting, but excessive blade vibration occurred with cuts made deep within a bundle (i.e., 6 to 7 inches). Damage to cladding walls and exposure of rod core materials could be caused by the vibration. Slitting saws and hacksaws will be used in future band-cutting tests.

Shear Basin Clarification Studies. Fines generation tests were made while shearing unclad sintered UO_2 pellets under water. Slurried fines generated in each test amounted to less than 1 per cent of the material processed. All these fines were less than 200 mesh. Similar testing is contemplated for clad pellets, some of which will be thermally cycled prior to shearing to simulate reactor operating effects.

Hydroclone tests were started on a 1-1/2-inch-diameter unit. Removal efficiencies as high as 50 per cent have been achieved using a fine lead oxide powder slurry as a stand-in for UO_2 slurries. A concentration factor (underflow concentration/overflow concentration) of 25 has been achieved at an overflow to underflow volume ratio of 80 and a 25 per cent removal efficiency.

Feed Preparation

Zirflex Process. Two batch Zirflex dissolutions were made this month in the blanked off reservoir of the recirculating tube dissolver. In both runs, condensate from the dissolver off-gases was routed to another vessel for metering, and a constant dissolver solution volume was maintained by incremental water addition.

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In the first run, 1.75-inch ID by 8-foot long 55 mil Zircaloy tubing was dissolved in 6 M NH_4F - 0.55 M NH_4NO_3 using a F/Zr mole charge ratio of 7. An average boil-up rate of 0.132 lb mole/hr/sq ft was maintained throughout the dissolution to remove ammonia. A maximum dissolution rate of 60 mils/hour and an integrated dissolution rate of 15 mils/hour was obtained.

In the second run, metal was dissolved from the annuli of simulated NPR elements, using a 5.5 M NH_4F - 0.5 M NH_4NO_3 solution with an F/Zr mole charge ratio of 7. The 3-foot-long elements consisted of 1.1-inch OD, Zircaloy-2 clad, uranium rod encircled by a 1.62-inch ID, Zircaloy-2 tube coated on the outside with a PVA-PVC plastic. Thus, only the surfaces of the 0.26-inch cylindrical annuli were exposed to the dissolvent. An average boil-up rate of 0.528 lb mole/hr/sq ft was used. A maximum dissolution rate of 63 mils/hour and an integrated dissolution rate of $\geq$15 mils/hour was obtained.

The heat of reaction for the Zirflex dissolution of Zircaloy-2 was determined by a heat balance for the second run described above to be about -140 K Cal/mole. This compares well with a theoretical estimate of -178 K Cal/mole.

Sulfex Process. One Sulfex run made under nonrecirculating conditions resulted in a penetration rate of 304-L stainless steel of 3 to 4 mils/hour with 2.5 M H_2SO_4. Average hydrogen evolution as measured by the off-gas monitor was 0.03 scfm/sq ft of stainless steel exposed to the dissolver solution.

In 4 M H_2SO_4, 347 stainless steel dissolved uniformly with an average penetration rate of 12 mils/hour. Under similar conditions, comparable penetration rates have been experienced previously with 304-L stainless steel. Hydrogen evolution during the run varied from 0.05-0.07 scfm/sq ft of stainless steel.

Further studies of electrolytic cathodic depassivation of 304-L stainless steel in dilute sulfuric acid were made with a carbon anode - passive 304-L cathode separation of 1.5-inches. Consultation with CPD personnel indicates an electrode spacing of 1.5-inches is feasible in proposed plant-scale dissolving equipment. At this electrode spacing and in nitrate-free boiling 4 M H_2SO_4, passive 304-L stainless steel may be depassivated by application of a potential of 1.5 volts for about 30 seconds. Depassivation may be accomplished in about 30 seconds, even in the presence of as much as 0.05 M nitrate provided the cathodic potential is increased to 4-5 volts. At 0.1 M nitrate, however, the steel repassivated within a few minutes when the applied 4-5 volt potential was removed.

Attempts to depassivate 304-L stainless steel by making it the anode (anodic depassivation) in an electrolytic cell met with failure. The steel dissolved rapidly as long as potential was applied but was passive in boiling 4 M H_2SO_4 when the potential was removed.

Dissolution of U-Mo Alloys. Various cations and anions were tested for their ability to complex molybdate ion formed during nitric acid dissolution of U-3 w/o Mo-0.2 w/o Al alloy. None of the cations tested -- Mn(II), Cr(III), Ni(II) and Co(II) -- appeared to complex molybdate ion to any extent. Phosphate ion at 0.05 to 0.2 M was found, as expected, to be effective in complexing molybdate ion.

At 0.2 M H_3PO_4 stable solutions of the composition 1.1 M U - 1.1 M HNO_3 can be prepared from U-3 w/o Mo alloy. In comparison dissolution to the same terminal uranium and acid concentrations with iron(III) as the molybdate ion complexant requires that the iron concentration be about 0.75 molar. Arsenate ion was also found to complex molybdate ion but not as effectively as phosphate ion. Yellow solids presumed to be uranyl molybdate precipitated when U-Mo alloy solutions containing 0.05-0.2 M H_3PO_4 or 0.1 M Na_2HAsO_4 were neutralized to acidities below one molar with either DIBAN or caustic.

Dissolution of U-3 w/o Mo-0.2 w/o Al alloy in solutions initially 12-15.5 M HNO_3 to yield dissolver solutions containing 1.0-1.5 M U and 4-8 M HNO_3 resulted in precipitation of about 80-90 per cent of the molybdenum. Under these conditions molybdenum is precipitated as a white solid tentatively identified as hydrated MoO_3. Such white solids were not obtained when the dissolvent was initially $\geq$11 M HNO_3. The white solids, after washing with water and 1 M HNO_3 and drying, contained about 57 w/o Mo and only 0.07 w/o U. These results are in agreement with results obtained at ORNL in dissolution of U-10 w/o Mo alloy.

Further studies on the re-dissolution of solids formed through use of off-standard procedures in iron(III) nitrate-nitric acid dissolution of U-Mo alloys were made. In all cases it was necessary to increase the dissolver solution acidity to 3.5-4.5 M HNO_3 to obtain complete re-dissolution of solids in 10 to 60 minutes. These results are in agreement with findings reported last month.

Flooded Tray Dissolver. Fourteen runs made in the period from July through October, 1959, were analyzed for dissolution rate data. All were recirculation runs in which uranium slugs were dissolved in nitric acid-uranyl nitrate. Over the range 2.5 to 13 M total nitrate, the data are correlated by the expression: Penetration rate (mils per hour) = (0.03 ± 0.01) (total nitrate M)$^{2.7}$. The penetration rates experienced in the recirculating dissolver generally were essentially identical with those that would be predicted for a single tank batch system.

Glass Column Hydraulic Studies. Hydraulic runs have been completed using UO_2 pellets and 3 to 8 mesh crushed UO_2. Current runs are being made on 8 to 100 mesh crushed UO_2. It has been significant that during the current series of runs on finely divided UO_2, no foaming problems have developed. On a previous series of runs with finely divided UO_2, serious foaming was experienced which was attributed to oil suspension in the sparge air. Current experience lends weight to this conclusion.

Materials of Construction

The corrosivity of spent Sulfex decladding solution to 304-L stainless steel was investigated. It was established that simple boiling of Sulfex decladding solution is not sufficient to assure a solution which may be contained in 304-L equipment. In other experiments, freshly prepared solutions of the composition 4 M H_2SO_4-25 g/l stainless steel were air sparged at 75 and 108 C (boiling) for 20, 40, and 90 minutes. Corrosion rates of 304-L in the resulting solutions were less than or equal to one mil/mo at 70 C. However, corrosion rates in these solutions increased to about one mil/hr when 304-L specimens were activated by contact with mild steel.

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Corrosion rates of 304-L stainless steel at 70 C in simulated Sulfex process solutions of the composition 4 M H_2SO_4 - 5-15 g/l stainless steel - 0.5-5 g/l Fe(III) added as $Fe_2(SO_4)_3$ were less than or equal to 1 mil/mo. At boiling temperature, similar solutions containing 0.5 g/l Fe(III) corroded 304-L at rates of about 1 mil/hr; attack was slight at higher Fe(III) concentrations. Corrosion rates at the boiling point and at 70 C were greatly increased when specimens were activated by contact with mild steel.

Simulated spent Sulfex decladding solutions containing 0.5-5 g/l Fe(III) added as $Fe(NO_3)_3$ were only mildly corrosive to 304-L stainless steel at both 70 C and the boiling point. In these solutions 304-L specimens were not activated by contact with mild steel. Similar results were obtained with decladding solutions containing 0.1-0.5 M HNO_3.

One or more Zirflex-type dissolutions in the 321 Building titanium dissolver are being considered. Corrosion rates of titanium in Zirflex solutions were markedly reduced in the presence of 0.1 M Cr(VI) and 0.1 M citrate ion (as suggested by ORNL personnel). However, corrosion rates were still high in the inhibited solutions, and some preferential attack occurred at the solution-vapor interface. Weldments have not been evaluated.

One pound samples of the 12 heats of nickel base alloys made at Battelle Memorial Institute under contract DDR-82 have been received. Corrosion testing of these alloys as both base and weld metal has been initiated.

Criticality Studies - Materials Preparation

The feed material for the seventh PCTR experiment to measure K_∞ (H/U atomic ratio of 44) using 3 per cent U-235 enriched uranium trioxide was prepared and delivered. The shipment consisted of approximately 200 pounds of polyethylene-moderated uranium trioxide.

The feed materials for 3 exponential experiments were also prepared and delivered. These 3 shipments also consisted of polyethylene-moderated 3 per cent U-235 enriched uranium trioxide of approximately 125 pounds each at H/U atomic ratios of 4, 6, and 12, respectively.

REACTOR DEVELOPMENT - 4000 PROGRAM

Preparation of UO_2 by Electrolytic Reduction

The surface area of typical uranium dioxide prepared by electrolytic reduction of uranyl chloride in molten NaCl-KCl was reported to be less than 0.01 m^2/g, as determined by the B.E.T. method. This finding, together with particle density measurements, indicates that UO_2 prepared by the electrolytic method is virtually non-porous.

Salt Cycle Process

An alternate method conceived for processing of mixed uranium-plutonium oxides employs anhydrous hydrogen chloride to effect simultaneous dissolution of uranium

and plutonium. Under these conditions the uranium dissolves in molten NaCl-KCl as U(IV), the plutonium presumably as Pu(III). Separation of uranium and plutonium would be effected by sparging with air, precipitating plutonium as PuO_2 and converting U(IV) to soluble UO_2^{++}. Uranium dioxide would then be recovered from the uranyl-bearing melt by electrolytic reduction.

A preliminary experiment indicated this approach is probably feasible. A sample of mixed oxide (prepared by calcination of an ammonium diuranate-plutonium hydroxide precipitate) was partially dissolved after 2 hours with HCl sparged into KCl-NaCl at 750 C. Analysis of the salt phase at this point indicated uranium dissolution was 90 per cent complete but only about 1/3 of the plutonium had dissolved. Sparging the salt solution with air for 30 minutes caused a precipitate to form and produced a supernatant with the characteristic reddish appearance of uranyl chloride. Analysis of the supernatant indicated no change in uranium content but showed that 84 per cent of the plutonium had precipitated.

Obviously, considerable development work remains on this approach but these results are considered to be quite encouraging as regards the possibility of processing irradiated uranium dioxide fuels by this technique.

In exploratory studies of potential pyrochemical decladding schemes for Zircaloy-clad UO_2 it was found that Zircaloy-2 dissolves in molten zinc chloride at 400 to 500 C or in molten $ZnCl_2$-KCl-NaCl at 450 C with the formation of zinc metal and a white solid phase. In the case of pure $ZnCl_2$ solvent the formation of a zirconium chloride-zinc chloride compound is suggested by the fact that dissolution of zirconium increased the melting point of the salt to greater than 450 C.

When a similar treatment was applied to a sample of Zircaloy-clad uranium dioxide both the zirconium and the uranium dissolved, again with formation of a white solid phase. It is suspected that uranium dioxide reacted with dissolved zirconium according to the reaction

$$ZrCl_4 + UO_2 \longrightarrow ZrO_2 + UCl_4.$$

In any event the possibility of zirconium cladding being present as a major impurity in the uranium and plutonium bearing salt phase in the Salt Cycle Process renders the decladding approach presently unattractive. Further work on decladding will emphasize that massive uranium dioxide can be converted to powdered U_3O_8 which hopefully can be separated from the cladding by mechanical means.

Aluminum Chloride-Alkali Chloride System

Distribution Studies. A continuation of the study of the distribution of uranium between aluminum and an aluminum-potassium chloride melt showed an increased extraction into the metal phase when potassium chloride is replaced by cesium chloride. Values for $D_U^{m/s}$ of about 150 and 5 were found at aluminum to cesium mole ratios of about 1 and 0.55, respectively.

The solubility of uranium appears to be very low in the cesium chloride system as compared to the lighter alkali metal halide systems. Further, a second liquid

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phase is formed as the uranium chloride solubility is exceeded. In preliminary experiments, the solubility of uranium trichloride in aluminum chloride-cesium chloride melts at 725 C is less than five grams of uranium per kilogram of salt where the aluminum to cesium mole ratio varies from 0.6 to 1.0.

Spectrophotometric Studies

Studies of the effect of composition on the visible and ultraviolet absorption spectra of molten UCl_4-$AlCl_3$-KCl have shown that with excess potassium chloride present, the spectrum is that of the hexa coordinated uranium ion, but as aluminum chloride is added, solubility drops and absorption at different wave lengths changes in relative intensity. With increasing temperature a general shift to longer wave lengths is observed for the absorption peaks, the magnitude being somewhat greater than expected.

In LiCl-KCl eutectic the uranium(IV) spectrum is entirely different than in the $AlCl_3$-KCl system, perhaps due to the strong competition for chloride ions exercised by the lithium ion.

It is concluded from these observations that in the $AlCl_3$-KCl system little complex formation occurs if aluminum chloride is in excess.

Continuous Ion Exchange Contactor Development - Jiggler Contactor

A qualitative demonstration run indicates a probability that a non-pulsed, non-fixed packed bed elution column may be paired with the jigged bed adsorber for continuous recycling of ion exchange resin. A simulated feed of 7 M HNO_3 was pumped through the adsorption section at 160 gal/hr/sq ft. Resin, with some feed, was moved from the bottom of the latter to the packed bed by pulsation. Resin from the elution section was returned by gravity flow to the top of the adsorption column.

Attempts to use a thorium-spiked simulated Recuplex feed and a 0.5 M HNO_3 eluant were erratic owing to difficulty in controlling the rate at which the resin was recycled. This may be explained on the basis of a changing ratio of resin to feed (slip liquid) which could be overcome if a means for maintaining a constant quantity of resin in the adsorption column can be found.

Analytical Services

Dissolution tests showed that the 9 M HCl + $Ni(NO_3)_2$ method developed for dissolving Al-Pu alloys was satisfactory for Al-Si-Pu alloys up to at least 12 per cent Si. The Pu occluded with the insoluble Si represented only ≤ 0.25 per cent of the total Pu--insignificant with respect to accuracy requirements.

X-ray spectrometry was used to identify cadmium as a major constituent on the surface of a "pip" pin, a holder for PRTR fuel rods.

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WASTE FIXATION

Radiant Heat Spray Calciner

The calcination of a neutralized waste simulating that in the Purex tank farm has been reported earlier. This waste contained a high concentration of sodium nitrate and required addition of sugar for successful calcination in the radiant heat spray calciner. A run was made this month to determine whether a neutralized formaldehyde-killed 1WW, such as would be produced if neutralized interim storage were adopted, could be calcined without the use of sugar. The only difficulty encountered was in atomizing the feed, which had been concentrated to 20 gal/ton and was a very thick slurry. This feed tended to plug an "interior mix" type nozzle but could be atomized with an aspirating-type nozzle. However, it still formed a deposit around the nozzle. These difficulties might well be alleviated by dilution. The product appears to be very low in nitrate and is probably a mixture of metal sulfates. It was relatively free from dust, had a particle size of seven microns (which compares favorably with powder produced from acid-side wastes), and had a density of 0.75 g/cc. On subsequent heating to 910 C, the powder contracted to a "clinker" but did not appear to become fluid.

Mineral Reactions

Satisfactory samples of Purex boiling tank condensate are now being obtained with a new pump installed on the 417 catch tank. The condensate has a cloudy appearance which is due to the presence of organic from the Na_2CO_3 organic wash. This organic passed through clinoptilolite columns at pH 5, 7, and 9, but deposited on the mineral at pH 3, partially plugging the column. Normal pH of the condensate is about 9.

Operation of the clinoptilolite column receiving tap water traced with Cs^{137} was resumed at higher flow rate. Column throughput was increased to 45,600 column volumes. A decontamination factor of 85 was attained at a flow rate of 6.3 gal/ft^2/min.

A literature survey was carried out on radiation effects on minerals and various materials. Much information is available on radiation damage to metals and ionic crystals, but little work has been reported on minerals and other materials of interest in waste fixation.

Fixation of Radioactive Wastes

The essential rejuvenation of and alterations of the CR In-Farm Scavenging Facility were completed. The installation of some of the experimental equipment was started. By the end of December, it is expected that a glass column and a scaled-up steel column will be set up and initial studies will be in progress.

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BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

Scientific papers titled, "Desirable New Geologic Research in Support of Radioactive Waste Disposal as Indicated by Hanford Experience," by R. E. Brown and "Movement of Radioactive Effluents in Natural Waters at Hanford," by J. F. Honstead, R. F. Foster, and W. H. Bierschenk were presented at the International Atomic Energy Agency Conference on Disposal of Radioactive Wastes, Monaco, November 16 - 21.

Field data obtained by geologic mapping in the Umtanum Ridge area were compared to those obtained from drilled wells near that ridge. Sediments directly overlying basalt in well 699-63-90 are probably correlative with the Ellensburg formation west of the Hanford region rather than with the Ringold formation. In this location sands and gravels of the Ringold formation are similar in appearance to presumed Ellensburg gravels. Additionally, a thin, now discontinuous basalt flow evidently once lay above the sediments in question in the well but was eroded during formation of the water gap between Gable Butte and Umtanum Ridge. The top of the topmost basalt flow is thus not necessarily the top of the Columbia River basalt series which includes these Ellensburg interbeds.

The Ellensburg sediments consist generally of finer and more poorly sorted materials than the recent glaciofluviatile gravels. Their effect on ground water movement and radioisotope behavior will differ from that of both the Ringold and glaciofluviatile sediments.

Two new equations for the rate of unsaturated moisture flow through soils were derived and tested with four soils. The equations are less empirical than those used in the past. Assumptions used for deriving one equation include that of movement in continuous, uniform capillary pores. For the other equation the assumption was made that water is moving over the surface of soil particles or that the pores are much wider in one direction. Results of experiments with four soils indicated that the actual conditions are somewhere between those assumed in the two equations. These studies will aid in understanding the mechanism of unsaturated flow and how best to define it mathematically.

Soil Chemistry and Geochemistry

Research on the calcite-fluorite reaction was continued with studies of the removal of U^{+6}, Ce^{+3}, and Sr^{+2} from solution. Uranyl ion removal was found to vary inversely with temperature, contrary to the behavior of Ce^{+3} and Sr^{+2}. It is postulated that UO_4^{-2} substitutes for CaF_4^{-2} in the resulting fluorite lattice. The oxygen is furnished by that dissolved in the influent solution. Dissolved oxygen varies inversely with solution temperature.

Ce^{+3}, on the other hand, can be included in the fluorite lattice by an omission, $2(CeF_3)$ for $3(CaF_2)$. Sr^{+2} can, of course, be included in a Ca^{+2} position with no lattice adjustments. Radioisotope removal data for the calcite-fluorite and calcite-phosphate reactions can be compared by the use of these methods.

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The results of laboratory equilibrium experiments in which 4.2×10^{-6} M Ce^{+3} was equilibrated with various sodium salt solutions indicated that both citrate and acetate anions complex with cerium and inhibit its removal from solution by a calcareous subsoil. The order of inhibition or complexing strength is 2 N citrate > 2 N acetate. The presence of oxalate ion, on the other hand, increased the removal of cerium from solution, probably by a scavenging action of precipitated calcium oxalate. Removal of cerium from solution was also increased by phosphate ions, apparently due to cerium phosphate precipitation.

Ground Waste Investigations

A technical paper titled, "A Review of Radioactive Waste Disposal to the Ground at Hanford," by D. W. Pearce, C. E. Linderoth, J. L. Nelson, and L. L. Ames, Jr. was presented at the International Atomic Energy Agency Conference on Disposal of Radioactive Wastes, Monaco, November 16 - 21.

The small experimental crib near Gable Mountain has now received 2900 gallons of calcium nitrate solution traced with Sr^{85}. All but one of the wells show nitrate breakthrough. Two of the wells show a small, erratic amount of Sr^{85}, but no significant breakthrough of Sr has been obtained.

Fifteen more wells have been driven for the purpose of obtaining a better definition of the shape of the liquid plume between the crib and ground water. The new neutron soil moisture probe was used in the study.

Laboratory soil column experiments indicated that the effect of column length on the slope of Sr breakthrough curves was greater where Mg was the complementary ion than where faster Sr breakthrough was obtained in the presence of Ca ions. A further series of column studies with Na as the accompanying ion was completed. Sr breakthrough was even slower in this case than with Mg. However, the degree of influence of column length on slope of Sr breakthrough curves was about the same as with the Mg-Sr system. These findings aid in understanding soil column relationships and in their mathematical description.

Field Apparatus Development

Measurement of moisture in soil using replaceable screen-wall thimbles showed that equilibrium was achieved in the thimble at virtually the same rate as in the soil. The presence of a second supporting screen, however, materially slows the approach to equilibrium. The application of the single-wall thimble is limited to moisture contents which allow the soil to be self-supporting when the thimble is removed.

Possible schemes which will permit more accurate neptunium monitoring were studied. Chelation with TTA and extraction on an anion exchange resin appear to be the simplest methods for possible application to an in-line system.

Ground water aquifer pumping tests were completed at the Gable Mountain test site. In 2 tests, each lasting 24 hours, the drawdown and recovery of water in all 13 wells in the pattern were measured. Subsequent 8-hour tests gave additional data on other wells in the pattern. Preliminary data evaluation indicated an aquifer transmissibility of about 4×10^5 gal/day/ft and a storage coefficient of about 0.06.

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Micromeritics

Several runs were completed, making a total of ten in the current series to measure particle deposition constants. Deposition on the walls of a 1-inch aluminum pipe, sectioned to permit direct examination of retained particles was measured. The deposition constant (deposition velocity) was found to be highly dependent on Reynolds number. At low Reynolds numbers (less than 6000) the deposition constant was markedly affected by surface roughness. Methods for characterizing surface roughness were examined. A stylus-type profilometer proved to be unsatisfactory due to scratches produced by the stylus in the aluminum.

Radioactivity in Foods

As a result of the finding by the Radiological Physics Operation shielded personnel counter than Zn^{65} was more commonly found in personnel than could be accounted for from local drinking water derived from the Columbia River, a survey of canned sea foods from local stores was undertaken. Of the 16 samples counted to date, nine contained amounts of Zn^{65} from 0.16 to 35 d/m/g. Only two contained greater than 0.7 d/m/g, and these were both oysters canned in the Pacific Northwest. This confirms previous data of Radiological Physics Operation which had counted oysters as the suspected source of Zn^{65}.

Pu^{241} Bioassay Procedure

The liquid scintillation bioassay procedure for Pu^{241} on samples already counted for Pu^{239} was tested and found to be capable of measuring as little as 5 d/m/sample with an overnight count.

Sr^{90} Analytical Procedure

An improved procedure for separating strontium from calcium was developed which is shorter and simpler and eliminates the fuming nitric acid usually used. In this procedure strontium and calcium are precipitated with ammonium carbonate which gives a more tractable precipitate than that produced using sodium carbonate. The precipitate is washed with water, then with acetone, and dried. Concentrated nitric acid is then added which metathesizes the calcium and strontium carbonates and precipitates the strontium as the nitrate. After washing with acetone and solution in water the strontium is reprecipitated as the carbonate. The radiochemical yield is greater than 82 per cent even in the presence of 100 times as much calcium as strontium.

ZnS Analytical Procedure

A program in support of the Meteorology Operation has resulted in an analytical procedure for ZnS particles on membrane filters containing other previously airborne particulate material. The membrane filter is dissolved in 3:1 ethyl

acetate-ethanol, exposed to a fluorescent light source for two minutes and the resulting emitted light from the ZnS counted 30 seconds later for 30 seconds by photomultiplier tube as in liquid scintillation counting. Although no effort has been made to optimize the sensitivity, samples containing as little as 3×10^{-8} g ZnS can be counted by this procedure which is adequate for the present problem. By counting a second time after adding a known amount of ZnS, correction can be made for any effect of dirt material present.

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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

Radioiodine Contamination

Concentrations of I^{131} in thyroid glands of jack rabbits were slightly lower than those observed one year ago. Values follow:

Location	µc/g Wet Wt. Average	µc/g Wet Wt. Maximum	Trend Factor
4 Miles S.W. Redox	2×10^{-3}	4×10^{-3}	-
Prosser Barricade	1×10^{-3}	2×10^{-3}	-
Wahluke Slope	1×10^{-3}	4×10^{-3}	+ 5

Columbia River Contamination

Concentrations of gross beta emitters in whitefish from F-1 averaged about the same as observed one year ago. The annual upstream migration of whitefish brought fish from the Hanford Reservation into the Priest Rapids Area. The average radioactive contamination in flesh was about 3 1/2 times those reported one year ago. Concentrations of beta emitters in waterfowl were about the same as those recorded last year.

Sample Type	Location	µc/g Wet Wt. Average	µc/g Wet Wt. Maximum
Whitefish Flesh	Priest Rapids	7×10^{-4}	4×10^{-3}
Whitefish Flesh	F-1	1×10^{-3}	4×10^{-3}
Whitefish Flesh	Ringold	2×10^{-4}	2×10^{-4}
Shorebird Flesh	Hanford Reservation	5×10^{-3}	6×10^{-3}
Coots Flesh	Hanford Reservation	2×10^{-3}	4×10^{-3}
Gull Flesh	Hanford Reservation	1×10^{-3}	3×10^{-3}
Grebe Flesh	Hanford Reservation	1×10^{-3}	4×10^{-3}
Merganser Flesh	Hanford Reservation	7×10^{-4}	1×10^{-3}
Heron Flesh	Hanford Reservation	6×10^{-4}	9×10^{-4}
River Duck Flesh	Hanford Reservation	1×10^{-4}	7×10^{-4}

C. columnaris held in Columbia River water showed a decrease of only 11% in 48 hours. A somewhat faster rate of death was noted during the succeeding three days with only 10 to 15% viable after 123 hours exposure. No difference was noted between the death rate in river water and in sanitary water.

Fallout Contamination

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

Sample Type	µc/g Wet Material Average	Trend Factor
Feces	2×10^{-5}	-
Bone	1×10^{-5}	- 6
Muscle	9×10^{-6}	-
Liver	6×10^{-6}	-

Swamp Contamination

Waterfowl collected at 221-U and Redox swamps contained slightly greater amounts of beta emitters in bone samples than those observed one year ago. Concentrations of fission products were as follow:

Sample Type	µc/g Wet Material Average
River Duck	
Bone	1×10^{-3}
Soft Parts	3×10^{-4}
Grebe	
Bone	1×10^{-4}
Soft Parts	3×10^{-5}
Coot	
Bone	3×10^{-4}
Soft Parts	3×10^{-4}

Effect of Reactor Effluent on Aquatic Organisms

Fall chinook salmon spawning observations were completed. A total of 281 nests were observed in the section of the Columbia River from Richland to Midway. This number is markedly lower than the count of 1485 for 1958 but appreciably more than the brood year (1955) count of 64. High and turbid water seriously impaired the enumeration of nests.

The routine monitoring test of effluent from the 100-KE reactor utilizing rainbow trout was concluded after a run of 22 weeks. Mortality was slightly increased even at an effluent concentration of 1 per cent although the sensitivity of the test was somewhat impaired by unusually high (30%) mortality among the controls.

Owing to the indications of adverse effects at the comparatively low effluent concentrations, a new monitoring test was started with chinook salmon which will simulate present and predicted concentrations in the Columbia as these fluctuate with seasonal changes in river flow and the migratory habits of the young salmon.

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Radiochemical analysis is not yet available on small suckers exposed to reactor effluent passed through a bed of aluminum turnings but gross beta counts suggest that the technique is effective in reducing contamination in fish.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Phosphorus

Exposure of cichlids (tropical fish) to P^{32} added to the water was continued through the month. No adverse effects are yet evident even in the highest level where the concentration in the fish amounts to about 3×10^{-2} μc/g. The fish have not yet reached maturity.

Strontium

Soils previously reported to have been surface contaminated with Sr^{90}, treated with phosphate, and cropped, were thoroughly mixed and recropped after mixing. Uptake of Sr^{90} from Cinebar soil was greater after mixing than before mixing the Sr^{90} with all the soil, but in neither case was there a significant effect from phosphate treatment. Uptake from Ephrata soil was reduced after mixing and there was better than 50% reduction of Sr^{90} uptake when very large amounts of phosphate were added. The ratio of Sr^{90} in stems vs. leaves was greater in plants grown on Ephrata soil. This suggests that Sr^{90} is less readily translocated in plants grown on alkaline as compared to acid soils.

Results from a number of experiments comparing the metabolism of Sr^{90} and Ca^{45} in rats are accumulating. While still incomplete, certain interesting indications can be drawn from the data. It appears that the mature animal's fecal excretion of intraperitoneally administered radioisotope is essentially the same for strontium and calcium and is not influenced by the calcium level in the diet. Urinary excretion of both elements, on the other hand, is influenced by the calcium level in the diet. The increment in urinary excretion occasioned by increased dietary calcium is about the same for both strontium and calcium; however, strontium excretion is high (approximately 1/3 of the injected dose) on the lowest calcium diets, while calcium excretion is negligible on very low calcium diets.

Discrimination between strontium and calcium is effected primarily in the process of absorption from the gastrointestinal tract. With increasing age (lowered calcium demand) and increasing calcium level in diets, the discrimination effected in the process of excretion via the kidneys becomes of increasing importance.

No significant biochemical or cellular changes in the blood have been observed in the adult miniature swine after seven months of feeding up to 25 μc/day of Sr^{90}. Six-week-old offspring from these swine, however, show a trend toward lower platelets, packed cell volume, hemoglobin and red-blood cell counts.

In addition, there is an indication that the pigs born to swine fed 25 μc/day weigh less both at birth and weaning and that there were fewer pigs per litter.

Iodine

Four young adult ewes were given a single oral dose of 1.25 mc of I^{131} and they will be sacrificed at 7, 15, 30 and 60 days after administration. With the sacrifice of these animals, the study on acute effects of radioiodine on the thyroid in sheep as a function of age will be completed.

Cesium

Plants grown in varying ratios of K/Cs showed little evidence of cesium toxicity, cesium carrier appeared to enhance slightly the uptake of Cs^{137} into bean plants.

Cerium-Praseodymium

Preliminary to a few oral administration studies, the distribution of Ce^{144}-Pr^{144} in the tissues of a ram 16 days after a single intravenous administration of 2 mc was determined. It appeared that the cerium was tightly bound in the tissues, since less than one per cent of the administered dose was eliminated in the urine during the experimental period.

Bone, liver, bulbourethral glands and spleen showed the highest concentration (5 to 10×10^5 per cent of administered dose per gram). Somewhat lower concentrations were observed in the skin, kidney, adrenals, lymph nodes and pituitary (1 to 5×10^5 per cent of administered dose per gram). Although these data are very preliminary, it was interesting to note the great variation in tissue concentration. The pituitary. for example, showed a concentration more than twenty times greater than the plasma and brain. During the 16-day period of the experiment, the white blood cell count of the ram dropped to one-half of the pre-exposure value.

Plutonium

In order to determine if there is any benefit or harm in the current practice of using tourniquets and snake-bite suction cups for contaminated wounds, a preliminary study was initiated in two pigs. Subcutaneous injections of Pu^{239} nitrate were made in the front limbs and the sites treated differently as to use of tourniquets and/or suction. Although difficulty was experienced in getting comparable concentrations at each injection site, some data as to transfer from the site may be gained.

Radioactive Particles

Current data on the accumulation of plutonium in the tracheobronchial lymph nodes in dogs after inhalation of plutonium oxide is given in Table 1.

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Table 1

Time after exposure	Ratio of the concentration of plutonium in tracheobronchial lymph nodes to that in lung
Immediately	0.001, 0.0001, 0.0003
One day	0.2, 0.0002
One week	0.16, 0.008
Two weeks	0.004, 0.14, 0.15
Ten weeks	3
Sixteen weeks	5, 3, 0.3, 11
Forty weeks	9, 88
Two and one-half years - (after I.T. administration)	21

The observed increase in the ratio of the plutonium concentration in lymph node to that in lung may result from several processes which include translocation of plutonium from lung to lymph node and more rapid clearance of plutonium from lung than from lymph node. The relative importance of these are under study to aid in the evaluation of the hazards from inhaled plutonium oxide.

Twenty-eight beagle dogs have been exposed to plutonium oxide for translocation and toxicity studies of up to three years duration. A total of 76 dogs will be exposed within the next three months.

Apparatus has been designed and assembled to study the effect of respiratory variables on deposition of plutonium oxide. Tests to find methods of hastening the clearance of Pu^{239} from lung will be continued after exposure equipment has been fabricated.

Skin Studies

A rapidly-growing mass was observed subcutaneously on a rabbit at a site exposed to 16,000 rads (from a P^{32} plaque) four years ago. A tumor is suspected and the mass has been biopsied. If this proves to be a tumor, it will be the first one (to our knowledge) described in a rabbit following irradiation of the skin. (Caution must be exercised in drawing any conclusions from one case.)

Gastrointestinal Radiation Injury

The radiomimetic drug, nitrogen mustard (HN_2), which is known to cause gastrointestinal lesions similar to those seen following X-irradiation, was studied for its effect on glucose absorption from the gut. Results after a sub-lethal dose of 1 mgm/kg and after a lethal dose of 2 mgm/kg were similar to those seen following lethal and sub-lethal X-ray doses, suggesting a similarity in the mechanisms for producing the effect.

Continued studies with I^{131} labelled polyvinylpyrrolidone (PVP) suggests the possible usefulness of this material as a diagnostic aid in the estimation of intestinal radiation injury. This synthetic serum albumin substitute is lost from the blood

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stream into the lumen of the intestine and is not hydrolyzed by enzymes there present. It has been used as a diagnostic tool for studying human gastrointestinal lesions. Our experiments with rats indicate that the normal loss of PVP into the intestinal tract is doubled after a 750 r whole-body exposure and quadrupled after exposure of the exteriorized intestine to 1,000 r. These results also suggest that the effect of radiation on serum protein levels may be explained by loss of these proteins into the intestinal tract, and that loss of synthesizing ability in the liver is not necessarily involved.

Tissue Transplantation for Radiation Therapy

An additional six Pitman-Moore miniature swine were exposed to 900 r of total-body X irradiation (LD/100). Two animals served as controls; the other irradiated animals were given either homologous adult marrow cells or fetal (110-day old) fetal spleen and liver cells at 72 hours post-irradiation. Careful handling and supportive treatment was extended all animals and included the furnishing of clean, dry quarters, administration of antibiotics and an increased feed ration. At 25 days after irradiation one of the two animals given fetal tissue is the only survivor. Although the animal is losing its hair, it appears otherwise quite normal and its blood picture is approaching normal. This, to our knowledge, is the first time a lethally irradiated pig has survived beyond two weeks following tissue transplant therapy.

Project Chariot

Approximately 100 samples of different kinds of plants, birds, and mammals from the site of the proposed harbor of Project Chariot have been analyzed for gamma emitters. Radioelements measured include Ce^{141}, Ce^{144}-Pr^{144}, Zr^{95}-Nb^{95}, Cs^{137}, Ru^{103}, Ru^{106}-Rh^{106}, Zn^{65}, Ba^{140}-La^{140}, and K^{40}. Significantly different levels of contamination which are attributed to ecological factors occurred in different species of organisms. Birds with highest values were the small longspurs and sparrows which feed upon insects and seeds and lowest values occurred in the aquatic forms. Among the plants highest values were in sedge, lichen and sphagnum moss; lowest values were in emergent weeds from ponds.

HA Kornberg
BIOLOGY OPERATION

HA Kornberg:es

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D. Lectures

a. Papers presented at Meetings

J. J. Davis, "The effects of environmental factors upon the accumulation of radioisotopes by ecological systems," November 13, 1959, Second Annual Texas Conference on the Utilization of Atomic Energy, Texas A & M, College Station, Texas.

b. Off-Site Seminars

W. J. Clarke, "Efficacy of tissue transplants in radiation therapy," exchange seminar, Washington State University, Pullman, Washington, 11/24/59.

R. F. Foster, "Discussion on Columnaris," Columbia River Advisory Group, Portland, Oregon, November 20, 1959.
* See below.

c. Seminars (Biology)

Dr. O. Biddulph, Department of Botany, Washington State University, Pullman, Wash., "Translocation in Plants," November 3, 1959.

E. J. Coleman, "Quantitative Autoradiography," November 4, 1959.

G. S. Vogt, "Methods of Tissue Staining for Electron Microscopy," November 4, 1959

G. R. Yesberger, "Incineration of Radioactive Wastes," November 18, 1959.

Dr. Sidney Marks, "A Summary of Data Relative to the Induction of Thyroid Tumors by Radiation," November 18, 1959.

d. Seminars (Local)

D. E. Warner, 10/9, 16, 23 and 30 to Hanford Laboratories Non-Exempt Orientation Program. "Radiobiology at Hanford"

D. E. Warner, "Radiobiology at Hanford," Central Stores personnel,11/17/59.

F. P. Hungate, "Genetic effects of radiation," 11/6, 13 and 20, IPD Information Meetings.

E. Publications

a. HW Publications (external distribution)
None

b. HW Publications (internal distribution)
None

c. Open Literature

Schiffman, R. H., "Method for repeated sampling of trout blood," The Progressive Fish-Culturist 21 (4): 151-153, October 1959.

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* R. C. Pendleton, 11/18/59, "Ecological Aspects of the Accumulation of Cs^{137}," Sigma Xi Society, Washington State University, Pullman, Washington.

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OPERATIONS RESEARCH AND SYNTHESIS OPERATION MONTHLY REPORT

November, 1959

ORGANIZATION AND PERSONNEL

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

OPERATIONS RESEARCH ACTIVITIES

Input-Output Simulation Model

A check of the multivariate analysis computing program was completed. Work was continued on the development of GCL estimation program with special attention to the applied phases.

Other

Further work was done in evaluating fair cost estimates in relationship to bids received for HAPO projects. Several important characteristics have been formulated and communicated to the Estimating Operation, CE&U. Work along this line is continuing.

Further work was done in analyzing Redox plant operating models and in communicating the results of the studies to Redox plant personnel.

OPERATIONS ANALYSIS STUDIES

Z Plant Information Study

A tentative computer logic structure based on best estimates of future Z Plant process requirements has been defined. This material is to be used to assist in determining to what extent the G. E. 312 computer system can provide process, operations, and accountability control. The object of this work is to evaluate the requirements currently specified by the team in terms of 312 computer internal program instructions such that the determination as to the feasibility of 312 computer use can be made. The use of IBM-APR equipment has been officially cancelled by CPD.

FPD Process Control and Experimentation

Further work was done in relating dimensional distortion experienced by co-extruded tubes during heat treating to the reduction ratio employed in the co-extrusion process. The Δ lengths and Δ wall thicknesses were found to be quadratic functions of the reduction ratio, and it was shown theoretically that the Δ diameters should be quartic functions. The measured Δ diameters are consistent with the theoretically predicted values.

Growth indices, as measured by X-ray techniques, are indicative of the tendency to grow dimensionally. These had been determined for several co-extruded tubes as was mentioned in an earlier report. The results of this previous analysis were difficult to interpret from a metallurgical viewpoint. It has since been

noted that the physical technique used in determining the growth indices was faulty. Measurements were again taken and the resulting data analyzed, giving results consistent with what was expected.

An evaluation is being made of the effects on fuel element quality of increased nickel content in the duplex and canning baths. The experiment was conducted, on the process line, and it is impossible to separate the effects of nickel concentration from possible time effects. The analysis of total bond count data was completed. Additional data pertaining to other quality characteristics are being gathered.

Data were analyzed from several experiments conducted in the pilot plant. One was concerned with evaluating the effect of boiling in caustic-nitrate on fuel element porosity as measured by total count. The others were designed to evaluate various steps in the cleaning process. The concentrations of altrex and diversey were varied; substitute cleaning agents were employed; and agitation by ultrasonics was evaluated.

Quality Certification Program

As indicated previously, a recommendation had been made that the feasibility of using quarter point measurements to compute the warp of a post-irradiated fuel element be investigated. This investigation has been concluded, and the quarter point measurements are now being routinely used to compute warp as recommended. Although the reduction in measurement error is not extreme, it requires little extra effort to calculate warp in this way. It does not involve taking more measurements, since the quarter point measurements are routinely taken for Δ diameter calculations.

Several other investigations are being made in order to improve the reliability of the post-irradiation fuel element data. The accuracy and precision of the weigher was evaluated. Recommendations for further evaluations were made based on the results of this analysis. Also, assistance was given in assessing the magnitude of errors associated with weasel data. Data are being collected to accomplish this. A device for measuring fuel element length is also being calibrated, and its precision will be evaluated.

Fuel Element Failures

Several analyses were made to determine if rupture experience is indicative of a real change in metal quality based on several months' experience. Allowances had to be made for changes in reactor operating conditions using the accepted rupture model.

Preliminary analyses indicate that measurement of post-irradiation porosity may be a good indication of rupture potential. Although only a limited number of post-irradiation porosity measurements have been taken, results found thus far are encouraging. An accelerated investigation is being made of this.

Optimization of Reactor Operations

The investigation of "fixed" costs in the net return equation is continuing. The first aspect being studied is concerned with manpower requirements under different

operating conditions. This includes overtime costs and possible loss of efficiency in performing downtime work when several reactors are down simultaneously.

Closely related to this program is a specific problem dealing with the assignment of supplemental crew personnel for charge-discharge work when more than one reactor is down. A simple method was developed of assigning these personnel which minimizes the total charge-discharge time for the reactor complex.

The problem concerned with evaluating decision rules for changing reactor operating conditions on the basis of rupture performance was completed. In addition to others, the two extreme rules were evaluated, where in one case the rupture experience is essentially ignored, and in the other case, each small piece of rupture information dictates operating conditions. The general method for evaluating other rules was also given.

Process Tube Leaks

Discussions were held relative to the status report on the statistical approach to the tube leak problem. It was agreed that the potentially most fruitful approach will involve a more detailed breakdown of the location of leaks contributing to subsequent external corrosion attack. Discussions were also held with personnel supplying the probolog data in order to resolve some questions that had arisen in the previous analysis.

Final Product Specifications

Considerable work was done in computing the consumer's and producer's risks for several combinations of values of the pertinent parameters. The results will be included in the proposal for part by part acceptance currently being prepared. An investigation is now being made of a sequential acceptance procedure to reduce the risks involved.

CPD Control

Over-all plant B-PID's for fiscal year 1959 were computed using the minimum variance estimate of B-PID. This was done in order to demonstrate the usefulness of this estimating procedure in better assessing the true situation, and can be useful in better establishing operating goals and limits.

Radiation Protection Studies

Analysis of data from the experiment to investigate the effect of exposure angle upon gamma film badge response is continuing. A report will be issued in the near future.

Experimental data to test the validity of the inverse square law as it applies to radium gamma film badge calibrations were reanalyzed over several different ranges of exposure.

Work continued on the statistical study for the Bioassay Operation to estimate the precision and accuracy of bioassay plutonium deposition estimates from spike samples.

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STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HAPO

2000 Program - Zirconium Corrosion

Statistical analysis was initiated on data for an autoclave calibration study being conducted by the Corrosion and Coatings Operation. The study will investigate the corrosion of zirconium in the autoclave as a function of several variables, including pressure and temperature.

Analysis is being continued on data from a pilot study investigating effects of sample position in the autoclave on corrosion.

2000 Program - Chemical Process Development

Data from several Sulfex dissolver runs were processed by multiple regression techniques on the IBM-709. Knowledge of the main controlling variables should lead to planned experiments which are amenable to statistical analysis, and possibly to the determination of a realistic causal model of the dissolution process.

4000 Program - Swelling Studies

Work continued on the development of the functional representation of pore radii distributions from micrographs of uranium samples.

4000 Program - Mathematical Analyses

Assistance was given in studying the properties of the solutions of a particular second order linear differential equation with periodic coefficients which expresses the transient behavior of a reactor during a period of variable reactivity.

A mathematical model is being constructed to aid Fission Product Chemistry Operation in the study of the heat and mass transport characteristics of a fixed catalyst bid during its regeneration phase.

6000 Program - Biology and Medicine

Work continued on statistical analysis and construction of a mathematical model of excretion in an experiment involving Pu inhalation by dogs.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Contract and Accounting Operation

A discussion was held with Data Processing personnel in connection with the utilization of IBM equipment. A clearer definition was made of the problem, and steps were taken to acquire data necessary to answer some of the questions posed.

Relations Operation

Psychological test score data obtained from plant personnel who participated in the "Understanding People" course during the past three years were analyzed.

DECLASSIFIED

W R Lewis
for Manager,
OPERATIONS RESEARCH & SYNTHESIS

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WR Lewis:blp

PROGRAMMING OPERATION
NOVEMBER 1959

A. FISSIONABLE MATERIALS - 2000 PROGRAM

Special Radioisotopes

A draft of a report on "Ionium (Thorium-230) For Radioisotope Preparation" was completed. This report presents a detailed review of study thus far on this subject. Although the survey of the uranium ore processing industry is not regarded as comprehensive, it has been sufficient to show that a large fraction of the industry has a potential for recovering thorium concentrates ranging from 2 to 5.3 per cent ionium. These figures are interesting, in view of the accepted values of eleven parts of thorium per million in the average rocks of the earth's crust. This latter figure is about six to sixteen times the amount allowable to provide the ionium contents reported above assuming complete dissolution of thorium and ionium.

B. REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. The RBU cross section library was completed during the month with the exception of key punching and checking which will require an additional two weeks. An error in the Monte Carlo code was detected, which is now being corrected. Work was continued on the input code; in particular a method was developed for carrying out a transformation of differential anisotropic scattering cross sections from the laboratory to the center-of-mass coordinate system, which permits optional use of library data given in laboratory coordinates.

A Meleager library tape was prepared for survey of mixed thorium-uranium-plutonium fuel cycles. A series of Meleager burnup cases were run in order to complete the check out of the code in comparison with earlier work. The Yankee reactor lattice analyzed last year was repeated, giving approximately the same results for both uranium and reactor-grade plutonium loadings. The long-burning (Phoenix) characteristic was observed for particular values of the parameters, as before, and was found to be strongly influenced by the fuel geometry and total scattering cross section, which determine the resonance absorption characteristics of the fuel. Much more spectacular "Phoenix" characteristics were as before obtained with plutonium feed having an artificially high ratio of Pu-240 to Pu-239.

Debugging is incomplete on the integrated IBM-709 program which employs 18 original IBM-650 codes for the initial evaluation of self-sustaining plutonium recycle in enriched thermal reactors. The integrated program operates but does

not produce correct answers for every variable. The vagarities are being cleared up with successive debug "shots" but the number of successive shots required to finish the code is most uncertain.

PRTR Plans and Schedules

Notice was received that 1.2 kg of high exposure plutonium originally assigned to Hanford by the Division of Military Application has been withdrawn.

A report supporting a request for about forty kilograms of high Pu-240 plutonium for PRP was completed. It was proposed in this report that this special type of plutonium be produced by irradiation of production grade material in the Savannah River reactors. Although the net amount of new funds needed to be budgeted was greater for a case involving Hanford irradiation of depleted uranium as an alternate production scheme for the high Pu-240 material, the route via Savannah River is more attractive because of minimum loss of production grade plutonium and top product materials; Savannah River irradiation is also favored because of the satisfactory progress and experience being gained with the trans-plutonium irradiation program and the minimum involvement of efforts at other sites. The shortening of the PRTR operating time by about two years to achieve certain program objectives is a major justification for the increased expenditures required by this high Pu-240 procurement program.

A detailed schedule of critical startup tests for the PRTR was drawn up in cooperation with the members of the startup council's committee on critical tests. The description of the individual tests is now under way.

Twenty-seven PRTR design tests were reviewed, as part of the PRTR Startup Council activities.

PRTR Hazards Evaluation

An outline was prepared of the calculational methods used in evaluating the consequences of a reactor accident. This outline includes the data tables which are available as well as the equations and general methods of calculation. The outline was utilized in estimating the consequences of a reactor accident in the PRTR if the containment vessel were not present. At month end, this series of calculations was in process.

PLUTONIUM VALUE STUDY

The Combustion Engineering Pressurized Water Reactor design was studied to form the basis for determining the types of plutonium fuel cycles to be examined in detail. Preliminary work was also done on the development of an improved, high-speed economics code.

C. BIOLOGY AND MEDICINE - 6000 PROGRAM

Radiological Consultation

Consultation was rendered concerning Washington State needs in the field of radiation protection, the need for limitation of rate at which dose is

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received, the techniques used with detachable ionization chambers for measuring the background gamma doses in the vicinity of the plant, and calculation of the dosage rates from Kr-85 liberated during the dissolving of irradiated fuel.

Advice was also provided on waste disposal problems in the nuclear industry, emergency dose, radiological hazards of plutonium, standards on survey and release of contaminated vehicles, and on the degree of leak tightness needed for reactor buildings and the effect of keeping the ventilation fans running.

A report was prepared covering the third quarter, 1959, activities at Hanford related to the Radiological Sciences.

D. OTHER ACTIVITIES

Hanford requirements for test reactor space were compiled and transmitted to the AEC at their request. The estimated space requirements (excluding those in Hanford production reactors) result from seven existing or planned in-reactor loops, plus approximately 500 capsule irradiations.

Dr. Joseph Kaplan, head of the International Geophysical Year Program for the United States, has accepted an invitation to address the Hanford Science Colloquium. His visit is tentatively scheduled for March 22, 1960.

Drafts were prepared of the program documents for the four plant improvement programs for which HLO is responsible. These are: Biology and Medicine Program; Plutonium Recycle Program; Other 4000-5000 Programs; and Laboratory Facilities.

Assistance was rendered in arranging for four tours (involving 89 people) through HLO and HAPO facilities.

Assistance was rendered the AEC Division of Reactor Development in formulating the plutonium recycle portion of their 10 year plan for civilian reactor development.

L H McEwen

Manager, Programming

LH McEwen:dl

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RADIATION PROTECTION OPERATION
MONTHLY REPORT - NOVEMBER 1959

A. ORGANIZATION AND PERSONNEL

L. G. Faust, R. C. Henle, R. C. Lawrence, and J. E. Atterberry were added to the rolls of the Radiation Protection Operation. T. E. Ludlow was deactivated to enter military service on November 6, 1959. The force of the Radiation Protection Operation now totals 133.

B. ACTIVITIES

There were no new plutonium deposition cases confirmed during the month. The total number of deposition cases that have occurred at HAPO is 237 and 170 are currently employed.

A potentially contaminated skin break occurred to an operator at the Purex plant. After superficial removal of about 40,000 d/m (0.02 μc/Pu) from his thumb, a precautionary check was made in the Whole Body Counter (WBC). About 5,000 d/m Pu was still remaining, apparently just under the skin. Skin scraping by an Industrial Physician reduced this amount to 4,000 d/m. No further action was planned. A total of 16 people was examined in the WBC during the month. One of these was a nonemployee, 12 were routine examinations, and three were involved in radiation incidents.

Positive findings of Zn^{65} in 95 per cent of the subjects examined in the Whole Body Counter led to investigation of sources of this radioisotope in humans. In addition to previously reported Zn^{65} in Columbia River water, some Pacific Ocean sea foods were examined as possible sources of this radioisotope. Pacific oysters showed the highest concentration of Zn^{65} in the sea foods examined and averaged 4×10^{-5} μc/gm oysters. A steady dietary habit of one pound of such oysters per week would result in less than five per cent of the permissible body burden for Zn^{65} "for persons in the neighborhood of controlled areas".

Data accumulated in the WBC during the past several months appears to indicate that employees working in the 100 Areas have a statistically different body burden of Zn^{65} than the balance of the people examined to date. On the average the body burden of Zn^{65} in 100 Area employees is 70 per cent greater than other employees. The source of this difference in body burden can probably be attributed to the small Zn^{65} content in the drinking water in the 100 Areas. Although it is possible to measure a difference between these two groups of employees, the maximum measurement of Zn^{65} in the body to date in the WBC represents only 0.1% of the maximum permissible body burden (occupational).

On November 16, the WBC was taken out of operation for installation of 1/8-inch lead lining on the interior walls of the iron cell. This work which will result in a desired reduction in the counting background will be completed early in December. A work order was issued to modify the hydraulic controls on the door to the iron cell for safety reasons. This work is expected to be completed in January. The Plant-wide brochure for the Whole Body Counter was completed for distribution next month.

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Analyses of Columbia River water obtained at Vancouver, Washington, for the past several months indicated Cr^{51}, Np^{239}, Zn^{65} and P^{32}, in that order, to be the most abundant radioisotopes and account for over 90% of the total radioisotopic content of the river at that point. A series of large volume (ten gallon) samples was obtained to substantiate previous estimates of downstream radioisotopic concentrations in the river. These estimates have been based on extrapolation of measurements obtained at Pasco and tended to overestimate the actual downstream conditions due to such things as uptake by living organisms and silting out. The daily quantity (in curies) of these radioactive materials passing a point near Vancouver was estimated at Cr^{51} - 900, Np^{239} - 70, Zn^{65} - 20, and P^{32} - 20. These radioisotopes in the Columbia River water at Vancouver represent 0.2% - 0.5% of the drinking water MPC "for persons in the neighborhood of controlled areas."

A program to exchange film badges and their calibration and their interpretation was initiated between HAPO and the Dow Chemical Company Plant at Rocky Flats and the University of California at Los Alamos. The objective of this program is to assess the uniformity of calibration and interpretation techniques between the various AEC sites.

The automatic film processor was placed into routine operation. The use of air agitation in the stop bath and in the fixer solution resulted in a 60% savings in the amount of nitrogen gas required. The processing solutions were used for three weeks with no apparent decrease in strength. Microflex timers were added in the wash water time cycle so that delays of 30 or 60 minutes in the wash water can be selected. An alarm was mounted in series with the main electrical power line to the automatic film processor so that it will actuate whenever the power to the machine is interrupted.

Lucite frames and cover windows for five prototype eye dosimeters were ordered. Delivery, which is promised for December, will provide the materials for assembly of prototype eye dosimeters for field tests.

The first ionization chamber finger ring was received from Product Engineering Company. Initial performance studies are in progress. The use of an "induction" reading plan whereby direct contact with the electrodes of the ring is not required has shown some promise in preliminary studies. The advancement of "induction" reading to a wide variety of ionization chambers is being considered. This system may also be used for charging ionization chambers and circumvents the problems encountered in making positive reproducible contacts with ionization chamber electrodes.

A tritium air sample chamber, interpreted through the application of pulse reader principles, was tested during the month and indicated that one MPC (2×10^{-5} μc/cc) of tritium gas could be detected in a few minutes. Two chambers of an improved design are now being fabricated for final performance evaluation. These chambers have been designed primarily for use in the PRTR program.

Data collection with the iodine adsorption sampler was continued at the 327 Building location. Favorable performance of this system continued.

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One employee of Radiological Development assisted Programming Operation in the calculation of the expected radiological consequences of an accident involving the rupture of the PRTR containment vessel.

Construction of the Columbia River continuous monitoring facility neared completion. Copper clad steel ordered for fabrication of the main water tank has not been delivered. Action was initiated to expedite shipment of this material or to utilize a suitable substitute.

The annual report of all plutonium deposition cases on record was prepared for distribution to pertinent supervision.

At the request of RPO studies were initiated by Biology to determine the effectiveness of tourniquets and/or suction cups for limiting the movement of plutonium in the skin following skin punctures.

At the request of AEC-HOO an exposure summary was prepared on a former employee of J. A. Jones Company whose private attorney has alleged radiation injury resulting from Hanford exposure. The total exposure of this employee as measured by personnel meters was less than 0.5 r.

The Manager, Calibrations, was designated as the radium custodian for HAPO (as it was several years ago). Other departments were asked to report their radium holdings so that central control and accountability can be re-established.

Minor plotting room procedural changes were tested in a radiological emergency exercise in the 703 Building.

Contributions were made to preparation of a report for presentation at the Governor' Advisory Council on Atomic Energy.

C. EMPLOYEE RELATIONS

There was a total of one minor injury for a frequency of 0.52. One security violation occurred during the month.

The Radiation Protection exhibit was displayed and well received at the Governor's Tenth Annual Industrial Safety Conference at Olympia, Washington, on November 12 and 13, 1959.

Radiological training included: A two-hour lecture on "Basic Aspects of Radiation" to 30 PEDO personnel; three information and orientation talks were presented to Plutonium Metallurgy and Biology Research personnel; a one and one-half hour lecture on plutonium hazards to 308 Building personnel; a one hour talk on "Use of Portable Instruments" to 325 Building personnel; a 15-minute talk on "Thorium Hazards" as part of the 321 Building Safety Meeting; and 16 hours of lectures and field training to 25 employees assigned to PRTR.

There were no suggestions received for evaluation. There are no outstanding suggestions at month end.

D. SIGNIFICANT REPORTS

HW-62699 "Analysis of Radiological Data for the Month of October, 1959" by R. L. Junkins.

HW-62873 "Monthly Report - November 1959, Radiation Monitoring Operation" by A. J. Stevens.

HW-62724 "Shielding Efficiency of Heavy Element Neoprene Gloves at Low X-ray Energies" by T. C. Mehas.

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ENVIRONMENTAL MONITORING - RESULTS (October 26, 1959 - November 22, 1959)

Sample Type and Location	Activity Type	Monthly Average	Units*	Trend** Factor
Drinking Water				
100-F Area	Isotopic	1.5	% MPC_{GI}	--
Separations Areas	Gross Beta	1.3×10^{-7}	μc/cc	--
Pasco	Isotopic	0.4	% MPC_{GI}	--
Kennewick	Isotopic	0.08	% MPC_{GI}	--
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	μc/cc	--
Columbia River Water				
Above 100-B Area	Gross Beta	1.2×10^{-8}	μc/cc	--
100-F Area	Isotopic	3.7	% MPC_{GI}	--
Hanford Ferry	Gross Beta	5.2×10^{-5}	μc/cc	--
Pasco	Isotopic	1.0	% MPC_{GI}	--
McNary Dam	Gross Beta	1.2×10^{-6}	μc/cc	--
Vancouver, Washington	Gross Beta	4.4×10^{-7}	μc/cc	--
Ground Water				
Outlying Test Wells	Gross Beta	1.7×10^{-4} (Max.)	μc/cc	--
Atmosphere				
I-131 Separations Areas	I-131	3.1×10^{-13}	μc/cc	--
I-131 Separations Stacks	I-131	3.6	curies/week	--
Active Particles - Project	--	1.6	ptle/100 m^3	--
Active Particles - Environs	--	0.3	ptle/100 m^3	--
Vegetation				
Separations	I-131	4.7×10^{-6}	μc/gm	+2
Residential	I-131	$< 1.5 \times 10^{-6}$	μc/gm	--
Eastern Washington and Oregon	I-131	$< 1.5 \times 10^{-6}$	μc/gm	--
Fission Products less I-131 - Wash. and Ore.	Gamma Emitters	1.0×10^{-5}	μc/gm	--

* The % MPC_{GI} is the percent of the maximum permissible limit for continuous occupational exposure to the gastrointestinal tract calculated from drinking water limits.

** The trend factor shows the n-fold increase (+) or decrease (-) from last month, where values of n less than 2 will not be noted.

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EXPOSURE EVALUATION AND RECORDS

Exposure Incidents Above Permissible Limits

	Whole Body	Localized
November	0	0
1959 to Date	7	9

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
November	21,328	105	4	0
1959 to Date	273,027	1,131	48	14

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	Average Dose Per Film Packet mr(s)
November	9,803	831	94	29	25	10.53	12.63
1959 to Date	116,677	9,318	907	227	439	7.33	15.39

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
November	1,193	0	0	0	7
1959 to Date	13,634	20	2	0	74
Fast Neutron					
November	301	13	1	0	6
1959 to Date	1,911	50	18	0	71

Bioassay	November	1959 to Date
Plutonium: Samples Assayed	808	8,293
Results above 2.2×10^{-8} μc/sample	21	392
Fission Products: Samples Assayed	807	8,240
Results above 3.1×10^{-5} μc FP/sample	1	34
Uranium: Samples Assayed	229	2,935
Confirmed Plutonium Deposition Cases	0	13*

*This brings the total number of plutonium deposition cases which have occurred at Hanford to 237.

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} μc U/cc Maximum	Average	Number Samples	Following Period of No Exposure Units of 10^{-9} μc U/cc Maximum	Average	Number Samples
Fuels Preparation	48	4.7	50	11	2.3	50
Hanford Laboratories	35	5.7	22	24	4.1	65
Chemical Processing	115	8.8	24	36	3.8	43
Chemical Processing*	18	11	2	-	-	-
Special Incidents	13	5.2	5	-	-	-
Random	1.2	5.2	5	-	-	-

* Samples taken prior to and after a specific job during work week.

Thyroid Checks	November	1959 to Date
Checks Taken	0	0
Checks Above Detection Limit	0	0

Hand Checks		
Checks Taken - Alpha	33,243	386,283
- Beta-gamma	49,304	369,169

Skin Contamination		
Plutonium	19	272
Fission Products	23	415
Uranium	7	116

CALIBRATIONS

	Number of Units Calibrated November	1959 to Date
Portable Instruments		
CP Meter	935	10,630
Juno	270	3,306
GM	823	14,831
Other	160	2,186
Total	2,188	30,953
Personnel Meters		
Badge Film	1,800	11,435
Pencils	836	13,119
Other	439	4,579
Total	3,075	29,133
Miscellaneous Special Services	295	4,183
Total Number of Calibrations	5,558	64,269

AR Keene
Manager
Radiation Protection

AR Keene:kc 1239954

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - NOVEMBER, 1959

GENERAL

Safety performance of the operation was considered marginal. There were no major injuries; the minor injury frequency rate was 2.53 which is below average experience. However, two minor injuries could have resulted in serious injuries.

There were no security violations charged to the Operation.

TECHNICAL SHOPS OPERATION

Total productive time for the month was 13,321 hours. This includes 12,159 performed in the Technical Shops, 730 assigned to Minor Construction, 158 to other project shops, and 274 hours to off-site vendors. The total shop backlog is 25,547 hours of which 50% is required in the current month, with the remainder distributed over a three-month period. Overtime worked during the month was 3.8% (599 hours) of the total available hours.

Distribution of time was as follows:

	Man-Hours	% of Total
Fuels Preparation Department	1992	15.0
Irradiation Processing Department	562	4.2
Chemical Processing Department	321	2.4
Hanford Laboratories Operation	9187	69.0
Construction Engineering & Utilities	933	7.0
Miscellaneous	326	2.4

Emergency service requests again declined permitting a reduction in the overtime work required. Other factors indicating the shops may be entering a period of relative normalcy are the reduction in total backlog and the lesser amount of work being subcontracted to J. A. Jones Co. and off-site shops. The exception to this statement is the Glass Shop where backlog is high and the situation complicated by the working force being temporarily depleted by the resignation of a glass technician. For the first time in recent history certain glass work is being subcontracted to off-site vendors. This work consists of pipettes, stirrers, etc. where multiple numbers were required and specifications could be formulated.

One open requisition is on file to replace the glass technician who resigned.

Security performance was considered satisfactory with no violations. Safety performance was considered marginal with 8 medical treatment injuries, two of which could have resulted in serious injury to personnel involved. Disregard of safety instructions and procedures was the main cause in both accidents.

RADIOGRAPHIC TESTING OPERATION

A total of 8,565 tests were made, of which 970 were radiographic (including x-ray and gamma-ray) and 7,595 were supplementary tests. Out of a total of 3,066 man-hours, 727 (23.7%) were in connection with radiographic tests, and 2,339 (76.3%) were used on supplementary tests. The supplementary test work included: autoclave, borescope, dimensional measurement (micrometric), eddy current, magnetic particle, penetrant (fluorescent O.D. and I.D.), stress analysis (static and dynamic electric strain gages), surface treatment (pickling and alkaline cleaning), and ultrasonic (flaw detection and thickness measurements).

The number of pieces handled this month totaled 6,864 items. The feet of material represented by these items amounted to 60,126 feet. The large number of pieces handled and the corresponding high footage achieved is only possible with the tubular products currently being tested.

Work was done for 23 different organizational components representing most of the operating departments and service organizations. A total of 47 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 25 different occasions for advice and information on general testing theory and applications for other than the jobs tabulated in Part II - Testing Statistics.

The status of the testing and treatment of the PRTR process tubes is as follows:

1. Ready for shipment to the contractor - 18 tubes completely tested, pickled, autoclaved and straightened.

2. Ready for straightening - 28 tubes completely tested, pickled, and autoclaved.

3. For ultrasonic evaluation - 4 tubes preliminary tests, pickled, and autoclaved.

4. For reprocessing:

   20 tubes having heavy corrosion product and/or acid staining.

   27 tubes having moderate to heavy corrosion product and/or acid staining.

NPR work has not yet progressed beyond some design items, although considerable planning has been completed. Principal effort is currently being expended upon building modifications and some equipment items. The building work includes; installation of a sprinkler system, additional heat, and structural modifications. The equipment items receiving first attention are the autoclave, alkaline cleaning, bath extension, and the recirculating hot air dryer extension.

Zirconium sheath tubing testing for both Ceramic Fuels and Plutonium Metallurgy continued at a high level. During the past month ultrasonic testing of the tubing has been firmly established using a 4 mil sensitivity limit. Also, continued evaluation of eddy current testing has allowed placing more value on this test as a screening procedure. Finished fuel element examinations continued to keep place with the tubing tested and represented another large area of testing. Radiographic facilities in Building 325, were completed and will allow better and more expeditious testing.

An extensive field job was undertaken at the PRTR site involving the cooling coil in the biological field. Numerous small diameter pipe welds were examined under difficult field conditions. All of the work was done on an expedited basis to allow placing of concrete.

Testing Statistics

Component	No.of Tests	Ft.of Weld or Material	No.of Pieces	Description
CE&U	253	129	253	Weld qualification coupons, PRTR
CPD	140	102	71	X-ray welds on vessel; x-ray welds on multi purpose dissolver; x-ray welds on autoclave.
FPD	136	100	136	NPR Fuel Elements.
HLO	6,450	59,427	6,283	X-ray dogs for tumor in lungs; x-ray saw blades for weld integrity; 9/16" O.D., zr-2 clad, swaged ceramic fuel rods; 680" I.D. x .035" wall x 8' long zr-2 tubes; x-ray fuel rods for core location for thermo tips; PRTR Calandria, x-ray rods for thermo cycling project; 9/16" O.D. zr-2 clad; 505" I.D. x .030" wall x 9' long; 687" I.D. x .057" wall x 10' long; .505" I.D. x .030" wall x 9' long zr-2 tubes; autoclave container vessels; 1/4" O.D. s.s. tubes, 12' long; build up film on 17' 3" tube; 1-1/4" O.D. s.s.; pickling preparation; fluorescent penetrant test; 2 s.s. diagrams .020" x 30" diameter; check flaws; magnetic particles, helium storage vessels; acid etch zirconium tubes audigage thickness meas. soot flame back lines on 184 - H boilers.

Component	No.of Tests	Ft.of Weld or Material	No.of Pieces	Description
IPD	1,586	368	121	Radiograph two horizontal control rods; radiograph four blocks to determine quality casting; fluorescent penetrant test, pigtails to detect surface irregularities. Magnetic particle on helium storage tank; procedure for the verification of bulk temperature surges at the DR reactor; audigage thickness readings on (2) s.s. acid storage vessels.
Total	8,565	60,126	6,864	

CONSTRUCTION OPERATION

During the month forty-three CPFF work orders were issued to J. A. Jones Company amounting to $103,679 and one fixed-price order amounting to $16,500. Six supplements to HL orders were issued amounting to $3,122. Total authorizations issued is $123,301.

There were forty-three existing HL orders at the beginning of the month with a total remaining unexpended balance of $46,380.

There were a total of twenty-three old CE&U orders active at the beginning of the month and six of these were closed out during the month. Total remaining unexpended balance of the seventeen orders is $172,874. Two supplements were issued in the amount of $5,125 which is included in the aforementioned figure.

J. A. Jones Company expenditures on Hanford Laboratories work during November were $84,088.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of Month	43	$ 46,380	23	$ 221,108
Issued during the Month (Inc. Supplements)	44	123,301	--	5,125
J.A. Jones Expenditures during Month	--	30,509	--	53,359
Balance at Month End	46	$ 139,172	17	$ 172,874
Orders Closed out during the Month	41	24,521*	6	51,103*

* Face value of orders closed.

1239958

J. A. Jones Expenditures	-	$ 84,088
HL Orders Issued	-	128,426
HL Orders Closed		75,624
Total Backlog		312,046

Authorizations to Jones Company during the month exceeded expenditures during the month by 50%. The work backlog is reasonable and monthly expenditures are close to forecast.

FACILITIES ENGINEERING OPERATION

Projects

The following summarizes the status of HLO project activity.

Number of authorized projects at month end: 23

Number of projects authorized during month: 2
- CGH-877 Pyrochemical Testing Facility - 321-A Building - HW-503.
- CAH-878 Additional Facilities for Isotope Study on Animals - 141-C Building.

Projects completed during month: 2
- CGH-829 Building 325 Basement Improvements.
- CGH-838 Fission Product Volatilization Studies Testing Facility - 292-T Building.

Project proposals submitted to the AEC during month: 2
- CGH-879 High Temperature, High Pressure Autoclave Facility - 306 Building.
- CGH-882 5000 Ton Hydraulic Press.

Projects awaiting AEC approval: 3
- CGH-879 High Temperature, High Pressure Autoclave Facility - 306 Building.
- CGH-882 5000 Ton Hydraulic Press.
- CGH-874 Consolidation of Plutonium Metallurgy Facilities,

Project proposals in preparation: 5
- Rattlesnake Springs Radioecology Research Area.
- Geological & Hydrological Wells - FY-1960.
- 327 Building Modifications.
- Physical Constants Test Reactor.
- Critical Mass Laboratory - Stage II.

The attached project report details the status of individual projects.

1239959

Engineering Services

Title	Status
326 Building Retention Waste Sump Modifications	Field work in progress.
Additional Lab Hoods & Air Exhaust Modifications - 146-FR	Field work in progress.
Glycol Heat Exchangers - 325-A	Field work essentially complete on first of four units.
Improve Process Ventilation, Labs 204 & 206 - 3706 Building	Field work complete.
329 Building Cooling Problem	Detail design is progressing.
Compressed Air System, 231-Z Building	Existing compressor relocated. New unit on-site. Work is complete except for control circuits.
Revised Electrical Service 1705-F Building	Work complete.
Air Conditioning Room 4 141-H Building	Installation work pending delivery of equipment.
Ventilation - 314 Building	Estimates have been completed.
Fire Detection System - 146-FR	Design work complete. Work order issued for installation.
Electrical Modifications - Room 24-A - 326 Building	Work order has been issued for field work.
Modifications, 3707-C Building	Computer section modifications essentially complete. Conversion of offices in lunch room not started.
Lead Lining, Shielded Personnel Monitoring Cell - 747-A Building	Field work 25% complete.
Winterize 306 Building Heating & Ventilating System	Field work complete.
Space Rearrangement - 3706 Building	Field work in progress. Work scheduled for completion in December.
Animal Farm Disposal System 141-M Building	Design complete. Estimate is being prepared.

1239960

Title	Status
108-F Building Solvent, Acid & Cylinder Storage	Cost estimate being prepared.
Electric Hoist - Graphite Shop - 3730-C Building	Design complete. Estimate to be received on alternate proposal.
Refrigerated Air Conditioning Room 130 - 146-FR Building	Design complete. Awaiting cost estimate for equipment from vendors.
Reactor Room Exhaust Ventilation Control 326 Building Basement	Design in progress for exhaust dampers to be controlled by alpha air samplimg device.
Revision to Cell Door Mechanism 747-A Building	Design completed.
Pressure Vessel Study	All vessels are marked for audigaging and the safety valve inspection is in progress.

Drafting & Design Services

The drafting work load is normal with a heavy backlog in electronics. The branch offices have sufficient work to keep all personnel busy. The Kirk Contract personnel (2 in 3706 and 1 each in 308 and 325 Building) will leave during December. Their contract expires December 31, 1959. One important job which is difficult to fill is that of electronics designer presently being filled by a Kirk employee. CE&U cannot continue this work (estimated at 96 man weeks) because of shortage of personnel.

Design and drafting work in progress includes the following:

1. PRTR prototype loop - "As-Built" - 314 Building.
2. Manipulator Model II "As-Built" - 327 Building.
3. Calandria revisions during fabrication - PRTR.
4. Miscellaneous equipment for high level radiochemistry cell - 325 Bldg.
5. PRTR Fuel Examination Ducts.
6. PRTR Gas Loop - In-Reactor.
7. Post Heat Treat Roller.
8. Shielding for Tensile Machine - 326 Building.
9. Autoclave installation, 306 Building.
10. Transfer Hood with Conveyor - to Transfer Pu Oxide - 308 Building.
11. Fuel Rod Wire Machine - 308 Building.
12. Vacuum Box for Welding of Fuel Elements.
13. Modifications to Billet Lathe and Hood.
14. Transistorizing of Radiation Monitoring Circuits.

1239961

In addition to the above work, miscellaneous small design-drafting jobs are in progress.

Design and drafting work is being performed on layout and details of projects CGH-834 - Modifications and Additions to High Pressure Loop, 189-D Building; and CGH-838, Fission Product Volatilization Studies Test Facility - 292-T Building.

Maintenance & Building Engineering - Landlord Functions

Costs: October - $126,783
September - $118,607
FY thru October - $427,807

Analysis of Costs: The $427,807 expenditure through October represents 29.3% of the budget. The expenditure pattern was revised to accommodate a budget cut. The component costs are still being revised in an attempt to provide a realistic picture. Cost continued to rise this month as was expected with the high level of maintenance in preparation for winter, and with a substantial activity in improvement work. Painting has started to taper off with major repainting being postponed.

Unusual Maintenance:

Item	October	FY Thru October
Heating & Ventilating Correction	$ 2,250	$ 4,643
Relocation & Alteration	5,884	10,798
Move Furniture	0*	237
Paint	1,359	3,763
Electrical Improvements	420	1,342
Lighting	244	392
Refilter	0	701
Miscellaneous	494	765
	$ 10,651	$ 22,551

*Charged in general.

Miscellaneous

Approximately 245 drawings including sketches, work sheets, and formal drawings were completed during the month of November by the Drafting Component.

Approximately 19,000 square feet of prints were reproduced during the month.

The total estimated value of the 27 requisitions issued during the month was $141,000.

1239962

TECHNICAL INFORMATION OPERATION

The procedure for off-site distribution of uncategorized classified reports is being reviewed and will be modified. It is expected that the new procedure will require that HOO-AEC approve all off-site distribution of such reports. The report distribution will be delayed, compared to our present practices, if distributed at all. Official instructions from HOO setting up the new procedure have not been received but changes in File practices are being readied, new forms are being drafted, and instructions to the field are being prepared.

The new requirement has already caused considerable inconvenience to HAPO authors. One document, HW-62774, "Eighth High Temperature Fuel Meeting -- Preliminary Data Only", should have been mailed off-site on 11-20-59 to the individuals who were to attend the meeting. At month's end HOO had not approved off-site mailing of the documents. The author has indicated that the copies cannot be received now in time for the meeting and that HAPO may have to drop out of the program.

A letter was received from the HOO Classification Officer encouraging HAPO review of NPR documents classified SECRET - RESTRICTED DATA for possible downgrading in accordance with the NPR Classification Guide. The Specialist, Classification-Declassification will undertake a review of all Secret documents related to NPR activities. The number of HAPO documents involved is roughly estimated to be 230. Since it will take some time to complete the review, the Specialist, Classification-Declassification advised the NPR Project Operation that documents of current interest and usefulness will be given priority attention at their request.

Plans are being made to insert a notice in Management Newsletters of all Departments reminding employees that unclassified papers prepared for presentation at classified or "secured" meetings, must be processed through the same clearance procedure as papers presented at an "open" meeting. At the present time unclassified papers prepared for presentation at "secured" meetings do not receive a routine review and clearance on the mistaken assumption that the proceedings of a "secured" meeting will be published as classified documents and that the unclassified papers are protected from broad public distribution by the overall classification of the proceedings. Experience has shown this assumption to be incorrect and the review procedures will be tightened to close this loophole.

A letter has also been distributed to the field in an attempt to evaluate the need for locating microcard readers at strategic spots throughout the plant. A growing number of AEC reports are now obtainable only in microcard form and the only available readers are in the 3760 Building. Seven readers were budgeted for in the Operation's FY-1960 Office Equipment Budget but these will not be procured (Cost - $350 each) until the need for them has been firmly established.

As indicated in an earlier report, we are no longer preparing a receiving report for Accounts Payable on periodical subscriptions. Accounts Payable has agreed that the Library's check-in records could be used in lieu of the receiving report but that these records (the Library's) shall be subject to periodic audits. During the month, Accounts Payable made a sample audit of publications ordered by the Library since June. Of the forty items checked, all but one had been received or claimed. The single exception was an oversight on the Library's part. The result satisfied the condition that the Library's records of receipt are considered adequate for financial control.

The annual membership lists have been sent to Department Managers for approval of 1960 renewals. Three managers have already returned their lists. Chances are favorable that the composite list of all HAPO memberships can be submitted to the AEC in ample time to get their final approval before the end of 1959.

An award of $100 was won by J. E. Brown, Writer & Clearance Specialist, for a suggestion that glossy photos used in papers submitted for clearance be replaced by inexpensive copies prepared by the A. B. Dick photo-transfer process. If the suggestion is widely accepted on the plant, worthwhile savings can be achieved.

Work Volume Statistics

	October	November
Document Distribution and Files		
Documents routed and discharged (copies)	17,780	17,305
Documents issued (copies)	12,522	9,501
Documents sent off-site (copies)	3,941	4,549
Document reserves filled (copies)	798	672
Documents picked up and delivered	19,662	18,465
Document Accountability		
Holders of classified documents whose files were inventoried	667	310
Documents inventoried in Files (copies)	7,963	23,822
Documents destroyed or retired (copies)	3,912	7,968
Documents revised (copies)	827	958
Documents pulled and documents filed (copies)	13,280	11,765
Documents reclassified	171	439
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	212,961	212,719
Reference and Publication		
Books cataloged (new titles)	103	142
Books added to the collection (volumes)	228	350
Ready reference questions answered by professional staff	98	95
Literature searches by professional staff	111	93
Reports abstracted (titles)	268	323
Formal reports prepared (titles)	8	7
Off-site requests for HAPO reports (copies)	242	294
Reports released to CAP (titles)	23	21

1239964

Library Acquisitions and Circulation	October	November
Books ordered (volumes)	235	260
Periodicals ordered	398	765
Books circulated (volumes)	2,120	1,578
Periodicals circulated (issues)	3,780	3,254
Inter-Library loans	65	96
Films borrowed or rented	17	19
Industrial film showings	60	38
Bound periodicals added to the collection	84	140

Library Collection:

	Main Library	W-10 Library	180-F Library	Ind. Med.	Total
No.of Books	28,048	8,285	1,515	1,990	39,838
No.of bound periodicals	12,800	1	1,431	96	14,328
	40,848	8,286	2,946	2,086	54,166

Classification and Declassification	October	November
Documents, including drawings and photographs reviewed for downgrading or declassification	2	5
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	44	11
Documents submitted to Declassification Branch, Oak Ridge	6	14

Manager,
Laboratory Auxiliaries

JL Boyd:jcw

UNCLASSIFIED 996671

BUDGET CLASSIFICATION Improvements to Production & Supporting Installations - 58-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 62399

MONTH November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CG-731	Critical Mass Laboratory	$1,000,000	$1,000,000 / 3-23-59	100 / 100	36 / 41	5-22-58 / 6-4-59	- - - / 6-30-60	2-24-59 / 6-30-60

USING COMPONENT: Physics & Instruments R & D

FED ENGINEER: D. S. Jackson

REMARKS: The contractor installed the reinforcing steel, erected forms and poured the concrete for the remainder of the reactor room walls. The portion immediately around the frame for the large shielding door was blocked out. It will be poured separately to better assure proper alignment of the door and frame in the wall. The roof decking was installed on the service building and mechanical work on the ventilation supply unit and service piping continued. Electrical wiring in the control building is nearing completion. Delays in receipt of some of the essential materials and the work stoppage early this year have prevented the contractor from meeting his own schedule, however his work is 62% complete compared to an officially scheduled 43%. Delivery of engineered equipment has been very poor to date. This portion of the project is only 2% complete compared to a scheduled 30%. Shipment of the mixing hood is imminent; the reactor hood should be shipped early in December. This will greatly aid the percent complete portion of the project. The instrument panel being fabricated by Minneapolis-Honeywell was supposed to have been delivered on November 23, 1959. The vendor recently informed the General Electric Company that the panel would not be shipped until late March, 1960. In discussions with the vice-president in charge of engineering for Minneapolis-Honeywell and their local district representative, the General Electric Company representatives informed them that delay of delivery of this equipment beyond January 30, 1960 would be intolerable and all possible legal action would be taken against Minneapolis-Honeywell should the panel not be delivered by then. This item could affect the contract completion date, including the possibility of lay-off and rehiring of personnel by the contractor.

CA-744	Metallurgical Development Facility - 306 Building	$2,650,000	$2,685,000 / 11-5-58	100 / 100	28* 55** / 23* 43**	16*** 6-30-58 / 17*** 3-20-59	- - / 9-1-60	9-30-59 / 9-1-60

USING COMPONENT: Reactor & Fuels R & D

FED ENGINEER: J. T. Lloyd

REMARKS: A new schedule will be prepared after opening of chemical processing tank bids on December 7, 1959. The opening of the chemical processing bid package, including tank installation, was extended to December 21, 1959. The extension was due to failure to obtain bids for chemical processing tanks on November 18, 1959 (tank bids were extended to December 7). Equipment procurement is otherwise proceeding satisfactorily. The unseasonal cold weather has hampered construction work to some degree. The siding and roof will be completed as soon as weather permits and temporary lighting will then be installed. This will permit interior work to progress during the winter months.

* Overall project. ** Contractor's portion. *** CPFF portion.

AM-7000-919 (5-58)

UNCLASSIFIED

L9bbE21

UNCLASSIFIED

BUDGET CLASSIFICATION Improvements to Production & Supporting Installations - 58-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 62899
MONTH November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CA-749	High Level Radiochemistry Facility	$950,000(1)	$960,000 / 10-3-58	100 / 100	98 / 99	6-15-58 / 8-14-58	- - - / 1-1-60	11-21-58 / 11-3-59*
		USING COMPONENT: Chemical R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS: The last equipment remaining to be installed, the transfer mechanisms, still lacks parts. These mechanisms are scheduled for installation by January 1, 1960. Approximately $17,000 for in-process equipment and start-up operations are outstanding. Approximately $10,000 of this is for a health monitoring station and wet storage manipulator tongs. This project will be closed out with exceptions about December 15, 1959. Beneficial use by the using component was attained on November 3, 1959. The contractor's exceptions were settled in a meeting on November 24, 1959 and the contractor has completed his work on this project except for repairing the motor on the truck door, which has broken twice.
* Beneficial use date; project will be closed out about December 15, 1959.
(1) Costs to date date with contingency items indicate an actual cost may range between $920,000 and $950,000.

CGH-790	High Level Radioactive Receiving and Storage Addition - 327 Building	$350,000	$345,000 / 4-23-59	100 / 100	97 / 77	6-23-58 / 10-9-58	- - - / 2-1-60	12-31-58 / 2-1-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: J. J. Peterson		

REMARKS:

Siding and roof deck scheduled for shipment from factory November 30, 1959. Installation of crane doors is in progress with some rework required to make them function properly.

CGH-819	Increased Laboratory Waste Facilities - 300 Area	$193,765	$30,000 / 11-24-58	100 / 100	0 / 0	3-30-59 / 5-1-60	- - - / - - -	4-1-60 / 3-1-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: J. J. Peterson		

REMARKS:

A project proposal for construction funds is being routed for signatures.

BUDGET CLASSIFICATION: General Plant Projects - FY 1959

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 62899
MONTH: November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION: AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT: CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED or Actual COMP. DATE: DESIGN / CONST.
CAH-827	Automatic Columbia River Monitoring Station	$39,000	$39,000	100	55**	4-3-59*	- - -	6-18-59*
			6-30-59	100	80**	11-5-59	3-31-60	3-1-60
		USING COMPONENT: Radiation Protection				FEO ENGINEER: D. S. Jackson		

REMARKS: The contractor began work at the job site on November 5, 1959. All work on the river intake line and underground piping has been completed. The monitoring building was constructed and the pump installed. Work remaining to be performed by the contractor includes installation of the electrical service, the heater, the cooler, the alarm circuit and painting the building interior. The plant forces portion of the project will be started after the contractor has completed his work. Difficulty in obtaining copper clad steel for monitoring tank may necessitate a change in vessel materials.

* A-E.
** Contractor only.

CAH-828	Central Storage Facility - 300 Area	$40,000	$40,000	N.S.	100	4-2-59	- - -	6-8-59
			7-30-59	100	99.5	7-15-59	12-31-59	11-25-59
		USING COMPONENT: Finance				FEO ENGINEER: R. C. Ingersoll		

REMARKS:

The storage building was accepted for beneficial use on November 25, 1959 with the following exceptions: Complete service piping to coolers, furnish and install locks, and submit data on sprinkler system.

CGH-829	Building 325 Basement Improvements	$70,000	$70,000	N.S.	100	2-13-59	- - -	8-11-59
			2-13-59	100	100	3-2-59	12-31-59	11-30-59*
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. C. Ingersoll		

REMARKS:

This project is complete and has been accepted subject to certification of the sprinkler system by the Washington Rating Bureau.

* Actual completion date, no exceptions.

AM-7300-019 (5-58)

6966E21

UNCLASSIFIED

BUDGET CLASSIFICATION

General Plant Projects - FY 1959

MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW - [illegible]

MONTH November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CAH-837	Animal Pens, Isolation and Examination Facilities	$77,000	$80,000	100	100	3-30-59	- - -	6-5-59
			3-17-59	100	93	7-10-59	4-1-60	12-21-59

USING COMPONENT: Biology

FEO ENGINEER: J. T. Lloyd

REMARKS:

The AEC has extended the contractor's completion from October 29, 1959 to December 15, 1959 and had allowed the contractor to November 30, 1959 to have the dog pens complete for beneficial use. The contractor did not meet this date. A concerted effort has been made by the contractor on the balance of the work. Windows are glazed, tile has been painted, steam piping completed, pen roof and cooling complete, transformer has been installed and miscellaneous electrical work is being completed. The plumbing fixtures are not installed and the tile field is not finished; concrete floors in rooms adjacent the present 141-FS structure have not been finished. The dogs are expected to be placed in the new pens by Friday, December 4, 1959.

CGH-840	Sheet Metal Shop Addition - 328 Building	$40,000	$40,000	N.S.	100	6-22-59	- - -	9-1-59
			6-18-59	100	86	6-25-59	5-1-60	12-1-59

USING COMPONENT: Laboratory Auxiliaries

FEO ENGINEER: J. J. Peterson

REMARKS:

The building was turned over to operations prior to scheduled completion to allow use of the building space for a crash tube straightening program.

* Date of occupancy by using component.

CAH-848	Geological and Hydrological Wells - FY 1959	$56,600	$56,600	N.S.	63	5-12-59	- - -	7-6-59
			6-24-59	100	63	7-16-59	5-31-60	3-30-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: H. E. Ralph

REMARKS:

Twelve of the sixteen new wells have been developed, plus redevelopment of four existing wells. To date 1,850 feet of new hole has been completed.

M-7300-019 58)

UNCLASSIFIED

BUDGET CLASSIFICATION

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63896

MONTH November, 1959

General Plant Projects - FY 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED.	PROJECT PROGRESS IN PER CENT CONST. ACTUAL	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED COMP. DATE DESIGN	ESTIMATED COMP. DATE CONST.	USING COMPONENT	FEO ENGINEER
0084 (AEC-167)	Pickling and Autoclaving Facility for Zirconium Tubes - C-25 Building, White Bluffs	$120,000	$120,000	5-25-59	100	100	100	100	3-2-59	3-10-59	- - -	- - -	5-15-59	10-15-59	Laboratory Auxiliaries	H. Radow

REMARKS: The remaining exception has been completed and acceptance signatures are being obtained.

General Plant Projects - 1960

CGH-860	Access for PRTR Fuel Elements - 327 Building	$81,000	$81,000	10-8-59	N.S.	34	N.S.	0	10-19-59	N.S.	- - -	8-15-60	1-15-60	4-30-60	Reactor & Fuels R & D	J. J. Peterson

REMARKS: Design on architectural and structural is progressing. A project proposal requesting a change in method of performing work from Lump Sum to CPFF Service Contractor has been submitted to the Commission.

CAH-864	Shielded Animal Monitoring Station - 100-F	$46,000	$46,000	8-6-59	N.S.	30	0	0	- - -	N.S.	- - -	4-1-60	1-1-60	4-1-60	Biology	J. T. Lloyd

REMARKS: The AEC has published the following as "Estimated Performance Schedule": Title II complete on January 10, 1960. Title III to start March 1, 1960 and to be complete on May 1, 1960. Title II being performed by Carson, Kesterson and Moe is approximately 30% complete.

AM-7300-019 (5-58)

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 6[illegible]
MONTH: November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION - AMOUNT	AUTHORIZATION INFORMATION - DATE	PROJECT PROGRESS IN PER CENT - DESIGN SCHED.	PROJECT PROGRESS IN PER CENT - DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT - CONST. SCHED.	PROJECT PROGRESS IN PER CENT - CONST. ACTUAL	STARTING DATE - DESIGN	STARTING DATE - CONST.	DIRECTIVE COMP. DATE - DESIGN	DIRECTIVE COMP. DATE - CONST.	ESTIMATED or Actual COMP. DATE - DESIGN	ESTIMATED or Actual COMP. DATE - CONST.
CGH-874	Consolidation of Plutonium Metallurgy Facilities	$285,000	None	None	0	0	0	0	1 *	2 *	- - -	- - -	5 **	11 **

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: J. T. Lloyd

REMARKS:

The General Electric Company was informally advised by the AEC that, if funds were available, they suggested both new structures be of concrete block construction. A letter was written to the AEC by the General Electric Company concurring with their suggestion. It was stated that funds were now considered sufficient for this type of construction. In the AEC Review Board meeting of November 25, 1959 action on this project was deferred until December 10, 1959. The AEC will learn from CPD what plans they have for space in the 234-5 Building.

* Months after authorization.

CGH-877	Pyrochemical Test Facility - 321-A Building	$70,000	$70,000	11-17-59	N.S.	0	N.S.	0	12-17-59*	2-17-60*	- - -	9-30-60	4-17-60*	9-30-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: R. C. Ingersoll

REMARKS:

The project proposal was approved and AEC Directive No. HW-503, dated November 17, 1959 was received on November 18, 1959. Work Release Authorization No. 56 was issued November 23, 1959.

* Project proposal dates.

CAH-878	Additional Facilities for Isotope Study on Animals - 141-C Building Addition	$61,000	$61,000*	11-18-59	0	0	0	0	12-7-59	2-15-60	- - -	4-15-60	12-31-59	5-15-60

USING COMPONENT: Biology

FEO ENGINEER: J. T. Lloyd

REMARKS:

The segregation of funds (required for AEC Managed projects) was transmitted to the AEC on November 16, 1959. A meeting was held with FEO, CE&UO Design and H. E. Bovay, Jr., Consulting Engineers; a tenative schedule of three weeks for design time was agreed upon. The AEC Directive dated November 18, 1959 and Work Authority dated November 25, 1959 have been received by the General Electric Company.

* $9,800 were authorized to the General Electric Company by Work Authority dated November 25, 1959.

BUDGET CLASSIFICATION Improvements to Production & Supporting Facilities - 60-a-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 62899
MONTH November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.
CAH-870	Facilities for Recovery of Radioactive Cerium - 325 Building	$490,000	$35,000	100*	0	9-18-59	- - -	2-15-60
			9-2-59	100*	0	N.S.	- - -	9-1-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS:

Comments were returned on the 90% preliminary design and report submitted by the A-E on October 29, 1959. Mr. W. L. Gallagher of B. D. Bohna Company made a trip to Richland to deliver and discuss the 100% preliminary design on November 24 and 25, 1959. The A-E estimate for this project is now $357,000 direct cost, not including corrosion testing on the stainless steel. As this is above the expected $300,000 HOO-AEC is re-evaluating the project.

Equipment Not Included in Construction Projects - Program Class 2900

CG-661	Additional Heat Generation Facility - 189-D Building	$464,000	$664,000	100	100	12-6-56	- - -	10-15-58
			9-18-57	100	99	12-3-58	8-31-59 *	6-30-60 **

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: J. J. Peterson

REMARKS:

The equipment has been accepted as meeting the specifications. A revised project proposal requesting an extension of time is being written. The primary reason for this extension is to correct the inadequacies which became apparent after start-up of the additional heat generation equipment. These inadequacies involve the temperature detection and recording devices.

* Partial beneficial use was attained.
** Probable date of extension necessary for correction of inadequacies.

CA-681	Hanford Equipment in the ETR	$1,044,000*	$1,140,000	100	100	9-17-56	- - -	10-15-58
			4-1-59	100	100	4-1-58	3-1-60	10-30-59

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: H. Radow

REMARKS:

The first intentional rupture test is scheduled for December 8, 1959. However, some flow problems have been encountered and getting these resolved may delay the test.

* Total indicated project cost, including accrual items listed as exceptions on completion notice.

AM-7300-019 (5-58)

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UNCLASSIFIED

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 62899

MONTH November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.
CG-785	In-Reactor Studies Equipment - 105-KW Building	$276,000	$276,000	98	0	1-5-59	- - -	12-8-59
			12-8-59	95	0	N.S.	12-31-60	12-31-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H. Radow		

REMARKS:

Comment drawings for the capsule removal facility have been distributed. As soon as these are resolved, requisitions for procurement of this facility will be processed.

CGH-801	X-Ray Diffraction Cell - 327 Building	$170,000	$170,000	40	0	6-10-58	- - -	2-1-60
			10-1-59	40	0	10-1-60	10-31-60	3-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

Design work on this project was re-started on this project on November 7, 1959, but after a re-evaluation of equipment funds by using component they requested that it be stopped on November 24, 1959. It appears that a revised project proposal, revising the project completion dates, will have to be issued.

CGh-805	High Temperature Tensile Testing Cell - 327 Building	$170,000	$150,000	100	0	8-26-58	- - -	6-15-59
			2-25-59	100	0	3-1-60	3-1-60	5-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

As there were not allocated funds available, there was no progress on this project this month. A revised project proposal will be issued requesting revised completion dates. The cell assembly purchase order with Washington Iron Works was cancelled with charges amounting to $2,787.40. The requisition for cell viewing plugs was cancelled.

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 62899

MONTH November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.
CGH-834	Modifications and Additions to High Pressure Heat Transfer Apparatus - 189-D Building	$700,000	$700,000 / 4-8-59	72 / 80	28 / 28	4-20-59 / 4-22-59	- - - / 10-15-60	2-9-60 / 10-15-60

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: H. Radow

REMARKS:

The portion relating to the test mock-up facility in the specification for the high speed valves has been deleted. This was done to obtain competitive bids and another two weeks was allowed for return of bids. Fabrication of the preheaters is progressing favorably and shipment is now promised in early December. Start of full-scale construction is being scheduled on this basis.

CGH-838	Fission Product Volatilization Studies Test Facility - 292-T Building	$70,000	$75,000 / 3-26-59	100 / 100	100 / 100 *	4-9-59 / 4-16-59	- - - / 11-30-59	9-15-[illegible] / 11-25-[illegible]

USING COMPONENT: Chemical R & D

FEO ENGINEER: O. M. Lyso

REMARKS:

A decision has been made to operate the facilities using trace elements in the initial runs and leave the top shielding off. Some minor modifications within the shielding are anticipated. Construction work is essentially complete with the exception of an exterior cask handling device. A modified jib-boom is planned for cask handling in the event scheduling problems should arise. An SWP stake and chain fence remains to be placed around the facility. A temporary change room has been provided by using the TC shack.

* Complete with exceptions.

CGH-857	Physical and Mechanical Properties Testing Cell - 327 Building	$400,000	$75,000 / 10-1-59	0 / 0	0 / 0	10-20-59 / N.S.	- - - / - - -	4-1-61 / 1-1-62

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS:

A purchase specification has been prepared for vendor design of remotely operated equipment. As there are no available allocated funds no other work was done on this project. A revision to the project proposal is being considered for this project.

AM-7300-019 (5-58)

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 62899
MONTH November, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION - AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED COMP. DATE: DESIGN / CONST.
CGH-858	High Level Utility Cell - 327 Building	$500,000	$70,000	0	0	10-20-59	- - -	1-1-61
			10-1-59	0	0	N.S.	- - -	11-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

Work was continued on a purchase specification for remotely operated equipment for this project.

CGH-866	Shielded Analytical Laboratory - 325 Building	$750,000	$10,000	90 *	0	9-5-59	- - -	12-15-59 *
			8-12-59	90 *	0	N.S.	- - -	6-1-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

Preliminary design will be completed in December, 1959. After reviewing the costs associated with building this facility in the basement of the 325 Building, it was decided to investigate a one story building to the southwest corner of the 325 Building. A project proposal for detailed design and construction funds will be written for funding from 60-a-1 funds.

* Preliminary design only.

CGH-879	High Temperature, High Pressure Autoclave Facility - 306 Building	$46,400	None	N.S.	0	8-3-59	- - -	2-1-60
			None	75	0	12-15-59	- - -	3-15-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: D. S. Jackson		

REMARKS:

A project proposal was submitted to the AEC on November 12, 1959. The project was approved by the AEC Review Board on November 25, 1959; the directive has not been received to date.

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of November 30th, the staff of the Hanford Laboratories totalled 1320 employees, including 634 exempt and 686 nonexempt. There were 547 employees possessing technical degrees, including 336 B.S., 112 M.S. and 99 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for November was 1.48 as compared with 1.51 last month. There were 4 security violations during November, bringing the total for the year to date to 42.

During the month, a pressure accumulator in 314 Building basement failed while under pressure of 18,000 psi. The end plug was ejected as a result of an inadequate number of threads of the proper quality to withstand the pressure. There were no employees injured although the damage totalled $3500.

A machinist accidently backed a mobile crane into the shop door with injury to his hand and $100 damage to the door.

PROFESSIONAL PLACEMENT

During November, HAPO participated in Ph.D. recruiting at M.I.T., Ohio State, Colorado, Utah, Wisconsin, Iowa State, Iowa, Oregon State, Oregon, and California. Referrals from these and schools previously visited this year are being received in increasing numbers for HAPO consideration. Three Ph.D. candidates visited for interviews during November and one offer was extended to a Ph.D. candidate.

Mid-year campus visitations have been completed except for four southwestern schools scheduled early in December. No mid-year offers have been extended to date; however, an appreciable number of June graduates have been developed as candidates. Seven offers were extended to BS/MS experienced personnel during the month and five offer acceptances were received.

Two Technical Graduates were added to the Program during the month and four were placed on permanent assignment. On November 30th there were 67 Technical Graduates and 7 Technician Trainees on the Programs.

TRAINING

One Laboratories manager participated in the leaders training course for "Business Operations in the Changing Environment". The Information and Orientation Series continued during November with presentations by members of the Operations Research and Synthesis component.

EMPLOYMENT

Eleven requisitions were filled during November. With the receipt of 8 requisitions, 2 cancellations and 5 placed on a hold basis, there were 7 openings

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at month's end, for which 4 candidates are in process, 2 transfers pending and one yet to be procured.

COMMUNICATIONS

According to information from the Relations Operation, distribution of the G.E. Monogram at Hanford will soon be extended to all non-unit, nonexempt employees as well as the current distribution list to exempt employees. A new bulk distribution for HLO printed communications material has been approved and is in the process of implementation. Extensive efforts have gone into the preparation of a half-hour television show, "Radiation Protection at Hanford", which will be broadcasted on KEPR TV on December 17th. H. M. Parker will discuss film sequences on HLO radiation protection, environmental monitoring and radiological sciences programs.

T G Marshall

Manager,
Professional Placement
and Relations Practices

TG Marshall:tr

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TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Oct.	Nov.
Requisitions		
At end of month	15	7
Cancelled	3	5*
Peceived	12	8
Filled	23	11

Nonexempt Transfer Request	Oct.	Nov.
Transfers		
Active cases at end of mo.	80	80
Cancelled	4	4
New	4	5
Transfers effected	4	1

* Includes 2 requisitions placed on hold.

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TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	265	47	10	14	6	2	2	4
Exp. BS/MS	155	29	25	1	33	19	5	20
Prog. BS/MS	74	-	-	-	3	2	1	5

*Offer totals include offers open on 9/1/59
Ph.D. 3
Exp. BS/MS 6

**On the Roll totals include 1958/59 Carryover acceptances.

B. Technical Recruiting Activity - HLO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	265	47	10	14	4	1	1	3
Exp. BS/MS	122	12	9	-	7	3	1	5

*Offer totals include offers open on 9/1/59
Ph.D. 3
Exp. BS/MS 3

**On the Roll totals include 1958/59 Carryover acceptances.

In addition to the above activity, 7 exempt employees have transferred into HLO from other HAPO departments and 4 technical graduates have accepted off-Program placement in HLO to da'

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C - Technical Graduate and Technician Training Program
Month ending November 30, 1959

	TG Program	TT Program
Number of Personnel on Assignment	67	7
(HAPO Tech Grad Program.....59		
(Western District E. P..... 8		
Distribution of Assignments by Departments		
HLO	21	2
CE&UO	3	0
FPD	0	0
IPD	34	5
CPD	9	0
Distribution of Assignments by Function		
R&D or Engineering	48	7
Other	19	0

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FINANCIAL OPERATION MONTHLY REPORT
NOVEMBER 1959

Personnel

There were no personnel changes during November.

Activities

GENERAL ACCOUNTING OPERATION

A report of results was issued for the physical inventory of movable cataloged equipment in the custody of Laboratory Auxiliaries Operation. Eight hundred and thirty four items were physically counted valued at $1,531,480. Three items valued at $630 were added to record as compared to three items valued at $1,850 in the FY 1959 inventory. One item valued at $180 was not located this physical inventory whereas all equipment was located in the FY 1959 inventory. The fact that only one item was missing, indicates close control over equipment and the use of proper procedures, particularly in view of the relocation of Radiographics Testing equipment from the 200 East Area to White Bluffs.

All field work in connection with the physical inventory of movable cataloged equipment in the custody of Biology is complete and the field reconciliation is in progress. A listing of unlocated items was forwarded to the Section Manager requesting that the equipment be located or a missing property report be prepared.

Preparations were completed and a procedure distributed for the inventory of movable cataloged equipment in the custody of Physics and Instrument R&D Operation. This inventory will begin December 14, 1959 with an anticipated completion date of December 30, 1959.

All Reactor and Special Material custodians were advised of the forthcoming annual physical inventory at the end of December 1959. Custodians were requested to submit inventory information to be compiled and forwarded to Contract and Accounting for use in preparing a detailed inventory schedule for the AEC.

The laboratory equipment pool (Building 3718) is ready for operation. No equipment to date has been received, however, numerous requests have been received for Laboratory Equipment Pool Tags to affix to equipment being transferred to the storage area.

A listing of equipment determined to be excess to the needs of HLO Custodians was circulated throughout HLO prior to processing a Declaration of Excess. Equipment valued at $6,186 was reassigned to new custodians.

In response to a request of SS Accountability material custodians were requested to submit forecasts for outside diversions of SS Material covering the fourth quarter fiscal year 1960 and the entire fiscal year 1961. Upon receipt of the information a consolidated report will be prepared and forwarded to SS Accountability.

Comparison of equipment expenditures for FY 1960 with FY 1959 at November 30, 1959 is shown below:

Program	FY 1959	FY 1960
2000	$317 084	$376 731
3000	60 558	9 344
4000	72 162	120 449
5000		6 466
6000	7 794	26 295
Totals	$457 598	$539 285

We are currently running substantially ahead of 1959 on expenditures and commitments.

At the request of Contract Accounting a quick survey was made to determine amounts that might be made available from equipment funds allocated Hanford Laboratories for possible transfer to operating funds. As a result of this survey and action taken by Contract Accounting funds available to Hanford Laboratories for 2000 Program equipment were reduced $233,000.

A review of the Authorization and Performance of Work Manual is nearing completion and the revisions will be published during the month of December. The revisions update the Manual to incorporate a number of changes in policy and procedure.

COST ACCOUNTING OPERATION

Information has been received from Washington-AEC that additional 4000 Program funds will be included in their next Financial Plan for HOO-AEC. Hanford Laboratories will receive the entire increase for the activities listed below:

Budget Activity #4420 - Reactor Fuels and Materials Development	
UO_2 Fuels Research	$300 000
Plutonium Ceramics Research	150 000
Physical Properties Research	225 000
	$675 000
Budget Activity #4114 - Plutonium Recycle Program	
Procurement of High Exposure Plutonium	$200 000
Chemistry - Pyrochemical Systems	120 000
Neutron Cross Section Measurements	50 000
	$370 000

In addition, we have formally received funds in the amount of $95,000 for the Plutonium Fuel Value Study and $30,000 additional funds from the U.S. Air Force to continue the Atmospheric Diffusion Studies through June 30, 1960.

Analyses were prepared during the month showing the status of funds allocated to HLO Sections as of October 31, 1959 for several of the research and development programs. The analyses took into consideration the actual program costs through October, the outstanding commitments for materials and services and a provision to finance salaries and related indirect costs of personnel assigned to programs on November 1 for the remainder of the fiscal year. These analyses

were submitted to the appropriate Section Managers along with a request for their review of the programs and to advise the Manager - Finance of their corrective action planned for those programs which the analyses indicated financial difficulty.

Arrangements were made, with the concurrence of project management, landlord representative, building occupants and Financial representatives, which resolved the several problems of partial occupancy by HLO personnel of new facilities. It was agreed that (1) all costs of this nature associated with the 308 Building (PFPP) be billed to the HLO Buildings and Utilities account, (2) cost of steam associated with the 309 Building (PRTR) be billed to CWIP as project cost until beneficial occupancy, with the exception of $150 per month to cover occupancy by RFRDO personnel in one of the PRTR buildings which will be billed to the HLO Buildings and Utilities account and (3) a monthly billing of $300 for 309 Building occupancy from the HLO Building and Utilities account to Plutonium Recycle Test Reactor Operation (Code 7570) until beneficial occupancy of PRTR.

The conversion of Hanford Laboratories' work order servicing organizations to separate time distribution has been deferred until sometime after January 1, 1960, due to a delay in programming by Data Processing.

Two new work identification codes were established during the month:

Code	Title
.17	Plutonium Fuel Value Study (4000 Program - Research and Development)
.53	IPD - NPR Rupture Detection (2000 Program - Research and Development)

Action as indicated occurred on the following projects and informal requests during the month.

Project	Description	New Authorization To HLO	Physical Completion Notices Issued	Financial Closing Issued	Transferred To Plant In Service
CGH-877	Pyrochemical Test Fac., 321-A Building	$70 000			$
CAH-878	Add. Fac. Isotope Study on Animals	9 800*			
CG-681	Hanford Equipment in the ETR		x		
IR-242	Modify 303-J Bldg. for Interim Test Fac. for Fuel Elements			x	4 247
IR-243	Relocation of 200-E Testing Equipment		x		7 585
IR-246	Alterations Positive Ion Acceleration Facility				18 839
IR-247	Electrical Service Experimental Animal Farm				9 552
CG-779	Add. to Separations Development Facilities				26 535

* $61,000 authorized to HOO-AEC.

Issuance of weekly project cost reports by HLO Cost Accounting started with the week ending November 8, 1959.

There were 33 new authorizations for $120,179 and supplements for $18,247 issued to J. A. Jones Construction Company by HLO during the month. At month-end, there were 68 authorizations still active and work was physically completed on 35 authorizations during the month.

GENERAL

Work on the audit of maintenance continued. The review's value will be somewhat limited because of the general lack of maintenance standards and of the difficulty in identifying maintenance costs with specific items of property.

The aid of the HAPO Procedures Specialists has been enlisted in attempting to simplify reporting of offsite trips and visits to HAPO. A proposal to limit routine reporting to weekly trip and visit forecasts plus a single monthly report of offsite trips has been submitted for their comment and action.

The 100-F Area badge house change and its probable effects on HLO (Biology) timekeeping were evaluated. The only apparent effect of significance will be a slight increase in Biology's available productive time.

The HLO contribution for "1959 at HAPO" is being prepared. Several groups have been contacted for pictures and the narrative is being drafted. Deadline for first rough draft is January 8.

Further work has been done to analyze technical contributions from Hanford Laboratories. Confirmation of 1957 figures is still needed.

Manager - Finance

W. Sale:bk

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
L. E. Mills	Magnetic Force Resistance Butt Welding of Fuel Elements

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