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HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

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HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
NOVEMBER, 1961

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By Authority of CG-PR-2/PR-24

DS Lewis 8-10-92

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Compiled by
Operation Managers

December 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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1250448

TABLE OF CONTENTS

	Page
Force Report and Personnel Status Changes	iv
General Summary . . . . . v through xiv Manager, H. M. Parker	
Reactor and Fuels Research and Development Operation . . . . . A-1 through A-42 Manager, F. W. Albaugh	
Physics and Instrument Research and Development Operation . . . . . B-1 through B-42 Manager, P. F. Gast	
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Invention Report L-1	

1250449

TABLE I. HLO FORCE REPORT

DATE: November 30, 1961

	At beginning of month		At close of month		Total
	Exempt	Salaried	Exempt	Salaried	
Chemical R & D	125	118	128	118	246
Reactor & Fuels R & D	198	189	173	153	326
Physics & Instrument R & D	94	60	92	58	150
Biology	34	47	36	47	83
Operations Res. & Syn.	18	4	17	4	21
Radiation Protection	38	93	38	93	131
Laboratory Auxiliaries	34	134	32	132	164
Financial	19	16	19	16	35
Technical Administration	104	59	97	59	156
Programming	18	4	18	4	22
General	4	3	4	4	8
Test Reactor & Auxiliaries	—	—	35	71	106
TOTAL	686	727	689	759	1448

BUDGETS AND COSTS

November operating costs totaled $2,185,000; fiscal year-to-date costs are $11,431,000 or 42% of the $27,138,000 control budget. The budget has been increased by $800,000 to reflect the additional amount promised by Washington-AEC for operation of the PRTR. Hanford Laboratories research and development costs for November, compared with last month and the control budget are as follows:

(Dollars in Thousands)	COST Current Month	Previous Month	FY To Date	Budget	% Spent
HLO Programs					
02 Programs	$ 49	$ 53	$ 219	$ 605	36%
04 Programs	853	974	4 735	10 855	44
05 Programs	85	69	350	993	35
06 Programs	198	206	1 027	2 720	38
	1 185	1 302	6 331	15 173	42
FPD Sponsored	119	130	600	1 400	43
IPD Sponsored	96	112	543	1 325	41
CPD Sponsored	140	164	673	1 570	43
Total	$ 1 540	$ 1 708	$ 8 147	$19 468	41%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

Metallic NPR fuel irradiated to 3600 MWD/T in the KER loops showed a decrease in density of ca. 6%. Other specimens irradiated to 2400 MWD/T decreased approximately 2.4%.

Heat treatment studies show that although preferred orientation in the uranium metal is an important cause of warp following a first beta heat treatment, warp on subsequent heat treatment is determined more by variations in cladding and uranium tube wall thicknesses.

A device to intermix the three flow streams of the NPR fuel elements was designed and tested in the hydraulics laboratory. Mixing efficiency of the mixer was found by introducing salt solutions into entering flow streams and measuring concentrations in each of the flow streams leaving the device.

A UO_2 fuel rod containing a 1/8 inch diameter segregated oraloy piece placed adjacent to the jacket operated satisfactorily in the MTR for 16 days at full power. No evidence of hot-spot failure was apparent.

Three advanced-type UO_2 fuel elements--vibrationally compacted concentric tubular and 19-rod elements and a hot swaged 19-rod element--were successfully irradiated in the PRTR at full power. The irradiation testing continues.

A cold-swaged UO_2 element fabricated with central thermocouple wire was operated at 70 MW in PRTR and revealed a center line fuel temperature 200 C less than the value used as a design basis.

A photomosaic of the cross section of an irradiated loose powder UO_2 fuel element revealed sintering and grain growth similar to that observed in pelleted UO_2, irradiated at comparable heat ratings.

A cold swaged UO_2-PuO_2 seven-rod cluster is under irradiation in the ETR 3x3 loop. Sixteen irradiation capsules containing ZrO_2-PuO_2 and MgO-PuO_2 fuel material have been completed with the exception of the autoclaving.

Three Pu-Al irradiation specimens containing 6.25, 27.17, and 16.13 w/o plutonium-240 have completed their first cycle of irradiation in the MTR as a first step in the evaluation of the Phoenix concept. The 6.25 w/o plutonium-240 sample is now being irradiated for a second cycle.

No change in ID was noted in six PRTR process tubes monitored in-reactor during the month. The smallest gas gap (between the process tube and the shroud tube) was 90 mils for Tube 1857 (nominal is 270 mils, specified minimum is 50 mils).

A new facility for stress-rupture testing of unirradiated pressure tubes at elevated temperatures is being put into use. It includes six stations for stress-rupture tests, and two for burst tests.

A practical method of removing oil contamination from D_2O was developed. Approximately 4000 lb of D_2O was successfully cleaned to less than 0.1 ppm turbidity by coagulating the oil with an aluminum hydroxide floc and subsequent filtration.

During measurements of the temperature drops through aluminum corrosion films in deionized water at 600 F, the oxide films built up in thickness and then flaked off during times of temperature cycling.

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Samples of EGCR graphite have been successfully irradiated in the GETR to 60,000 MWD/AT. Samples of NPR graphite will be charged into the GETR during the November 27 shutdown to start long-term proof test irradiations.

In research on the swelling phenomenon, low burnup uranium specimens showed marked increases in porosity along the grain boundaries after annealing at 615 C, but at 575 C very little effect was observed. A drastic increase in fission product gas mobility near 600 C is inferred.

A creep test in-reactor was successfully initiated on a 20% cold worked Zircaloy-2 specimen. Incorporation of water cooling coils in the creep capsule has alleviated excess gamma heating problems. At the test temperature of 310 C an initial creep rate less than the ex-reactor rate was observed. After 300 hours at a stress of 30,000 psi the rate is 2.2×10^{-6} in/in/hr. The ex-reactor rate for comparable conditions is 2.7×10^{-6} in/in/hr.

Irradiation at 75 C to 10^{19} and 10^{20} nvt (fast) causes minimum plastic stability in the transverse direction for annealed Zircaloy-2. The point of instability, defined as the limit of uniform strain, is at a considerably higher strain value in the longitudinal direction. Cold working prior to irradiation was observed to reduce the effect of irradiation on plastic instability in the transverse direction.

An exposure of 10^{17} nvt (fast) was found to have different effects on cold worked and stress relieved molybdenum foils. The cold worked foil showed a slight increase in x-ray lattice parameter while the stress relieved material showed no change.

Fourteen boiling burnout points were determined in the laboratory with an electrically heated model of a 19-rod bundle fuel element. The burnout heat fluxes found were roughly the same magnitude as those found with test sections consisting of a single tube. This indicates that severe penalties need not be paid in the form of reduced heat fluxes or lowered burnout safety factors when using 19-rod bundles as fuel elements in nuclear reactors.

2. Chemical Research and Development

In laboratory tests simulating reactor water-treatment processes, 20 ppm alum was found to be optimum for the removal of water impurity colloids. At this alum concentration, the alum floc and primary colloids form agglomerates which are large enough to settle rapidly or to be easily filterable.

Adsorption of P-32 and As-76 as phosphate and arsenate from process water onto aluminum turnings was studied under conditions which simulated those of reactor operations. The addition of sodium silicate at a concentration of 10 to 50 ppm as silicon reduced the adsorption of these isotopes by three orders of magnitude.

Preliminary measurements indicate the seepage of thermally warm (130 F) spring water into the 181-B forebay effects an approximate five degree rise in the intake water temperature. This and other measurements indicate that the warm water seepage corresponds to about six to nine per cent of the total influent volume.

A chromatographic ion exchange process was demonstrated for the recovery and purification of promethium-147. A total of 26,600 curies of Pm-147 was obtained. The product was radiochemically pure but contained some (non-radioactive) samarium and neodymium.

Studies of the extraction of cesium-137 from synthetic 103-A Purex waste supernate by dipicrylamine have revealed that the extraction efficiency is grossly affected by temperature. The extraction of cesium-137 is improved about six-fold when the temperature of the system is lowered from 50 to 6 C.

Measurements were made at various temperatures and in the presence of inert and oxidizing atmospheres to determine the release of radiocerium, euthenium and zirconium from the sodium cerium sulfate salt which is to be used for the offsite shipment of kilocurie quantities of Ce-144. Maximum measured releases for cerium, ruthenium and zirconium were 0.11, 3 and 5.5 per cent, respectively.

Tests indicate that the double bellows jiggler ion exchange column is a competitor to the Higgins unit as a semi-continuous contactor. The jiggler unit contains no internal valves.

Laboratory data have been obtained to show that strontium and rare earths can be extracted from formaldehyde-treated Purex wastes using di-2-ethylhexyl phosphoric acid in the solvent. Inerts (chromium, iron, sodium, aluminum) and unwanted fission products (zirconium, niobium, ruthenium) are not appreciably extracted.

Final material balances on the overall strontium-90 recovery program in the Hot Semiworks indicate that 745,000 curies of strontium-90 which met product specifications and 170,000 curies of strontium-90 requiring some further purification were recovered from a total input of 1,180,000 curies.

The HAPO I Fission Product Shipping Cask (for cerium-144) was loaded and unloaded successfully using a slurry of non-radioactive $Na_2SO_4 \cdot Ce_2(SO_4) \cdot 2H_2O$ and finely divided copper powder as feed, and 4 $\underline{M}$ HNO_3 as dissolvent. Capacity of the filter cask exceeded the design capacity.

A neutron multiplication instrument has been tested in the laboratory as a monitor to detect approach to criticality. Both a solid state neutron detector and a conventional BF_3 counter are under study.

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In the advanced process control studies it has been shown that the C-column can be represented by a mathematical model which has the characteristics necessary to represent experimental profile data. Coefficients of the simultaneous differential equations were determined using the analog computer.

Cathodically produced deposits of two to three gram UO_2 crystals can be consistently prepared at 550 C in the $PbCl_2$-2.5 KCl system. Impurity levels in these large crystals are as low as 20 ppm Pb and 10 ppm K. Other studies indicate the LiCl-KCl system to be suitable for the growth of large, ceramic grade UO_2 crystals; and the crystal growth characteristics may depend strongly on the uranium concentration in the melt, formation of the larger crystals being favored by high uranium concentrations.

Equilibrium experiments with clinoptilolite show that cesium is readily extracted from synthetic, formaldehyde-treated IWW waste at a pH as low as 1.0.

A Micro Pilot Plant run was completed in which the decontamination performance of a cation resin (Amberlite IR-120) followed in series by a mineral (clinoptilolite) was evaluated. Optimum removal of cesium-137 and strontium-90 from Purex condensate waste occurred at about pH 4; cesium was largely removed by clinoptilolite while strontium was primarily removed by the organic resin.

Measurements were made on the kinetics of erythrocyte hemolysis in isotonic solutions following absorption of gamma radiation. Erioglaucine at a concentration of 5×10^{-6} M and several amino acids at 5×10^{-5} M were found to protect the erythrocytes from radiation-induced hemolysis.

3. Physics and Instrument Research and Development

A reactivity increase will occur in the NPR if water gets into the annular steam vents around the process tubes. This expected effect was determined by exponential pile measurements to be 15% increase in buckling when the steam vents are half-filled with water. This corresponds to an increase in k_{eff} of about 1%.

IPD is being aided through a technical review and audit of the NPR primary flow monitor and the total instrumentation system for the Heat Exchanger Building.

The reactor automatic control studies being conducted jointly with IPD moved forward with approval of a Production Test which authorizes experiments to obtain in-core neutron flux data as a function of control rod position. Test equipment will be installed at 105-KW during the next scheduled reactor outage.

Buckling measurements continued on a C-reactor mockup lattice. This work is a portion of a program to establish the safety of an overbored C-reactor during a flooding accident.

Measurements of the critical mass of plutonium nitrate solutions continued in the Critical Mass Laboratory. The effect of the vessel walls on criticality was determined. Roughly speaking, the critical volume of a reflected assembly would have been lower by a volume equal to the stainless steel vessel wall volume if the walls had not been present.

In the correlation of theory with experiment, calculations were extended to include plutonium nitrate solutions. The results cover concentrations ranging from 30 to 700 grams per liter. Initial comparisons indicate agreement with critical masses measured to date. More detailed comparisons are being made.

An analog simulation of a chemical separations pulse column is being developed to guide process improvement. The first of four possible mathematical models of varying complexity to be tried gave results in reasonably satisfactory agreement with experimental data.

In the Plutonium Recycle Program, a practical method for handling the non-linear aspects of equations giving isotopic changes with exposure has been developed. The method, involving a new approach to the coding of this general type of problem for machine solution, will handle the equations in a simple and reliable manner with improved accuracy and represents a significant advance over MELEAGER.

Measurements of the fuel temperature coefficient of 1.8 w/o LX PuAl were under way in the PCTR. Data have been taken for fuel temperatures up to 450°C. Preliminary data indicate that the variation in reactivity with temperature is extremely small.

In other calculational developments, a multi-group code HFN, was successfully applied to several test cases in preparation for its use in studies of plutonium "value" in breeders. The same code, however, encountered difficulties in application to a thermal, graphite-moderated reactor problem. Difficulties with the Monte-Carlo portion of RBU were also experienced in application to a test case.

Further computations regarding breeder-type extended-lifetime neutron flux monitors showed that the optimal initial composition for a detector located in graphite moderator is U-235:Pu-240 = 6:4; and for a detector located in a fuel channel it is U-235:Pu-239:Pu-240 = 5:1:4.

An invention report was filed on "A Quantitative Method for Mapping and Displaying Values of a Variable," a mapping system developed for the nondestructive test for heat transfer quality of fuel core-to-cladding bonds.

Some exploratory experiments showed it may be possible, with microwave techniques, to detect certain types of defects on the inside surfaces of fuel sheath tubes.

Some improvement has been obtained in the uniformity of low-energy gamma response with a new thermoluminescent dosimeter design. The response of the best of four tested varied less than ± 25% over the energy range 34 to 100 kev.

An automatic system was developed for recording on punched paper tape the digitized data from dimensional measurements on NPR fuel elements.

Satisfactory results were obtained from tests of the alpha and beta detection systems for the Automatic Laundry Monitor which is under development.

Provision of extensive nondestructive tests and evaluations of destructive tests on NPR primary piping continued as a high-priority technical assistance service to IPD.

Analysis of dispersion data from atmospheric tracer studies will be facilitated by the successful separation of diffusion and wind direction trend effects on the measured horizontal growth of the plume. Data, which heretofore had not stratified according to the customary meteorological variables, were found to separate nicely into two groups according to the presence or absence of wind direction trend, the trend effect diminishing with distance as the scale length of effective eddies increased.

In the area of experimental techniques, a basic contribution to the fast neutron cross section field may result from the development of a high resolution neutron detector system. Measurements of total cross sections from 3 to 15 Mev with at least two per cent precision and a time resolution of 0.4 ns/m were indicated to be possible.

4. Biology

More than 2,000 waterfowl heads have been collected from sportsmen in the sampling program that includes the States of Washington, Oregon, and California.

Zinc was found to markedly increase the gut absorption ratio of strontium to calcium. This was done in perfusion studies. An explanation for the phenomenon is not apparent.

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Other changes in strontium and calcium relationships were found in studies of milk and blood plasma. With time, after lactation in ewes begins, the transfer of both strontium and calcium to the milk increases, such that there is increasing difference in concentrations of the two ions in milk and plasma.

TTHA orally fed at doses that are possibly practical for humans appears to be effective for plutonium.

Fish can survive up to two days in water containing 50 per cent D_2O. In 25 per cent D_2O, fish appear reasonably pleased with their environment.

5. Programming

At AEC's request, 725 different uranium price schedules were computed and printed in tabular form. The output includes the cost components and total uranium cost as a function of U-235 enrichment for all combinations of separative duty and natural uranium costs in five per cent increments for 50 to 170 per cent of the values making up the post-July 1, 1961, uranium price schedules and a few additional special cases.

A preliminary production cost estimate of about $50 per pound of purified mercury-204 isotope (1 barn cross section mixture) was developed for the monoisotopic photosensitization process. Little technical data is available on this process generally; and particularly, with regard to separating Hg-204 which involves separating the high nuclear cross section (2500 barns) Hg-199 isotope whose 2537°A line hyperfine structure overlaps that of Hg-204. Such interference does not exist for the other low thermal cross section ($\approx$ 2.5 barns) Hg-202 isotope; and separations costs less than $50 per pound could be expected for 3-barn mixtures which may have considerable use.

TECHNICAL AND OTHER SERVICES

A new attack on constructing a mathematical model of the fuel element fabrication and scheduling process has produced a totally linear model fully equivalent to previous models which contained nonlinear restrictions. The new system is now being studied by Manufacturing Studies, Fuels Preparation Department.

All reactor management except D have been informed of the proposed computer simulation of reactor operations. Each area was visited during the month to describe the general scope and information requirements, and to introduce the personnel who will be performing the work.

Work continued on the problem of computing probabilities of detecting cracks in welded primary piping for the NPR Project.

Attention is being given the measurement requirements to demonstrate conformance to purity specifications for the final product. It appears that part-by-part inspection may have to be discontinued for models having high production rates due to limitations in analytical work loads. Alternate means of assuring acceptable product quality are under investigation.

Five new cases of plutonium deposition were confirmed by bioassay analysis during the month. In all instances the deposition was estimated to be less than one per cent of the maximum permissible body burden. The total number of plutonium deposition cases that have occurred at Hanford is 277, of which 201 are currently employed.

The highest concentration of filterable beta emitters measured locally in air since the resumption of weapons testing occurred on November 13-14, and was 110 $\mu\mu c/m^3$. Subsequent measurements have been in the range of 5 to 10 $\mu\mu c/m^3$ which is comparable with values throughout the Northwest and about 100 times the pretest level.

The limited volume capacity of the 307 retention basins, which intercept low level waste from several of the HLO buildings prior to release to leaching trenches, necessitated trucking of some 40,000 gallons of off-standard waste to the 200 West crib.

Whole body exposure in excess of 1 r during a four-week period was received by two individuals during November. A minor construction employee accumulated a dose of 1.1 r in small daily increments while working in an effluent basin. An HLO employee of the Physical Testing Operation similarly received a dose of 1.1 r during the four-week film dosimeter period.

There are 17 currently active projects having combined authorized funds in the amount of $5,864,000. The total estimated cost of these projects is $10,717,000. Total expenditures on them through October 31, 1961 were $2,665,000. In addition project proposals have been submitted to the Commission requesting $224,000 total project funds on two new projects.

Project CAH-914, Rattlesnake Springs Radioecology Facility was completed during the month. Estimated final cost is $89,000 compared to authorized funds of $90,000. Completion was November 20, 1961.

Project CAH-896, Stress Rupture Test Facility, was completed during the month. Estimated final cost is $85,000 compared to authorized funds of $90,000. Completion was November 3, 1961.

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SUPPORTING FUNCTIONS

PRTR operated for a total of 653 MWD during the month for a plant operating efficiency of 31%. Heavy water loss totalled 3200 pounds for a chargeable operating cost of $46,000. Helium loss was 205,000 scf. Three additional UO_2 elements were exchanged for plutonium bringing the core inventory to 39 Pu-Al and 46 UO_2. Difficulties were experienced with the performance of primary pumps, helium compressors, and some of the instrumentation.

Excellent control of equipment by the Biology Operation was evidenced by the recent physical inventory. All 828 items of movable catalogued equipment were accounted for.

Advanced Degree - One Ph.D. applicant visited for an employment interview. Two offers were extended (one for HL), no acceptances occurred and two rejections (both HL) were received. Current open offers total three. During November, 12 universities were visited by HAPO personnel for the purpose of Ph.D. recruiting.

Technical Graduate Program - Six Technical Graduates were placed on permanent assignment and two terminated. One new Technical Graduate was added to the payroll. Current program members total 76.

The Advanced Engineering "A" Course now has an enrollment of 20 students consisting of 7 permanent HAPO men, 12 Engineering and Science Program men, and 1 Technical Graduate. A permanent employee dropped the course during November.

Continuing assistance is being given exempt employees affected by work reductions. The Boeing Company visited HAPO during the month and at month end had extended offers to 12 employees.

Paul F. Gast

for Manager
Hanford Laboratories

HM Parker:PFG:st

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REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Resistance Changes in ZrO_2 Films. Electrical resistance is currently being studied as a means for monitoring the protective condition of zirconium oxide films in hydrogen containing atmospheres.

A major problem in measuring the resistance drop across the ZrO_2 film on a piece of Zircaloy is making a reproducible contact. During the past month a number of contacts were tried including platinum wire, $Ni_{0.9}Li_{0.1}O$ powder, $Ti_{0.1}Fe_{1.9}O_3$ powder and graphite. Of these, the graphite has the best combination of mechanical and electrical properties and still allows diffusion of water vapor to the oxide surface under the contact.

Diffusion of Copper in Coextruded Zircaloy-2. Experimental measurements show that copper diffuses into Zircaloy to a depth of approximately 1-1/4 mils during the coextrusion process. The copper concentration diminishes rapidly from the Zircaloy surface to this depth.

The copper concentrations at various depths in the Zircaloy-2 were determined by etching 1/2-mil increments from coextruded Zircaloy tubes following surface copper removal. Fresh nitric - HF etch solution was used to dissolve each increment. The etch solutions were then analyzed for copper. The analyses showed that up to 1/2-mil depths the Zircaloy-2 contained 76,000 ppm copper as compared with 400 ppm of copper at a depth of 1/2 to 1 mil and 80 ppm of copper at a depth of 1 to 1-1/2 mils. The 80 ppm is still slightly higher than the residual copper which is present in the Zircaloy-2.

These results show that at least 1-1/2 mils of Zircaloy surface must be removed in order to eliminate the copper-contaminated surface layer. Corrosion studies of Zircaloy samples copper plated and annealed (January 1960 Monthly Report) showed that corrosion rates were substantially higher as a result of the copper contamination, unless the copper-contaminated layer was first removed by etching.

Corrosion Evaluation of Zr Alloys Fabricated at HLO. The corrosion resistance of thirteen experimental zirconium-base alloys fabricated at Hanford is being determined in 360 C water and 400 C steam. The alloys are being tested in the cold-rolled (20 percent cold work) condition and annealed (750 C, 2 hours) condition.

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Based on corrosion data to 43 days at 400 C and 30 days at 360 C, the alloys which exhibit the best corrosion resistance are those which approximate the composition of Zircaloy-2, and the alloys of low Nb and V content.

The effect of annealing was especially striking in the case of the 1.0 percent V alloy. Annealing produced a three-fold decrease in corrosion at 400 C and a 60-fold decrease at 360 C. Some alloys exhibit better corrosion resistance in 400 C steam than in 300 C water. Examples of this are the 1.0 V alloy, the 0.5 Cu, 0.5 Mo alloy, and the 1.0 Cr, 0.5 Nb, 0.1 V alloy.

Based on the corrosion data to date, it appears that the corrosion behavior of HLO fabricated sample stock is comparable with commercially prepared alloys of the same composition.

Dynamic Autoclave Tests on Electroless Nickel Aluminum Specimens. Corrosion tests have been started on 1245 and X-8001 coupons coated with electroless nickel. Inch-square coupons were pre-autoclaved and heat treated at 300 C before dynamic testing in 300 C, pH 10 water at 25 ft/sec flow rate. Coupons will be removed periodically and examined for failure of the protective nickel film. Changes in weight are also being followed. In the initial exposure, all eight specimens lost 3 to 4 milligrams during a 72-hour test. Total weight loss represented about 1 to 2% of the total nickel film weight. Partial loss of the film formed during autoclaving has been observed. Otherwise, no evidence of failure or changes in appearance of the specimens was observed.

Experimental Aluminum Cans and Spires. Samples of two experimental alloy lots of cans and spires have been in test in 360 C water for two months. The two alloy compositions are 1.0% Ni, 0.5% Fe, 0.1% Ti in 99.995 percent pure aluminum (CA72), and 1.0% Ni, 0.5% Fe, 0.1% Ti in commercial purity aluminum (C-810). During the first month of exposure the corrosion of both alloys was similar. At two months of exposure the corrosion of the CA72 had decreased to the low rate seen previously with high purity alloys. The corrosion of the C-810 was still comparable to that of X-8001 at two months. The advantage of the C-810 alloy over X-8001 has previously been determined as a longer induction time and the exposures to date have not been long enough to establish the induction point of this lot of material. No differences have been noted between the corrosion of can material and spires for either alloy.

Radiometallurgy Laboratory Studies

Examination of one NIN element exposed to 2000 MWD/T at simulated NPR conditions in the KER facility showed the end closure to be in excellent condition with the brazed layer intact and well bonded to the uranium. It appeared that improper welds may have caused the loss of support tabs (RM 587). A 22" long KER size tube-in-tube element irradiated in the ETR 6x9 loop was examined and appears to be in good condition (RM 589). A composite of the complete transverse section from NaK swelling capsule 14-97 was made (RM 565).

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

Basic Metallurgy Studies

Notch Sensitivity of Zircaloy-2. The mechanical behavior of Zircaloy-2 cladding, in particular, the effects of wall irregularities on the plastic deformation and strength of the cladding, is being investigated with tensile tests at 280 C. Results obtained with notches of large radius indicate negligible strengthening and greater reduction in elongation than with sharper notches. Test data for large radius notches display more scatter in elongation and strength values than sharp notch specimens. Initial results on multiple notch specimens indicate that considerably more elongation is associated with a double notch specimen than with a single notch.

All components for three capsules have been fabricated for a one-cycle irradiation in the ETR. V-notch samples from rolled Zircaloy-2 plate and cladding material as-extruded on N elements are being prepared for capsule loading.

Metallic Fuel Development

Charging Force Studies for Present Reactors. A test set up has been designed and fabricated to determine charging forces for fuel elements; particularly of overbore geometry. Tests have been made using one, two and four overbore size (2.140-inch diameter support circle) fuel elements in a 2.145-inch diameter aluminum process tube. The elements were used in "reactor chargeable" condition, and the process tube was of "reactor service" quality. Tests were performed using water for lubrication.

Incipient galling of the tube was seen after the single element was charged. After charging two elements the galling increased, and after a four element charge considerable galling was seen. All elements in this series were oriented so the supports of each element contacted the same area on the process tube.

Fuel Irradiations. Irradiation of the full-sized NPR tube-in-tube fuel element in the 6x6-M3 loop in the ETR has continued with the loop outlet temperature being maintained at 271 C. Maximum surface temperature is approximately 300 C. At the end of the current reactor cycle on November 13, the average total exposure was approximately 300 MWD/T.

During the outage following the end of the cycle, the fuel element was removed from the reactor and disassembled, and diameter and warp measurements were made. The outer diameter of the inner tube was one mil greater than when the piece was charged and it had warped 25 mils toward the center of the reactor core. Warp measurements on the outer tube showed that it had warped 50 mils toward the center of the reactor core. When the fuel element is recharged into the reactor it will be rotated 180 degrees to see if the warp will reverse itself.

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Post-irradiation fuel density measurements have been made on samples from KSE-3 single tube elements irradiated to 3600 MWD/T. Fuel from an undistorted section of the tube wall decreased 5.8 percent in density while fuel from a distorted section of the tube wall (produced by inner bore buckling) decreased 6.5 percent in density.

Measurements made on three NIE's (prototype NPR inner tubes) irradiated to 2400 MWD/T show an average fuel swelling of 2.36 percent. This value compares favorably with data obtained on other elements at similar exposures.

Irradiation has continued into the last of six cycles scheduled on the production brazed irradiation test, GEH-4-63, 64, in the GEH-4 loop of the MTR. The test is operating at a specific power of 62 kw/ft and should have a burnup of approximately 1390 MWD/T at the end of this cycle. The cycle should be complete and the test discharged by the end of November.

Another test, GEH-4-68, 69, 70, the variable braze thickness irradiation test, has been approved by the Reactor Safeguards Committee and is scheduled to go into the GEH-4 loop of the MTR at the end of November. Five cycles have been requested.

Metallographic examination of the Zircaloy-2 capsule which failed in DR Reactor by severe overheating reveals a beta Zircaloy-2 structure in the tubular capsule body. The structure extends from the inner surface through about 25 percent of the wall thickness. Assigning the beta to alpha + beta transformation temperature of approximately 950 C to the inner surface of the capsule would give an outer surface temperature of 700 C. At temperatures in this range, corrosion through the capsule wall in four days is not unexpected. Of the seven additional capsules being readied for charging in DR Reactor, two have been rejected for questionable welds.

Single Tube Fuel Element. Several experimental fuel elements are being fabricated for an evaluation of the single tube, dual enriched fuel element concept. The fabrication steps of extrusion, recessing, and end closure brazing have been completed. Fabrication was completed on the basket and other accessories. One element is to be irradiated in the ETR 6x6-M3 loop. Using a dummy fuel element and the basket assembly, a flow test was run to determine the flow conditions of the experiment. In the ETR irradiation the fuel element is expected to operate at a maximum specific power comparable to N Reactor conditions.

Metallic Fuel Measurement. Methods of numerically analyzing measurements of radial displacements and thicknesses of tubular elements have been developed. The resulting equations have been programmed and the program output approved. Programming Operation is writing an input subroutine to read data from punched paper tape and a storage routine which will store records on magnetic tape. The program is called TUM. The document describing the numerical analysis, HW-71521, has been published.

Thermocoupled Elements. The first of the new design thermocoupled fuel rods has been completed and sent to IPD. This fuel rod is one inch OD, has a 25-mil thick Zircaloy-2 jacket, 1.6 percent enriched uranium and a 0.465-inch diameter Zircaloy-2 core in the center. The end caps were brazed in place using the standard Be-Zr braze. This fuel element is to be charged into KER Loop 1 to measure crud-film effects on fuel element temperatures and to determine if a thermocoupled fuel rod of this type can be used to monitor crud-film deposition.

Heat Treatment Studies. Sections of Zircaloy-2 clad, I&E fuel with 0.94 percent enriched, Fe-Si additive uranium cores were heated at a series of alpha phase temperatures and times before subsequent beta heat treatment to determine the effect of Fe-Si alpha solubility and degree of precipitation on beta treated grain size. These studies were completed and have shown:

(1) Slight refinement in beta treated grain size as a result of two 16-hour soaks at 950 F (510 C) to 1050 F (565 C) prior to beta treatment;

(2) Alpha grain growth occurs at 1150-1200 F (620-650 C) with pronounced growth of the precipitate on preferred crystallographic planes;

(3) The beta treated grain size is increased as a result of the high alpha temperature pre-treatments.

Room temperature warp measurements have been completed on a group of Zircaloy-2 clad NPR inner tubes after their third beta heat treatment and on a group of bare uranium tubes of the NPR inner tube geometry after their second beta heat treatment. Comparison of these data with the warp data from the previous heat treatments indicates that the Zircaloy-2 clad tubes have increased their total warp with each heat treatment while the bare uranium tubes showed a marked increase in warp on the first heat treatment over the as-extruded warp, but on subsequent heat treatment decreased in warp. The following tentative conclusions have been based on the warp data taken on these tubes to date:

(1) Differences in preferred orientation and/or residual stresses are a major cause of warp on the first beta heat treatment.

(2) The cladding can be beneficial in restraining the warp on the first heat treatment.

(3) Differences in clad thicknesses and differences in tube wall thicknesses are the major causes of warp on subsequent heat treatments.

Extrusion Behavior of Zirconium Alloys. A series of zirconium alloys being prepared by double vacuum arc melting will be used to determine

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extrusion constant versus temperature data, resulting structure, mechanical properties, and corrosion behavior. The object of the work is to determine whether a corrosion resistant alloy with extrusion characteristics more nearly matching the extrusion behavior of uranium, and with greater ductility than Zircaloy-2, can be developed by altering the tin and oxygen content of a nominal Zircaloy-2 composition. Two zirconium sponge blends are being used to yield a high (1300 ppm) and low (560 ppm) oxygen content and for each blend the tin content is being varied from 0.10 to 1.50 w/o. The iron, nickel, and chromium contents are being held at the nominal Zircaloy-2 composition.

The ingot hardness for these alloys completed through final machining and conditioning is shown in the following table. It is interesting to note that the oxygen content has a greater hardening effect than the tin addition. Samples have been submitted for chemistry of these melts.

Ingot Hardness-Zr-Sn Alloys

Ingot No.	Nominal Composition		BHN*
61	Zr	Low O_2	121
59	0.1% Sn	"	148**
87	0.25% Sn	"	130
85	0.50% Sn	"	137
86	1.00% Sn	"	143
84	1.50% Sn	"	153
60	Zr	High O_2	166
91	1.00% Sn	"	181

*3000 Kg load.
**Ingot surface completely fusion conditioned.

Melting of the ingots for this program is virtually complete, the one ingot remaining will be melted late in November. The necessity for side wall fusion conditioning has been eliminated through the use of higher melting currents. Four thousand amps and 34 volts will produce a side wall requiring about 1/32 to 1/16 inch of machining for 100 percent cleanup.

Closure Development. Work was continued on the projection welded brazed closure on Zircaloy-2 clad NPR inner tubes (1.260-inch OD by 0.430-inch ID) to determine the welding conditions to give the optimum projection weld and Zircaloy-2 cap to uranium bond. The 600 KVA resistance welding machine was used in making the closures. Destructive examination of a closure which appeared to be nearly 100% bonded by ultrasonic examination showed a good metallurgical bond between the cap and the uranium; however, the projection weld was not fused entirely across the projection interface. The projection weld can probably be improved by a slightly higher weld power setting.

One closure which was approximately 85 to 90% bonded as shown by ultrasonic examination was given the standard beta heat treatment to determine the effect of the heat treatment on a poor cap to uranium bond. The post heat treatment examination showed that the bond between the cap and the uranium on the ID on the cap wedge was not appreciably affected; however, the unbonded area on the OD of the wedge was more than doubled in size. The upset problem which had been encountered from the closure process on the OD of the element between the welding collet and the retaining ring has been reduced somewhat by altering the collet and using a different retaining ring and weld pressure setting. The upset may be completely eliminated with a collet of different design now being fabricated.

Twelve closures of the NPR "self-brazing" type, with cathodically etched V-shaped uranium/Zircaloy interfaces, having ID and OD bonds of copper plated on the cap sidewalls, were processed to completion and ultrasonically tested. The uranium/Zircaloy bonds were indicated generally sound, but the Zircaloy/Zircaloy sidewall bonds were generally spotty. Considering the rough, striated surface condition of the Zircaloy cladding where it contacts the cap, it is not surprising that some of the valleys between ridges fail to fill in completely with the Zr-Cu braze alloy generated in situ, leaving small discontinuities which are detected by the ultrasonic beam, and which represent potential channels for access of water to the core material. Another group of specimens is in preparation, similar to the above-mentioned group, but with close attention to snugness of fit of the cap in the end grooves. The rough faying surfaces of the sidewalls have been smoothed to aid in filling in with the self-generated braze material. A tool to press the cladding more firmly against the cap walls during hot pressing has been devised for trial.

NPR inner fuel elements have been fabricated for a production test to compare the irradiation performances of braze bonded versus unbonded tapered end cap closures. The caps in both cases are Zr-2 rings with cross sections consisting of a rectangle plus a 60 degree included angle taper in the axial direction. Mating cavities are machined into the fuel ends by a combination of acid and mechanical milling. The tapered portion of the cap extends into the uranium. The bonded closures are brazed and welded in accordance with current NPR fuel specifications. The unbonded pieces are vacuum electron beam welded.

An N inner fuel component is permitted by production specifications to vary in wall thickness as much as 0.024 inch. Concentric Zircaloy end caps machined to fit the OD must be correspondingly enlarged on the ID, and thus a gap of 0.024 inch may exist between the cap and the inner clad. This variable gap has caused inconsistent results in attempts to solid state bond end caps to the fuel cladding. A sizing die has been designed to slightly enlarge the ID clad diameter, after counterboring for the cap, and to improve the concentricity of the projecting clad walls. Results show that eccentricity of the inner and outer projecting clad walls can be reduced to 0.002 inch total indicator reading. Further closure bonding studies will be carried out utilizing fuel samples subjected to sizing prior to closure.

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Support Development. A proof run of N Reactor inner fuel tube supports, as furnished by the vendor, were mechanically tested. The supports were made from 0.030 inch thick Zircaloy-2, the maximum thickness the vendor's existing equipment could form without cracking. Tests of these supports in the "as fabricated" thickness and in the "as final" etched thickness, 0.026 inch, showed the elastic stiffness to vary as the cube of thickness. An "as etched" thickness of 0.033 inch is needed to achieve the required elastic stiffness and would increase the plastic strength to a value well above the minimum requirements of specification in HW-65023. Results of warm bend tests on Zircaloy-2 strip show that equipment that will form 0.030 inch thick Zircaloy-2 at room temperature should easily form 0.035 inch thick material if the strip and forming dies are heated to 200 C. Similar mechanical tests on the first proof run of outer fuel tube supports showed that the 0.010 inch steel shoe increased the crushing strength 45 percent. These tests also revealed the need for minor shape changes to improve crushing strength.

The machine settings required to produce support attachment welds conforming to process specification CX565.2.2, the present supports, fuel and tooling are now established. These specifications define weld strength and penetration limits. Metallographic examination during the month showed the penetration to be within limits. Adequate strength was shown by previous shear tests. An electrode which attaches both sections of the locking clip simultaneously has been fabricated and is being installed on the spike welder in the 306 Building.

2. REACTOR PROGRAM

Corrosion and Coolant Systems Development

Diffusion of Water Vapor in NPR Core Graphite. Diffusion data for H_2O vapor through NPR core graphite were obtained using 650 C and 800 C graphite and various concentrations of CO, CO_2, and H_2O added to helium. These data confirmed earlier observations that CO_2 increases but CO decreases the water transport rate. It has been demonstrated that addition of the proper concentration of CO_2 along with the CO counteracts the inhibiting effect of CO on the rate of water transport through the graphite. Preliminary data for a second graphite thimble cut from another block of NPR graphite indicate about the same, to slightly higher, water transport rates as measured for the first thimble under similar conditions.

NPR Fuel Rupture Testing in the IRP. Two rupture tests were made with co-extruded uranium - Zircaloy-2 tubes (KSE-3) which had been irradiated to 2000 MWD/T in KER at 242 C. The first tube was subjected to a rapid cool down (held 5 minutes at 300 C and then reduced to 160 C within 4 minutes) after detection of the rupture. This element had an incubation time of 86 minutes. The final activity which was recorded in the loop filter was 9.7 R/hr. When discharging the element in the 105 KE basin it was seen that the element had a bulge about two to three inches long and about 1-1/2 inches wide.

The other 2000 MWD/T tube was subjected to a slow cool down following a 62-minute incubation period. The final activity of this piece was 131 R/hr at the loop filter (this was the highest reading which had been obtained on any of the rupture tests). This element was very badly ruptured for about 9 inches in length. The entire circumference was ruptured and the element would not fit into a 2-1/8" ID rupture can (original outside diameter of the element was 1.739 inches).

A third rupture test was made with a similar KSE-3 tube which had been irradiated to 3555 MWD/T in KER at 190 C. This element had an unusually long incubation time of 160 minutes. A fast cool down was used following the rupture detection. Final activity readings at the loop filter were 5.2 R/hr.

Analysis for Hydrogen in Cooling Water. Improved procedures are now being used to measure hydrogen concentrations in KER-1 coolant samples. Data obtained to date for four coolant samples indicate that the gas concentration is about 4 to 5 cubic centimeters (STP) per liter of coolant and the average hydrogen concentration is about 0.5 cubic centimeters per liter.

Corrosion Testing. The corrosion of carbon steel, stainless steel, and Zircaloy-2 in recirculating deoxygenated water at 300 C and pH 9.0 is comparable to corrosion under the same conditions except at pH 10.0. The rates were: carbon steel, 0.1 mil/year; stainless steel, 0.06 mil/year; and Zircaloy-2, $<$ 0.01 mil/year. Some slight indication of crevice attack was apparent at the edges of the samples.

In raw Columbia River water at 210 F, the corrosion rate of carbon steel was approximately 6.5 mils/year. The carbon steel samples were uniformly pitted over the entire surface. The 70-30 CuNi alloy exhibited a corrosion rate of 0.08 mil/year with no evidence of pitting.

Corrosion of Stellite by Permanganate and Alkali. The corrosion of Haynes Stellite alloys in $KMnO_4$ solutions was negligible and no pitting was observed on the photomicrographs. However, using a constant $KMnO_4$ concentration and varying the NaOH concentration, deniritic pitting was observed. The attack calculated on a uniform basis increased with increasing NaOH concentration and the photomicrographs indicate that the pitting also deepens with the increase in concentration. Further evaluations are under way using constant NaOH and varied $KMnO_4$ concentrations.

Hydriding of Zircaloy-2 in Nitric Acid Solutions. No increase in hydride in Zircaloy-2 samples was caused by contact with rapidly corroding steel at 95 C. Steel wires, held against the Zircaloy pieces by spring tension, were corroded in various HNO_3 solutions to nearly complete dissolution of the steel. "Scars" of iron rust were left on the Zircaloy samples. Hydride needles were detected in all Zircaloy samples but were uniformly distributed, with hydride content less than, or nearly equal to, 20 ppm. No denser population of hydride was noted at the rust "scars".

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Non-Uniform Corrosion of AMS 5616. The evaluation of AMS 5616 (Greek Ascoloy) as a suitable material for NPR diversion valve components continued during the month. After seven cyclic decontaminations in alkaline permanganate and Bifulf-18 the stressed samples were examined under the microscope. Samples heat treated to 32 Rc (NPR specifications) did not exhibit cracking but were covered with a large number of pits 1 to 5 mils deep. In general these pits were not connected, but in some cases series of pits formed grooves parallel to the longitudinal axis of the specimen.

Effluent Activity and Corrosion Testing in Single-Pass Tubes. Three effluent activity tests in SP-7 and 8 were completed. These involved addition of EDTA, phosphate, and citrate, respectively, to process water in SP-7 and comparison with process water in SP-8. Another series of effluent activity tests is ready to start in SP-3 and 4. These will include additions of silicate, carbonate, and calcium to process water. The required chemical addition facilities must be relocated from SP-7 and 8.

Structural Materials Development

Pressure Tube Burst Test Facilities. The facility for stress-rupture testing of unirradiated pressure tubes constructed under Project CAH-895 was formally accepted from the contractor by the AEC with only minor exceptions. Startup tests are in progress and initial stress-rupture testing should commence during December. Architectural design was initiated under Project CAH-922 for a facility to burst-test irradiated pressure tubing at elevated temperature.

Nonmetallic Materials Development

NPR Graphite Irradiations. The long-term proof test irradiation of NPR graphite has now been approved by the AEC, and initial irradiation of the H-4-1 capsule will begin this cycle (Cycle 29) in the D-7 position of the GETR. This experiment will determine long-term radiation damage effects to NPR moderator graphite in a manner analogous to that used for the H-3 series EGCR experiments.

Thermal Diffusivity of Graphite. The thermal diffusivity of a transverse TSX graphite sample was measured at temperatures from 25 to 675 C by the flash method. Measurements were made at 50 C intervals by controlling an electrically heated furnace which surrounded the sample. Values of the thermal diffusivity, specific heat, and density, decreased from 0.25 cal/cm sec $^{\circ}$C at 25 C to 0.13 cal/cm sec $^{\circ}$C at 675 C. A preamplifier has been added to the apparatus and measurements have been started on a parallel sample of TSX graphite.

Pore Size Distribution of TSX Graphite. Because of the current interest in the reactivity of TSX graphite to oxidizing gases, the size distribution of micropores in this material was determined by nitrogen desorption at 77 K. The micropores, that is, pores with a radius $\leq$ 300 A, completely determine the surface area of the graphite and probably influence its

penetration by gases. The measurements disclosed a broad peak with a maximum at about 18 A. While most graphites exhibit a peak in the vicinity of 20 A, a peak near 80 A has not been previously observed except in graphite which has undergone some oxidation.

The measurements also allow an independent determination of the surface area of the sample by summing the micropore areas. The specific surface area found in this manner was 0.479 m^2/gm, which is in excellent agreement with the value 0.476 m^2/gm obtained by the BET method.

Irradiation Damage to Plastics. A small amount (probably less than 10%) of the oxidation which occurs during gamma irradiation of polyethylene in air results in C-O-C structures. The effect of dose rate on the formation of ether linkages has recently been found to be similar to that observed for carbonyl (viz., increasing the dose rate decreased the concentration of ether and carbonyl for the same total dose). A study of the dose rate effect on transvinylene formation has shown that larger amounts of transvinylene are formed at higher dose rates.

Compatibility of graphite with Helium Containing Water Vapor. It has been demonstrated that CO_2, even in the presence of small amounts of CO, is an adequate system for maintaining water levels suitable to prevent hydriding of zirconium. However, this atmosphere is not compatible with graphite at high graphite temperatures. The exposure of TSX graphite to He containing approximately 1% CO_2 at temperatures from 775 to 825 C has yielded burnout rates from ~10 to 150%/KOD with an activation energy of 60 kcal/mole. The addition of a few percent CO decreased the oxidation rates slightly.

Thermal Hydraulics Studies

NPR Flow Mixer. A device to intermix the three flow streams of the NPR fuel elements was designed and tested in the Hydraulics Laboratory. Such a device could be placed near the middle of a process tube full of fuel elements and would prevent large variations in the temperatures of the coolant streams and the different components of the fuel elements.

A special test section consisting of the mixer preceded and followed by an NPR fuel element was constructed to test the efficiency of the flow mixer. Arrangements were made to introduce into and remove the flow from the three flow channels in the fuel elements with separate pipes. While a salt solution was pumped into one of the entering pipes, plain water was pumped into the other two and samples were taken from all three of the flow streams leaving the test section. These samples and samples taken from the combined exit flow streams were then analyzed for salt concentration.

In general, it was found that when the salt solution was introduced into the outer or middle annular flow stream, the salt concentrations in each of the three exit flow streams were about equal. When the salt was introduced into the center hole flow stream, the salt concentrations in the two exit flow streams were slightly less than in the exit center hole

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stream. It was concluded that the efficiency of the mixer was well within acceptable limits but that further improvement could be made by slight modifications which would result in a more complete interchange of the flow from the center hole with the two annular flow streams.

Shielding Studies

Using the new shielding computer code, a calculation was made to correlate experimental data obtained in the bulk shielding facility on an iron-iron limonite configuration. This configuration consisted of 24 inches of iron backed up with 24 inches of iron-limonite concrete. The initial correlation was unsatisfactory. It was found that the low cross sections in iron at about 25 Kev have a large effect on the leakage of lower energy neutrons through the shield, and that small energy intervals would have to be taken in this energy range in order to give fair agreement with experimental data. However, using the present group equations, it is not desirable to decrease the width of the groups below the average lethargy jump per collision, ξ. The equations assumed that every group is fed only by the previous group, and there is a limit to the increase in accuracy obtainable by increasing the number of groups. The reason for this limitation is that, if the lethargy range of the i-th group is larger than the average lethargy jump per collision ξ, the neutrons actually enter the i-th group not only from the (i-1) group, but also from earlier groups. The shield code is being reprogrammed to allow scattering from several preceding groups. This will improve the group equation so that a closer look can be taken at important cases such as the low cross-section regions in iron.

B. WEAPONS - 3000 PROGRAM

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

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Thermal Hydraulics Studies

PRTR Calculations - Moderator and Reflector System Heat Loads. Data taken during operation at 70 MW were analyzed to compare moderator and reflector system heat loads with values predicted by design calculations, and to check on values extrapolated from data taken at 35 to 45 MW.

Data taken at a PRTR power level of 70 MW indicate a moderator heat load of about 4.5 MW, approximately the value predicted by data taken at lower powers. Design calculations had predicted 2.2 MW.

Also for 70 MW, data indicate a reflector system heat load of 0.6 to 0.7 MW, in good agreement with the design value of 0.65 MW. Extrapolations of data taken at lower powers had indicated a heat load of 0.8 to 0.9 MW at a reactor power level of 70 MW.

Component Testing and Equipment Development

PRTR Components. Completion of the capacitance probe for measuring the liquid level in the PRTR moderator storage tank is expected for reactor test installation about the first of December.

Eight PRTR nozzle caps and nozzle cap plugs were modified to permit use of a wider gasket which had proved superior to the original cap and gasket during earlier test loop evaluation. These eight units have been installed in the PRTR. As yet, no reports have been obtained on their performance.

The impeller, mechanical seal, and flywheel assembly of the prototype PRTR primary pump was loaned to the reactor to allow quick repair of a primary pump with a damaged mechanical seal. The original pump components were too radioactive to permit maintenance access. Since no test work was in progress utilizing the pump, no interference with test or development work resulted.

The design work for the automatic drain system for HX-7 condensate was completed and Design Change No. 107 covering this modification was issued for approval.

Comment issues of all the drawings involved in the new facility for adding hydrogen to the suction of the low pressure compressors in the helium pressurization system have been received. Preparation of the design change covering this modification has started.

Scope drawings of the liquid shim rod assembly and the instrumentation flow diagram have been completed and forwarded for review.

Critical Facility Components. Assembly and installation of the slip clutch for the weir drive assembly were completed and the unit tested satisfactorily. The adjustable weir is now ready for reactor operation.

The additional swivel joints required for the thimble hoses have been received and will be tested as soon as pipefitter manpower is available. Receipt of the additional joints was delayed as it was necessary to cancel the original order and locate another supplier who could meet delivery requirements.

The first prototype control rod is essentially complete except for the installation of the cadmium plated aluminum tubing. Testing of this first prototype safety rod with a spiral retractable cable supplying power to the 12 volt DC lift magnet is under way, and early results look quite satisfactory. The remaining two safety rods are approximately 70% complete with an estimated six man-weeks of machinist and four man-weeks of electrician time required for completion.

Gas Loop Components. The in-reactor prototype test section for installation in "B" cell has been assembled, minus the inner tube, and delivered to Minor Construction. This test section will be used to check out the gas loop equipment and to obtain operating characteristics of the in-reactor test section prior to installation in the PRTR.

Two hundred and seventy-five hours of cyclic operation have been obtained on the CO_2 diaphragm compressor since the last diaphragm rupture.

Rupture Loop Components. Modifications and repairs of laboratory equipment to perform Rupture Facility Design Test No. 4 on the in-reactor test section, charging machine adapter, and special tools are 75% complete. Major items of repair needed on the single tube prototype facility to ready it for operation included installation of a new heat exchanger tube bundle and the replacement of all heating elements in the pressurizer.

Hazards Analysis

PRTR Process Specifications. Conformance with the approved PRTR Process Specifications was audited 30 times during the month. One violation of a process specification was revealed by the audits. This violation occurred when the process water pressure was allowed to drop below 100 psig during reactor shutdown.

Reviews by Reactor Safety Organization. Material was prepared for presentation to the General Electric Technological Hazards Council at the next meeting. This material included the following reports:

1. Organization for Operation of the Plutonium Recycle Test Reactor.
2. Experimental Program for PRTR.
3. Plutonium Recycle Critical Facility Fuel Element Drop-in Accident.

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Critical Facility Safeguards Analyses. The following design changes are being made to the Critical Facility:

1. A mechanical "dump valve - cell crane" interlock will be provided to assure that the moderator is drained from the reactor tank during fuel element charging. Interlock action will be such that a valve on the bottom of the reactor tank will be open when the cell crane is over the tank.

2. Reanalysis showed that the addition of a light water reflector would have a stronger positive reactivity effect than was previously estimated. Initially, sheets of cadmium, 0.020 inch thick, will be wrapped around the reactor tank to eliminate the reactivity effect of a cell flooding accident.

3. A grid plate will be installed at the bottom of the reactor tank to prevent fuel elements from swinging together if the tank were tilted.

Additional studies using analog simulation of the reactor were made with the following refinements used in calculating the consequences of reactivity addition accidents:

1. Complete reanalysis of PRCF reactor kinetics parameters.

2. Redetermination of the reactivity worth of core positions in possible loading configurations.

3. Use of the negative reactivity contribution of moderator voids formed by heat transfer and radiolytic dissociation.

4. Determination of the effect of reactivity addition rates on the severity of an excursion.

The studies showed that no fission products would be released upon the addition of 11 mk in 0.7 second to a large, two-zone, unreflected reactor. If the safety circuit failed, the addition of 33 mk in five seconds to a reactor loaded with 12 Pu-Al fuel elements would release fission products from the cell. Results are summarized below:

	33 mk		11 mk	
	Scram	No Scram	Scram	No Scram
Max. Power Level	4.6 MW	20,000 MW	300 KW	600 MW
Energy Release	1.4 MW-sec.	4,200 MW-sec.	60 KW-sec.	300 MW-sec
Max. Avg. Fuel Temp. (°F)				
UO_2	--	--	212	1200
Pu-Al	212	Sufficient to melt jackets & vaporize fuel element cores.	212	920

For the scram studies, the reactor was scrammed at 150 watts with two, 35 mk safety rods. The studies were made assuming that the reactor was critical with moderator at full level.

Plutonium Fuels Development

PRTR Aluminum-Plutonium Fuel Elements. Eight Mark I-H 19-rod cluster fuel elements were transferred to the PRTR this month. This brings the total to date up to 51 low exposure plutonium spike fuel elements delivered to the PRTR. The remaining 17 clusters should be completed by December 1961. At the present, a concentrated effort is being given to the six Mark I-H flux monitoring fuel elements requested by the Applied Physics Operation.

The recovery of plutonium (as aluminum-plutonium alloy) was calculated for the six reductions of PuO_2 using the cryolite process. The initial recovery as 13 w/o Pu master alloy was 94 percent; remelting the flux twice with aluminum increased recovery to 97 percent. Since three percent of the plutonium remained in the flux, additional remelting of the flux is planned until further recovery is unwarranted.

Phoenix Experiment. The three Phoenix irradiation specimens containing plutonium with 6.25, 27.17, and 16.13 w/o Pu-240 have completed their first cycle of irradiation in the MTR. GEH-21-1 which is the 6.25 w/o Pu-240 sample is now being irradiated for its second cycle. The aluminum capsule holders have worked very well and underwater manipulations have been performed with a minimum of difficulty. An underwater guillotine has been built that will be used for cutting the Al-Co flux monitoring wires prior to counting.

Reactivity measurements on the irradiated samples have been completed in the ARMF. ARMF measurements on the sample containing plutonium with 16.13 w/o Pu-240 (GEH-21-3) were started about 3.5 hours after the MTR was shut down and the reactivity was measured continuously for the first 36 hours. It will now be measured at different intervals until it is reinserted in the reactor. These measurements will permit determining the reactivity effect of the short-lived fission products.

Phoenix-Type Flux Monitoring Foils. A high temperature tube furnace has been modified to pyrolytically deposit graphite on a base material. The thin graphite coating will be impregnated with a dilute plutonium solution and baked at a high temperature to simulate a thin plutonium film.

Irradiation Testing. Radiometallurgical examination is continuing on the UO_2-PuO_2 seven-rod cluster pellet element. All the rods have been sampled for fission gas and they will now be sectioned. Full length autoradiographs of the irradiated rods are being made by placing them on glass for 48 hours. The exposed glass is then scanned with a densitometer and the relative exposure along the length of the rods can be determined. It was found the irradiation induced damage to the glass anneals out after exposure so it will be necessary to run the densitometer scans as soon after exposure as possible. One of the densitometer scans revealed a void in

1250476

about the center of one of the fuel rods indicating the fuel material had moved into the end clearance. The rod was tapped on one end and another radiograph showed that the fuel material had moved back together. This indicates that the fuel pellets are still quite loose in the cans.

The cold swaged UO_2-PuO_2 seven-rod cluster with swageable end caps (GEH-11-7) has been completed and inserted in the ETR 3x3 loop. It is scheduled to commence irradiation on November 27 and operate until December 26.

Fabrication of the cosine enriched UO_2-PuO_2 seven-rod cluster which will be irradiated in the ETR has commenced. The plutonium enrichment will be varied from 3.42 percent at the top, to 0.946 percent in the center; and 3.58 percent at the bottom in an effort to achieve a uniform power generation along its full length. This element will be incrementally loaded and cold swaged with swageable end caps.

Calculations are in progress for the four full-size swaged and vibrationally compacted UO_2-PuO_2 elements which will be irradiated in the PRTR. The core material for these clusters will be fused normal UO_2 uniformly enriched with 0.45 w/o high exposure PuO_2.

The four specimens (GEH-21-13, 14, 15, and 16), each containing UO_2-0.154 a/o PuO_2 and UO_2 (1.00 a/o U-235) pellets, for the tests in the MTR hydraulic rabbit facility (VH-4) were modified but have not been charged into the reactor. The personnel at the MTR requested a verification of the power generation values. In the test proposal, the specific power was stated to be 20 kw/ft. The cases were rerun by computer and the values were found to be as follows: UO_2-PuO_2 case - 20.3 kw/ft, and UO_2 case - 19.2 kw/ft. In addition, a dummy fuel element (GEH-21-17) loaded with a mild steel core and made equal in weight to the test elements, was sent to the MTR as requested for in-reactor, charge-discharge tests. The steel core will serve to actuate the magnetic timing device which is mounted on the ex-reactor, VH-4 tube section about six feet below the reactor mid-plane.

The design is nearly completed on a more advanced fuel element experiment, designated ICARUS, which is to be conducted in the hydraulic rabbit facility. In the ICARUS experiment, a remotely-operated, self-contained transport vehicle positions the fuel capsule in the maximum flux region of the reactor and at any specified time may be signaled to release the element and allow it to move out of the active zone. By using this technique, the presently required flow reversal, with its associated short-term but highly restrictive near-stagnant water condition, is eliminated in the discharging of fuel elements. Success of the ICARUS experiment will mean that UO_2-PuO_2 fuel cores may be operated at significantly higher specific power values than previously allowed in the hydraulic rabbit facility. A flow tube mockup is being designed and some parts are presently on order. In discussions with personnel at the MTR, it was deemed necessary to conduct flow tests in order to establish several design and operating parameters.

The eleven discharged high and low density UO_2-PuO_2 capsules which have exposures on the order of 10,000 MWD/T of UO_2-PuO_2 are still at the MTR awaiting shipment to HAPO.

The irradiated Zircaloy-clad capsule (GEH-14-27) containing an Al - 2.1 w/o Pu - 2.0 w/o Ni alloy core and fabricated by injection casting was recharged into the MTR. The goal for the specimen is a minimum of 50 percent burnup of the plutonium atoms.

Development work is proceeding on a temperature measuring technique designated as the HELIOS experiment. The experiment will be performed on UO_2-PuO_2 fuel material in the SNOUT Facility at Hanford. A remotely-operated, thermocouple-equipped device is employed. Upon recognition of the proper signal, the device causes the thermocouple hot junction to impinge against or be injected into the specimen at high velocity permitting the measurement of high temperatures before the thermocouple is destroyed. Fabrication of the UO_2 - 5 a/o PuO_2 pellets has been initiated. Ex-reactor tests with the device mockup were conducted at elevated temperatures (500 C) and the results met or exceeded the predicted performance. It was decided to eliminate further device tests and initiate construction of the in-reactor assembly as soon as the design and drafting work is completed. The fuel pellets are designed so that they may be used for the reactivity measurements as well as the irradiation test.

Exploratory work on a second approach, known as the ARGUS experiment, to the problem of fuel element property measurements in-reactor at elevated temperature is under way. In the ARGUS experiment a remotely-operated optical device would be employed to measure or observe the thermal properties of a fuel element while it is operating in a reactor.

Oxide Fuel Development. Activation of a hood facility for loading UO_2-PuO_2 elements was completed.

Improvement of over-all density and density distribution in vibratory compacted rods has been effected by recording random noise on a magnetic tape and feeding this signal into the amplifier of the vibratory compactor. This approach allows the use of low frequency noise (below 200 cps) without the attendant large displacements characteristic of high acceleration sinusoidal shaking in the low registers. The first use of this system was successful in producing a random noise spectrum on the tape. Unfortunately, a "no-fidelity" amplifier had to be used to act as a preamplifier for the system. This introduced a large 60-cycle component into the signal. With a slight refinement of this system and a modified feeding system, the loading of PuO_2-UO_2 mixes will be started.

A method for attaching a plastic "cow" bag to the open end of a vibratory compacted fuel element was evaluated for two loadings. In the first trial a brass sleeve was clamped in the counterbore of the tube and the cow bag was taped to this sleeve. A nylon funnel was threaded to the top of the brass sleeve and the tube was filled with UO_2 while being vibrated on the

1250478

exciter table. Although the sleeve was not dislodged from the tube, it did move half way out of the counterbore and was badly abraded.

For the second trial the brass sleeve was machined smaller and a rubber finger cot was stretched over the end before the assembly was seated in the counterbore. A stronger clamp was used to hold the sleeve in the tube and the loading operation was repeated. This time the sleeve remained seated in the counterbore and was easily removed after the clamp was released. This loading method may provide a simple means of obtaining an easily decontaminated tube end for final closure welding on vibrationally compacted elements.

High Exposure UO_2-PuO_2 PCTR Loading. A self-oiling die for the Kux automatic pellet press was designed to fabricate UO_2-PuO_2 pellets for a PCTR loading. Shrinkage and densification data were determined from a sintering experiment in which green pellet diameter and binder concentration were varied. It was determined that sintered density was sensitive to the concentration of polyvinyl alcohol binder used in the green pellets. The average density for pellets with two percent binder was 94.6% T.D., whereas the average for pellets with three percent binder was 89.2% of theoretical density.

Fabrication of Elements for the Resonance Integral Experiment. The Pu-240 effective resonance integral experiment fuel elements have been completed and delivered to the Reactor Lattice Physics Operation. This fabrication consisted of sixteen rods made of aluminum-plutonium alloy cores canned in 35-mil wall, 0.680-inch ID Zircaloy tubing approximately 31 inches long (Dwg. No. H-3-14246).

The core alloys were made from accurately weighed amounts of high exposure (approximately 16 percent 240) and low exposure plutonium. The cores were cast to the finished diameter. Since it was desired to cast as much of the alloy as possible, the crucible skulls were held to a minimum which was 3-1/2 percent of the alloy charge. After canning the cores in Zircaloy tubing, the fuel element rods were heated to 600 C (operational temperature) for one hour. After heating, a helium leak test was run on all rods and no leaks were found.

UO_2 Fuels Development

Irradiation Tests. The third Hanford defect element test was terminated after eight days of irradiation because of high activity in the effluent piping system. Preliminary examination revealed a bulge and longitudinal split at one end of the defected Zr-2 clad rod. The failure, which apparently occurred during initial startup, appears to be the result of ductile fracture. Examination is continuing.

A second enrichment experiment (93% enriched UO_2 non-uniformly dispersed in natural UO_2) was discharged from the MTR after 16.6 days of irradiation at full power. No evidence of failure appeared. The element was returned to Hanford for radiometallurgical examination.

1250479

A document entitled "Hydriding in Purposely Defected Zircaloy-Clad Fuel Rods," HW-65465, was completed. In it are discussed the hydriding characteristics of Zircaloy-2 and Zircaloy-4 (nickel-free Zircaloy-2) as determined from irradiation tests of purposely defected fuel elements.

PRTR Fuel Elements. Three unusual UO_2 fuel elements, in addition to the loading of swaged 19-rod clusters, were irradiated in the PRTR, at the full reactor power of 70 MW. Included are: (1) a vibrationally compacted Mark II-C nested tubular fuel element; (2) a vibrationally compacted, Mark I, 19-rod cluster; and (3) a hot-swaged Mark I, 19-rod cluster. Irradiation testing of these fuel elements is continuing.

The thermocoupled PRTR Mark I cold swaged UO_2 fuel element was recharged into PRTR tube 1550. Prior to its discharge in May 1961, the element provided fuel center temperature measurements at reactor power levels to 15 MW. In November, fuel centerline temperatures were recorded during level operation at 70 MW, at several lower levels, and during flux tilt and compression tests. Several scrams and normal shutdowns were recorded. Maximum fuel centerline temperatures in the range 950-1050 C (coolant temperature 255 C) were recorded during 70 MW reactor operation. These are approximately 200 C less than had been earlier estimated. Heat generation of the test element during 70 MW operation is estimated to be 0.92 MW on the basis of earlier recorded power factors for tube 1550. Several of the original six thermocouples had developed open circuits by late November. Irradiation will continue through the remainder of the present cycle.

Hot Swaging. Zircaloy clad UO_2 fuel rods were hot swaged to an average bulk density of 94% T.D. This bulk density was routinely obtained in nine-foot long rods by loading -20 mesh fused UO_2 (as a stand-in for recycled UO_2) to an initial density of 70-73 percent T.D., and swaging at $\sim$700 C. No decrease in density occurred during roll-bar straightening.

Utilization of the newly installed hot-swage feeding device resulted in better rod surface finish and less rod diameter variation. A water spray device at the exit of the swage cools the rods to $\sim$80-100 C before entering the rear feed chuck and will thereby greatly increase the life of the enclosed "Viton" tubing.

Surface pitting (0.001-0.005 inch in depth) which sometimes resulted from arcing between fuel rod and swage machine components was virtually eliminated by electrically grounding the rod upon exit from the inducting heating coil. Rod rejection rates and buffing time were greatly reduced.

Vibrational Compaction Studies. Fused UO_2 was compacted to 88% T.D. in an eight-foot long, 0.565 inch OD Zircaloy tube suspended from a nine-foot long steel beam. The beam was supported horizontally between a fixed fulcrum and a 5000-pound thrust vibrator. Investigations are continuing with modified fixtures designed to facilitate fuel loading and to permit determination of the effects of beam length and stiffness. The resonant-beam technique holds promise of simpler remote refabrication of fuel elements in shielded facilities.

Remote Fabrication Studies. An industrial TV vidicon tube of the type proposed for future remote fabrication work has been subjected to the sonic vibration environment of the vibrational compaction equipment. The free tube resonated at a rather low frequency of approximately 382 cps. The intensity of resonant response was sufficiently high to cause picture distortion. Fortunately, this frequency is below the level normally used in fuel element compaction operations. The test caused no detectable change in the structural characteristics of the tube.

Construction of the remote fabrication studies room is approximately 85% complete. The first portion of the special Zircaloy wire for rib spacers has been fabricated on-site and is now available for use with tube cladding.

BMI Cooperative Program. A joint HAPO-BMI program was initiated to investigate high-temperature isostatic pressing of partially pre-densified fuel assemblies. Twenty-four, 16-inch rods fabricated by cold swaging, hot swaging, and vibrational compaction have been sent to BMI for testing in December. These specimens contain fused UO_2, electro-deposited UO_2, and mixtures of fused and micronized UO_2 compacted to densities ranging from 70 to 92% T.D.

Corrosion and Materials Studies

PRTR Aluminum Shroud Tube Corrosion in Water Vapor. The corrosion of several aluminum alloys in an argon (58%) water vapor (41%) hydrogen (0.6%) and oxygen (0.3%) atmosphere at 260 C and 315 C is being studied. This atmosphere simulates the atmosphere in the PRTR calandria over the D_2O moderator. Coupons of 6061, 6063, and X-8001 aluminum alloys as well as samples of PRTR shroud tube (6063) and an experimental alloy containing 2.5% Fe and 0.64% Ni were exposed to a very slow flow of the atmosphere gas. The 305 C samples showed linear weight gains with time. No measurable weight gains have occurred on the 260 C samples. Metallurgical sections of coupons exposed for periods up to 1500 hours at 315 C showed the 6061, 6063, and PRTR shroud tube sample had experienced about a 5-mil intergranular attack in 1150 hours. The X-8001 alloy, the special alloy and all the alloys at 260 C showed no intergranular attack. This test is continuing, although concern for PRTR shroud tube corrosion has been alleviated by a recent re-estimate (by Thermal Hydraulics Operation) that the probable maximum temperature of the shroud tubes is about 230 C.

Stress Corrosion Cracking. The susceptibility of austenitic stainless steels to chloride stress corrosion cracking has been reported for tests performed in boiling, saturated $MgCl_2$ solutions in contact with air. A preliminary investigation to determine whether the presence of oxygen is necessary to produce stress corrosion cracking in this system has been completed. "U" bend specimens of 304L stainless steel were tested in boiling, deoxygenated, 42% $MgCl_2$ (154 C). The boiling $MgCl_2$ was maintained virtually free of oxygen by bubbling deoxygenated argon through it during the test. Chromous chloride solution was used as an oxygen scavenger for the argon gas. Samples of water through which the argon gas

1250481

was bubbled analyzed less than 50 ppb oxygen (the detection limit for the analysis).

Under the conditions of this stringent test (boiling $MgCl_2$), the reduction of oxygen concentration did not reduce the susceptibility of the 304L stainless steel to stress corrosion crack. All of the samples tested (representing vapor blasted, polished and as-received surfaces) failed in less than 60 hours. Samples with vapor blasted surfaces failed in less than three hours. The actual failure time of the remaining samples is not known but was greater than five hours. In a previous test in non-deoxygenated $MgCl_2$, 304L samples with as-received surfaces failed within three and nineteen hours.

Recovery of Oil-Contaminated D_2O. Procedures for removing oil contamination from D_2O recovered from the helium compressors were evaluated. Attempts to coalesce the suspended oil droplets by ultrasonic vibration were unsuccessful as were attempts to remove the oil by direct filtration. A highly successful procedure was developed, however, using an aluminum hydroxide floc to coagulate the oil droplets. The coagulated oil and floc mixture was then removed by filtration. This procedure was tested both in the laboratory and the PRTR facility. The residual turbidity in the clarified filtrate was less than 0.1 ppm. Approximately 4000 pounds of D_2O have been recovered using this procedure.

A study of possible methods of reducing the "permanganate demand" (a measure of the reducing capacity of the solution) values of recovered D_2O is in progress. It seems likely that the relatively high permanganate demand values being experienced now are caused by the presence of small amounts of oil in the D_2O. A procedure similar to that described above for oil removal is being tested to determine its effect on reducing the permanganate demand. If this procedure is successful, it may be desirable to use the aluminum hydroxide treatment on all recovered D_2O scheduled for re-use or return to Savannah River for processing.

PRTR Process Tube Monitoring. Six PRTR process tubes were monitored in-reactor during the month. No change in ID was noted. A previously reported indication that two tubes had developed ovality in the lower portion of the tubes was found due to instrument malfunction. The insulating gas gap is relatively uniform in all positions measured with the exception of position 1857. In tube 1857 a 90-mil gap was measured, a 30-mil reduction from the previous inspection the latter part of September. No explanation has been found for the continual change in the insulating gas gap in this tube location. Visual inspection disclosed marks not previously observed at the contact points between the inner tube wall and the top and bottom fuel end brackets in two of the tubes inspected. No contact marks were found on the inner wall of tube 1857 which was installed for the first time during the September shutdown.

Construction is under way on all phases of the new process tube monitoring probe; however, original delivery dates for some items has passed and new delivery dates from the fabricators indicate that the new device will not be operational prior to late March 1962. The first prototype

model for a device to measure the depth of gouge marks or localized wear-corrosion areas on the inner wall of the process tubes has been completed. The device uses a dial gage actuated by an air cylinder. Mockup tests in the process tube in 314 Building have been encouraging.

PRTR Sheath Tubes. Inspection of 1000 sheath tubes of 0.680 inch ID is nearing completion. A total of 227 tubes have been found to date to give indications which are detected by either the fluorescent penetrant test or the immersed ultrasonic test. Of these 227 tubes 65 percent contained indications detected by the fluorescent penetrant test, but not by the ultrasonic test; 37 percent contained indications detected by the ultrasonic test but not by the fluorescent penetrant test, and eight percent had indications detected by both the fluorescent penetrant and the immersed ultrasonic tests at the same location in the tube. These percentages add to greater than 100 percent since any given tube may have several indications detected variously by one or the other or both tests. Fluorescent penetrant indications are usually small particles impressed into the inner surface. Particles are found in stringers one-fourth to one inch long with individual particles 10 to 50 mils in diameter. The depth of the impressed particle is typically from one-half to four mils deep. The ultrasonic test was performed using a focusing crystal with a spot diameter on the tube wall of 40 mils. The reject level is set using standard grooves on the inner and outer surfaces one mil deep by 125 mils long. The ultrasonic test has detected open gouges or pits that do not retain the fluorescent penetrant, and a few of the larger impressed particles. The apparent lack of sensitivity of the ultrasonic test is believed to be the result of the very small size of the particle with respect to the crystal spot diameter.

04 Program Radiometallurgy Studies

Borescope examination of a Zircaloy-2 process tube recently discharged from KER-3 revealed numerous longitudinal scratches and several reddish colored rings. Based on metallographic examinations no significant quantity of hydride was discovered in the high power portion of the tube either as it was received or after annealing at 540 C (RM 354). Examination of HD-5, a purposely defected four-rod UO_2 cluster revealed that one of the rods had burst near the end and that gross swelling had occurred in the burst area (RM 640). Examination of two rods from the heterogeneously enriched UO_2 four-rod cluster element, GEH-4-62, showed that the sites where enriched fuel was located had recrystallized leaving a core at the center of the fuel (RM 643).

Autoradiography on glass strips of seven UO_2-PuO_2 fueled rods, each three feet long (GEH-11-3) has produced accurate flux profiles. Since the discoloration of the glass fades after the rods are removed, the fading rate is being calibrated. Nevertheless, it is hoped that this autoradiography process may be further exploited (RM 668).

X-ray diffraction studies have been run on an irradiated Zircaloy-2 sample and an unirradiated standard (RM 512).

The U-235 natural U diffusion study sample GEH-14-281 was cathodically etched and replicas were made for electron microscope studies after the first anneal (RM 513).

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

2. PLUTONIUM UTILIZATION STUDIES

Plutonium Silicides

As reported previously, $PuSi_2$ was synthesized by heating compacted pellets of plutonium dioxide and silicon to 1385 C for 30 minutes in vacua. X-ray diffraction analysis agrees well with the ASTM diffraction data card for $PuSi_2$. Precise lattice parameter measurement is forthcoming.

Subsequent to dissolution of the silicide in HCl, quantitative chemical analysis for plutonium is performed by coulometric titration. The silicon is found by difference. Inherent error in this procedure lies in the assumption that all of the plutonium is separated from the silicon. If it is not, plutonium results will be low and silicon high. With these considerations in mind, analyses of the above silicide agree well with the x-ray data. Stoichiometric $PuSi_2$ consists of 81 w/o Pu; chemical analyses gave 78.4 w/o. The melting point is approximately 1800 C, and the density is 9.1 g/cc.

Plutonium Nitrides

Initial investigation was begun on PuN. Experiments reported at Los Alamos show synthesis may be accomplished by flowing NH_3 over PuH_3 at 550 C. An experiment similar to this will be performed during the next reporting period.

The initial attempt was made to form PuN by arc-melting alpha plutonium in a nitrogen atmosphere. The surface of the plutonium metal button coated with a shiny, black substance which readily oxidized in a one percent oxygen - 99 percent nitrogen atmosphere. X-ray analysis will be used to identify the product.

Gas Evolution Studies

Gas evolution experiments were performed using carefully chosen samples representative of a single commercial lot of fused UO_2. The ranges of particle sizes studied were: -60 +80 mesh (U.S. standard mesh sizes), -80 +100 mesh, -100 +200 mesh, and -200 +325 mesh. Specimens weighing 0.12 gram were heated in a tantalum crucible to 1460 C and the evolved gases were quantitatively measured in a known volume system. Qualitative analyses by a mass spectrometer will be made shortly.

To establish the gas contribution attributable to the tantalum crucible alone, the empty crucible was heated at 1460 C until the pressure in the system remained constant. A pressure increase of 10 ± 3 microns was observed. Each UO_2 specimen was run repeatedly until the outgassing of the powder was complete. In most cases this occurred during the second heating cycle, giving an indication that all gas had been evolved from the UO_2 during the first cycle.

Specimens were held at 1460 C for one hour prior to measurement of the evolved gas. In the case of the -60 +80 mesh sample, it was necessary to hold at 1400 C for two hours before outgassing was complete.

Preliminary gas evolution data are shown in the following table:

Particle Sizes (U.S. Standard)	Gas Evolved (cc/gram) at 1460 C for One Hour
-60 +80	0.46
-80 +100	0.25
-100 +200	0.25
-200 +325	0.11

If the gas evolved were only adsorbed, surface area considerations predict a trend opposite to that shown above. The observed phenomenon could possibly be due to mechanically entrapped gas which may conceivably exist in greater quantities in the larger particle sizes.

ZrO_2-PuO_2 and MgO-PuO_2 Fuel Capsules

The sixteen capsules containing ZrO_2-PuO_2 and MgO-PuO_2 fuel material have been completed with the exception of autoclaving. All the capsules were clad in 0.035 inch thick Zircaloy and the MgO-PuO_2 capsules were assembled by shrink-fitting into large diameter aluminum sleeves for heat transfer purposes. The irradiation test proposal is being prepared. A brief summary of the irradiation conditions is given in the following table:

No. of Capsules	Composition	Power Generation (kw/ft)	Center Core Temp. (°C)
2	ZrO_2-2.18 w/o PuO_2	17	1680
2	ZrO_2-2.18 w/o PuO_2	22	2800
2	ZrO_2-10.39 w/o PuO_2	17	1650
2	ZrO_2-10.39 w/o PuO_2	22	2740
2	MgO-3.05 w/o PuO_2	29	1700
2	MgO-3.05 w/o PuO_2	50	2205
2	MgO-13.52 w/o PuO_2	29	1700
2	MgO-13.52 w/o PuO_2		

1250485

3. UO_2 FUELS RESEARCH

Irradiation of Impact-Formed UO_2

A photomosaic of the cross section of an irradiated, high-energy-impact-formed UO_2 fuel element core revealed in-reactor sintering and grain growth generally similar to that observed in other types of UO_2 after irradiation at comparable heat ratings.

Ultramicrotomy of UO_2

Tests were conducted at the electron microscopy laboratory of California Research to determine the feasibility of using an ultra-microtome for making thin sections from UO_2 crystals for reflection microscopy studies. Specimens transparent to electrons were produced, but they were badly fragmented, and little or no control of sample quality was achieved. The minimum thickness was approximately 200 A. Additional tests will be conducted in a microtome vendor's laboratory, with a microtome claimed to provide a lower thickness limit of about 70 A.

Metallography of ThO_2-UO_2

Difficulty has been encountered in etching metallographic samples of ThO_2-UO_2. A satisfactory etching technique consists of immersion of the specimen in a boiling mixture of 100 ml of concentrated HNO_3 plus one drop of HF. Etching time varied from 15 to 45 seconds, depending on the ratio of ThO_2 to UO_2 in the sample.

Electron Microscopy

Application of Fiber Optics. Discussions were conducted with a fiber optics systems manufacturer, to assess the potential value of fiber optics in electron microscopy. Several promising areas of application were found. Particularly interesting was the use of a phosphor-coated fiber bundle for the microscope screen, to allow increased photographic sensitivity (up to 100 times faster), and to couple the microscope with a low-light-level television system. Limitations appear to be mainly in image resolution, determined by fiber diameter (minimum 2.5 microns), method of bonding fibers, and maintenance of fiber position. Sample fiber bundles were obtained for evaluation.

Refractory Alloy Temperature Indicators

Refractory metals are being considered for use as in-reactor temperature indicators in fuel elements. Fine, angular, metal particles dispersed in UO_2 should change in microstructural appearance on particle shape at the in-reactor isotherm corresponding to the melting point of the metal. Several pellets containing two w/o of molybdenum (melting point 2620 C) as -200 +325 mesh powder have been examined by ex-reactor heating with a high thermal gradient. The post-heating microstructure showed no change in molybdenum particle appearance in the zone in which they had been

molten. A change from angular particles to more rounded particles in the molten zone had been expected. Other metals and alloys in various shapes will be similarly evaluated.

Electrodeposited UO_2

Electrodeposited UO_2 was partially purified (as shown in the following table) by heating in hydrogen at 1000 C for 10 hours. The UO_2 was treated as recovered from the electrode, without the usual aqueous washing treatment for salt removal.

Effect of H_2 Treatment at 1000 C on Salt Content of Electrodeposited UO_2

	ppm K	ppm Pb	O/U
As electrodeposited-unwashed	1400	12,100	2.013
After H_2 treatment	360	250	2.001

Fused UO_2

The effect of uranium nitride inclusions on internal pressure as a function of temperature for fuel capsules containing fused UO_2 is being determined. The fused UO_2, which originally contained uranium metal inclusions, was heated for six hours at 1000 C in nitrogen. The nitrogen content increased from 150 to 450 ppm. X-ray diffraction analysis showed the presence of a new component, tentatively identified as UN_2. Metallographic examination revealed a change in the appearance and shape of the inclusions.

A swaged stainless steel fuel capsule containing the UO_2 described above was equipped with a capillary tube and pressure transducer, and heated. The rate of increase in pressure from room temperature to 600 C was approximately the same as that previously measured for a capsule filled with sintered and crushed UO_2. Above 600 C, the pressure began to decrease, indicating a gettering action occurring within the capsule. The maximum pressure observed, 125 psig, occurred at 610 C. The pressure at a maximum temperature of the experiment, 700 C, was 100 psig. Additional experiments will be performed, extending the temperature range to 1000 C, so that a comparison can be made between measured pressures and those predicted from vacuum gas extraction analyses of the UO_2.

High Power Laser

GEL has initiated development work on the use of the laser as a heat source for exploratory welding and cutting studies. Threshold laser action of the large ruby crystal (0.6" OD x 8" long) was reached with 11,000 joules of energy. Additional capacitors are being added to the power supply for higher laser output.

4. BASIC SWELLING PROGRAM

Irradiation Program

Capsules 7 and 8, each containing three, hollow, split, uranium cylinders, have been discharged from the reactor. These capsules operated at constant temperatures of 525 C and 575 C, respectively, regardless of reactor operation. All capsule components, including the thermocouples and heaters, retained their original integrity throughout the irradiation. The specimens in these capsules were subjected to one serious thermal cycle during their irradiation; this occurred when the electrical power supply to the heaters was accidentally lost. Subsequent re-establishment of the power supply and improper instrument operation caused a thermal excursion into the high alpha or low beta region for a period of almost one minute. It is not known whether or not an excursion of this short duration will significantly alter the swelling that would have otherwise been observed. The capsules will be stored in the reactor basin until they have "cooled" sufficiently to be handled in Radiometallurgy where they will be opened, and the specimens recovered for examination.

Four additional capsules, each of which contains three, hollow, split, uranium cylinders, are ready for charging in tandem, two to each test tube. These capsules will be charged for irradiation upon completion of control instrumentation tests. An additional capsule that contained an open circuit in its heater and a small leak on its inner chamber has been repaired and is ready for laboratory tests. A previously assembled capsule is being used at the reactor to test a new instrument facility. Redesign and modification of a capsule to be used for metallographic studies on uranium has begun. All critical components such as the heaters and thermocouples are available and a prototype capsule incorporating design modifications is being assembled for tests.

Four unmonitored NaK-filled capsules, each containing six samples, have been charged into the MTR for irradiation at ambient temperatures. The samples are U-U diffusion couples which consist of 1/4 inch thick slices from a Zircaloy-2 clad extrusion that has a uranium core containing 0.15 percent U-235, and a 0.030" uranium shell containing three percent U-235. It is intended that two of the capsules be irradiated at a flux of 5×10^{13} nv for two cycles and the other two for four cycles.

Post-Irradiation Examination

A specimen of natural uranium, GEH-14-36, irradiated in a NaK environment at temperatures below 200 C to a nominal burnup of 0.26 a/o has been subjected to post-irradiation examinations, both before and after a one hour annealing treatment at 600 C. This specimen has been analyzed radiochemically for burnup and the results indicate that the nominal burnup value, 0.26 a/o, is in error and should be 0.17 a/o. With this burnup the observed swelling due to irradiation and the post-irradiation annealing treatment agrees much better with swelling data previously obtained for uranium subjected to post-irradiation annealing treatments.

Two hollow cylindrical specimens, each with a thickness of 0.030", from swelling capsule 6 have been annealed for 100 hours at 575 C and 615 C, respectively. These specimens had been irradiated at 330 C to a burnup of 0.034 a/o, and initially showed no evidence of internal porosity. The specimens had been irradiated in the as-extruded condition and consisted of fine, equiaxed recrystallized grains. Neither of the annealing treatments caused a significant change in the grain size. After the annealing treatment at 575 C, very sparse porosity located randomly throughout the specimen was detected by electron microscopy. In the case of the specimen annealed at 615 C, far more porosity (increase in number and size of pores) had developed, and the major porosity was present at the boundaries of the small, equiaxed grains. Since the annealing temperatures differ by only 40 C, it may be presumed that gas mobility increases markedly at a temperature of about 600 C. This same conclusion was reached in previous analysis of pore size distribution curves derived from unrestrained annealing studies of uranium irradiated to 0.29 a/o burnup under conditions of restraint.

A spherical specimen of uranium irradiated to a burnup of 0.28 a/o at a temperature of 615 C has been annealed for 100 hours at 615 C, and processed for metallography. This specimen together with similar spherical specimens which were also annealed at temperatures equivalent to the irradiation temperatures will be utilized to establish whether porosity in the as-irradiated state of these specimens had attained an equilibrium configuration. Both immersion density measurements and quantitative metallographic determinations of volume changes due to swelling induced by annealing will be made.

Pore Size Distributions

Computer input data from pore diameter measurements of specimens from capsule irradiations, both before and after annealing, are being obtained. Many very small pores, 400 to 1000 A in diameter, are present in a spherical specimen irradiated unrestrained in NaK at 575 C to a burnup of 0.28 a/o. Normally for a determination of pore frequency distribution curves, these small pores are neglected. Since it is of extreme interest to establish whether post-irradiation annealing at 575 C has changed the initial size and number of pores in the specimen, additional micrographs at higher magnifications, 35,000 X, have been obtained. These micrographs show the small pores at a size sufficiently large to be measured with a Zeiss Particle Size Analyzer. Measurement on these micrographs is in progress.

A recent computer program has permitted calculation of apparent pore size frequency distribution curves for two hundred individual electron micrographs. This information, together with total pore volume estimates will be utilized to check: (1) heterogeneity and homogeneity of pore distribution data from various areas on a given specimen, (2) variances due to particular parameters, such as burnup, temperature, etc., and (3) pore size distribution and total pore volume changes. This information will then be used to deduce whether pores grow by an agglomeration or by a diffusion process.

Fission Product Mobility

One of the U-U diffusion couples, GEH-14-281, has been vacuum annealed at about 500 C for one hour employing a slow heating and cooling rate. This sample is now being processed for changes in hardness and metallography in the vicinity of the U-U interface. Microhardness traverses have been made across the as-irradiated U-U interface, but the wide scatter in the data makes interpretation extremely difficult.

5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

An in-reactor creep test is being conducted at 310 C and 30,000 psi stress on a 20 percent cold worked Zircaloy-2 specimen in a capsule modified with water cooling jackets. A third generation creep capsule, designated Capsule III-3, was modified by installing water cooling jackets immediately over the heaters. The water cooled jackets provided the necessary cooling to maintain a 310 C test temperature previously unobtainable in the helium cooled creep capsules. Final temperature control was achieved with the use of separate controllers on each of the heater sections in the capsule giving an end-to-end temperature gradient on the specimen of less than 1 C. Temperature is measured with a Leeds and Northrup K-3 potentiometer from calibrated chromel-alumel thermocouples. A stress of 30,000 ± 150 psi was applied to the specimen after the reactor had come to full power. The in-reactor creep test data were compared with ex-reactor creep data obtained in another creep capsule run outside the reactor. Comparison was also made with calculated rates for the same stress and temperature conditions. Initially, the in-reactor rate was much lower, as was the total plastic strain. As the tests continue into second stage creep, the in-reactor rate approaches the ex-reactor rate. If present trends continue, the in-reactor rate will exceed the ex-reactor rate after about 700 hours. The instantaneous creep rates at 300 hours are 2.2×10^{-6} in/in/hr for the in-reactor test and 2.7×10^{-6} for the ex-reactor test. Total plastic strain at 300 hours is 0.122 percent in-reactor and 0.262 percent ex-reactor. Instrumentation and control is such that transients, if they do occur, can be followed through reactor shutdowns and startups on this specimen without upsetting temperature, stress, or calibrations.

Capsule and Instrument Development

In order to conduct creep tests in the reactor in the 250 C to 400 C temperature range, future capsules of the third generation type must be internally cooled. The next capsule for charging, Capsule III-5, also containing a 20 percent cold worked specimen, is being modified with water cooling jackets. In addition to the water cooling, one more of the convection baffles is being removed so this capsule will operate in the region of 220 C to 250 C.

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Tests of the thermal properties of the creep capsules have been completed by simulating gamma heating in the laboratory. The results agree with prior predictions that the convection of helium is the controlling mode of heat transport. The data when correlated with previous reactor thermal behavior can be used to predict the operating temperatures of a capsule to within 10 C. These correlations also apply to the capsules with internal water cooling. However, a marked reduction of the temperature range over which the capsule can be operated results from the introduction of water cooling. Increasing the capacity of the electrical heaters in the capsule will help overcome this limitation.

6. GAS-GRAPHITE STUDIES

EGCR Graphite Irradiations

The H-3-3 capsule containing EGCR graphite has operated through three periods in the GETR and is being removed for disassembly. All indications are that the capsule worked perfectly through the last irradiation which brought the exposure to approximately 60,000 MWD/AT (EGCR) at the peak flux positions.

Irradiations of Special Graphites

A reirradiation of Dragon Project and Armour Research Foundation graphites developed for fuel matrices was recently completed. Because samples were irradiated in non-instrumented capsules, their irradiation temperature was estimated by heat transfer calculations. The estimated temperature range was 500 to 700 C. The contraction rates were relatively high compared with nuclear-grade graphites, as tabulated below.

Graphite	(nvt x 10^{-20} E > 1 Mev)	% Length Contraction
ARF-2-4	10.4	0.098
	11.94	0.309
ARF-3-2	10.4	0.126
	11.94	0.295
HX-10 ( )	12.93	0.730
HX-10 ( )	8.62	0.182
HX-12 ( )	12.93	0.942
HX-12 ( )	8.62	0.429
EY-X-60 ( )	12.92	1.271
EY-X-60 ( )	8.62	0.711

These samples will be irradiated again several times.

Oxidation Studies for EGCR Hazards Evaluation

A program was conducted to determine the influence of water vapor on air-graphite oxidation rates for EGCR hazards analysis. Water vapor concentrations ranged between 0.05 wt % and 22.4 wt %, temperatures between

500 and 600 C, and graphite chemical reactivity from 1 to 2.5 (CSF = 1.0). No catalytic effect on oxidation rates by water vapor was discernible.

Graphite-Water Vapor Reaction under Gamma Irradiation

A third series of measurements in the Co^{60} gamma facility on the rate of oxidation of TSX graphite by He containing a small partial pressure of H_2O vapor have been completed. The cylindrical graphite sample upon which the oxidation measurements were made had a 3/16 inch diameter hole drilled down its axis thereby increasing its surface-to-volume ratio by about 70% over that of the solid cylinders used in the previous tests. The net H_2O vapor concentration ranged from 15 to 40 ppm. Net oxidation rates obtained are compared below to those found during the second series of rate measurements in which a solid cylinder of TSX graphite was employed.

T°C	Rate (Hollow Cylinder) x 10^6 (gm/gm hr) H_2O conc. = 15 to 40 ppm	Rate (Solid Cylinder) x 10^6 (gm/gm hr) H_2O conc. = 155 ppm
500	- 1.42	--
600	- 1.97	- 0.54
700	- 2.95	- 0.89

It is readily apparent that even though the H_2O vapor concentration was appreciably less in the case of the hollow cylinder, its increased surface-to-volume ratio resulted in a pronounced increase in the oxidation rates. An explanation of this effect will have to await the accumulation of additional data.

A calculation of the activation energy yielded a value of 5.4 kcal/mole, whereas that found for the solid cylinder was 8.8 kcal/mole. Because the low reaction rates are subject to relatively appreciable experimental error, it is not presently known whether this difference is significant.

Thermal Cycling of Coated Graphite

The thermal cycling of coated graphites in air over a temperature range of 250 to 1200 C has continued. Three samples of Speer 901-S graphite coated with pyrocarbon and Si-SiC have been tested and performed satisfactorily. Five samples of Si-SiC coated, Great Lakes AX-75 graphite with various geometries have survived the tests. All coatings were prepared by the Minnesota Mining and Manufacturing Co. In the following tabulation of results, Speer graphite is designated by the prefix SP, whereas samples of AX-75 are designated by the prefix A.

Sample #	Geometry	Initial Weight (gms)	ΔW(gm)	No. of Cycles
SP-1	0.292" dia. x 1.05" long	1.9232	+0.0012	900
SP-2	"	1.9761	+0.0014	955
SP-3	"	2.0088	+0.0002	390
A-1	0.5" dia. x 4" long	25.8223	+0.0038	900
A-2	"	26.0285	+0.0029	900
A-1b	0.5" dia. spheres	2.4377	+0.0008	1033
A-2b	"	2.3553	+0.0001	1033
A-1 rppd	Rectangular parallel-piped 0.5" x 0.5" 4"	19.1011	+0.0030	1033

7. GRAPHITE IRRADIATION DAMAGE STUDIES

Samples of TSX, CSF, and natural flake graphites were encapsulated in a graphite cup for irradiation in GEH-13-8. Replicas were taken from each sample after cathodic vacuum etching and after subsequent oxidation at 850 C in tank helium containing a small amount of water. In addition, optical micrographs, in bright field and polarized light, were taken to aid in locating areas of interest for post-irradiation examination. X-ray determinations of crystallite and lattice dimensions were taken just prior to encapsulation. The results for TSX tend to confirm that the bar from which this sample was taken was not typical. High ash values were also obtained from the same bar.

Ten samples of TSX from a bar verified as typical are being prepared for etching studies and some of these will be included in future irradiations for microscopic studies.

8. ALUMINUM CORROSION AND ALLOY DEVELOPMENT

Aluminum Corrosion Under Heat Transfer Conditions

Corrosion testing of X-8001 cladding under conditions of high heat transfer continued during the month. The test is being operated with a bulk water temperature of 600 F using high purity deionized water. During the first 30 hours of testing the temperature drop across the water, oxide, and crud films increased from 43 F to 59 F. It has been observed that accidental and planned shutdowns of the loop cause thermal shocks large enough to flake off corrosion product oxide as evidenced by decreased temperature drops across the film at these times. While the temperature drop has increased to as high as 68 F, sloughing off of oxide has brought the temperature drop down to as low as 52 F. During an uninterrupted period of 286 hours the value of the temperature drop increased from 52 F to 60 F, indicating a gradual buildup of oxide and/or crud film is occurring. Coupons of X-8001, 304 S/S, and Zircaloy-2 have been discharged for corrosion measurement, but the data are not as yet available. The test has now operated a total of 602 hours at 600 F and a pH of 6 to 7.

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Aluminum Alloy Development

Several melts made to determine the reproducibility of the corrosion resistance of three high purity base aluminum alloys have now received an exposure of one year in 360 C water. The three alloys, represented by six melts of each formulation, are (1) 0.64% Ni, 2.1% Fe; (2) 1.2% Ni, 1.8% Fe; and (3) 1.5% Ni, 1.5% Fe, all prepared from 99.995% base aluminum. At one year all these melts still show very low penetrations, the highest penetration being 0.58 mil. X-8001 at one year's exposure shows a penetration of about 12 mils.'

After six months of exposure to 360 C water, melts of the 1.2% Ni, 1.8% Fe in 99.995% base aluminum fabricated to determine the effect of casting variables still show that the only change in casting procedure which affected the corrosion resistance of the alloy was a slow cooling rate. Different holding times, holding temperatures and pouring temperatures have not changed the corrosion characteristics of the alloy.

9. USAEC-AECL COOPERATIVE PROGRAM

Development of an Ultrasonic Test for Sheath Tubes

Analysis of the results of inspecting recent shipments of Zircaloy sheath tubing reveal that the major cause for rejection is the occurrence on the inner surface of impressed particles which may or may not be associated with small cracks. As currently used at HAPO, the immersed ultrasonic test for sheath tubing has been shown to be insensitive to the majority of these impressed particles. Consequently, a series of pit-type standards is being prepared to study methods for increasing the sensitivity of the ultrasonic test to this type defect. The presence of large grains in Zircaloy tubing has been reported to cause objectionable noise in the ultrasonic test. To measure the magnitude of this effect a series of standard flat plate samples is being fabricated with varying grain sizes. Grain diameters under 15 microns were obtained by low temperature short-time annealing during the rolling process. Anneals in the range of 1400 F for five hours produced plates with an average grain diameter of 25 microns. Both small amounts of cold work and high-temperature long-time anneals are being utilized to produce plates with grain diameters greater than 25 microns.

Magnetic Force Welding SAP

Welds performed on M583 and SAP930 alloys are equivalent to welds obtained on M257 material. All welding parameters have been investigated and operational limits established for each parameter. Welds are presently being evaluated to determine consistency of the welding process using the apparent optimum weld conditions.

Boiling Burnout Studies for 19-rod Fuel Elements

Fourteen boiling burnout points were determined in the laboratory with an electrically heated model of a 19-rod bundle fuel element. These data are the first of a series planned under the cooperative USAEC-AECL program to provide information for design and hazards analysis purposes for 19-rod bundle fuel elements.

The test section was made up of 19 Inconel tubes, 0.564 inch OD, 18 inches long and were installed in a 3.25 inch ID vertical process tube. Twelve of the rods were wrapped with wire to maintain a 0.074 inch spacing between rods and to promote coolant mixing. Fourteen of the tubes had thermocouples placed to measure the inside surface temperature one inch from the downstream end. The inner seven rods had about 83% of the heat flux of the 12 rods of the outer ring. This approximates the radial power distribution of a 19-rod fuel element in a reactor.

The tests were performed by setting a flow and inlet water temperature and then increasing the power in steps until boiling burnout was reached. The onset of boiling burnout was indicated by a temperature excursion of one of the surface thermocouples. The tests were performed at a pressure of 1200 psig and at flow rates of 0.5 to 3.0 lb/hr-sq ft. Experiments with this test section were terminated when thermocouple readings indicated that one of the rods had failed.

A summary of the burnout results, subject to minor modifications as the data analysis progresses, is reported below:

Flow Rate lb/hr-sq ft	Heat Flux B/hr-sq ft	Outlet Enthalpy B/lb	Outlet Steam Quality % by weight
498,000	560,000	750	29
480,000	549,000	708	22
491,000	621,000	679	17
500,000	683,000	620	8
492,000	606,000	722	24
498,000	767,000	551	17 F subcooled
991,000	668,000	674	16
1,010,000	698,000	631	9
973,000	770,000	626	9
1,000,000	872,000	585	2
1,980,000	766,000	619	8
1,970,000	922,000	594	3
2,000,000	1,058,000*	580	1
2,930,000	1,037,000	596	4

*This run was stopped short of burnout due to limitations of the power available at that time.

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Burnout was always detected on rods of the outer 12-rod ring except in one case where burnout occurred on one of the rods of the inner 6-rod ring. The color patterns found on the rods when the test section was removed provide some further qualitative information concerning the occurrence of boiling burnout in 19-rod fuel elements. The color patterns indicate that the coolant within the bundle had a much higher enthalpy than did the water between the bundle and tube wall. Patterns indicating the presence of boiling burnout were found on seven of the twelve rods of the outer ring, all on surfaces oriented away from the process tube wall. Three or possibly four of the seven inner rods showed boiling burnout patterns, all at the downstream end of the section. These patterns show that burnout was a somewhat general phenomenon and occurred on a number of rods rather than just one. The higher enthalpy of the water within the bundle was undoubtedly responsible for the fact that burnout occurred on the inner surfaces of the rods, and also occurred on some of the inner rods even though their heat flux was but 83% of that of the outer rods. The higher enthalpy of the coolant within the bundle also shows that the wire wraps are not perfect mixers, even though other tests have shown them to be reasonably effective in promoting mixing.

The boiling burnout heat fluxes found in these experiments were roughly the same magnitude as those found using a single tube with flow through the inside. This indicates that severe penalties need not be paid in the form of reduced heat fluxes or lowered burnout safety factors when using 19-rod bundles as fuel elements in nuclear reactors.

Efforts were made to apply the data from these experiments to the PRTR. The experimental heat fluxes were considerably higher than those encountered in the PRTR and it was found that a direct quantitative determination of a burnout safety factor for the PRTR could not be made. However, it would appear that a burnout safety factor of at least five exists for the Mark I fuel element in the PRTR at current operating conditions. The fact that the 18-inch long test section was operated at 1305 KW, a power level higher than that permitted for the full length (7.33 feet) PRTR fuel element, is some evidence of this.

10. IRRADIATION EFFECTS IN STRUCTURAL MATERIALS

The purpose of this program is to investigate the combined effects of radiation and reactor environment on the mechanical properties of structural materials. Special attention will be given to the determination of mechanical property changes produced in metals by irradiation at elevated temperatures in contact with water.

Ten specimen quadrants containing 180 tensile specimens of Zircaloy-2 and types 304 and 348 stainless steel were successfully removed from the ETR G-7, hot water loop after cycle 41. These quadrants were concurrently replaced with quadrants containing 44 Zircaloy-2 bend test specimens and 108 tensile specimens of either type 348 or 304 stainless steel. The total number of both Zircaloy-2 and stainless steel specimens discharged from the loop to date is 288, representing exposures from 10^{19} to 10^{21} nvt.

Quadrant disassembly and shipment of these specimens to Hanford for testing is scheduled for next month. The loop outlet water temperature reached and was successfully controlled at 280 C during cycle 41.

The analysis of tensile data for Zircaloy-2 specimens irradiated in contact with 75 C water to exposures of about 10^{19} and 10^{20} nvt (fast), reveals that minimum plastic stability occurs in the transverse direction for the annealed condition. The point of instability is defined as the point of maximum tensile load before the onset of necking, and denotes the limit of uniform strain. The corresponding true stress and strain values at instability for annealed specimens irradiated to 10^{19} nvt are 73,000 psi and 0.012 for the transverse direction, and 79,800 psi and 0.048 for the longitudinal direction. At 10^{20} nvt these values are 77,500 psi, 0.0075 and 82,400 psi, 0.045, respectively. These data show the longitudinal direction to be markedly superior to the transverse direction in plastic stability. Little effect of working direction on instability is observed for cold worked, irradiated specimens. Cold work actually improves stability for the transverse direction; whereas, in the longitudinal direction 10 percent cold work shifts the point to 89,000 psi and 0.015 strain and 70 percent cold work subsequently increases it to 117,000 psi and 0.026 strain (at 10^{19} nvt).

Unirradiated, notched tensile specimens representing 0 to 20 percent cold work were tested during the month. The specimens contained 60 degree, "V" notches having a root radius less than 0.001 inch. Each notch was cut 0.15 inch into a 0.677 inch gage width. A dye marking technique was used to indicate the point of transition from slow to rapid fracture. The measured ratio of the notch strength to the ultimate strength (of an unnotched specimen) was about 1.50 for both levels of cold work. A notch-sensitive material is arbitrarily defined to have a ratio less than one. A value of 1.50 denotes good notch toughness. This was also shown by the regions of rapid fracture which were 100 percent shear. The variation of notch strength with strain rate over the range 0.005-20 min^{-1} was found to follow the relationship $\sigma = a + b \ln \dot{\epsilon}$; where σ is the notch strength, $\dot{\epsilon}$ the strain rate, and "a" and "b" are parameters. The respective values for "a" and "b" for 0 percent cold work are 95,000 psi and 1,600 and for 20 percent cold work, 131,000 psi and 1,200. The relatively small value of the slope, "b", again indicates good notch toughness in the unirradiated condition.

11. REACTOR STUDIES PROGRAM

Conceptual Design Studies

Following completion of the study of a 300 MW(e) inverted fuel cluster type supercritical pressure power reactor, the selection of a subject for the next conceptual design study has received attention. Under consideration are several variations on the supercritical theme: a 300 MW(e) pressure vessel-type reactor; a large, 1000-2000 MW(e) reactor; and a small, demonstrator-type reactor for evaluating the three proposed pressure members --

pressure vessel, pressure tube and inverted fuel cluster. Also under consideration for conceptual design study are a low cost, process heat reactor and a small -- ca. 1 MW(e) -- high temperature, plutonium-fueled reactor.

No decision has yet been made on which, if any, of these avenues to pursue, but some material has been assembled as a basis for discussion of the matter with Commission personnel.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Recent work aimed at determining the nature and magnitude of the combined effect of neutron irradiation and interstitial carbon impurities on the properties of molybdenum can be divided into the following categories: development of procedures for preparing and characterizing single crystal specimens for pre- and post-irradiation tests; installation of necessary laboratory facilities for preparing polycrystalline specimens for Instron tensile tests and for stored energy release measurements; preparation of foil specimens for optical and electron microscope deformation studies; and fabrication of capsules for irradiating single and polycrystalline specimens.

A quasi-systematic analysis of the amount of metal removed during rough grinding, polishing, and final polishing by chemical and electrolytic means has been made. Three molybdenum crystals 1-1/2" long, one from each of three carbon concentration levels, were mounted longitudinally in plastic, ground, and then cut into three sections. The three sections from each crystal were then subjected to final polishing by (1) a 10-second to 2-1/2 minute chemical attack with a solution consisting of 10 g $K_3Fe(CN)_6$, 10 g KOH, and 100 ml H_2O, (2) a 30-second to 2 minute electrolytic attack in a solution consisting of 25 cc (c) HCl, 10 cc (c) H_2SO_4, and 75 cc methyl alcohol at an applied potential of 15-17 volts, and (3) krypton ion bombardment for 1/2 hour. As suspected, a pronounced orientation dependence exists. Certain crystal orientations of the polished surface pitted very easily, and these pits delineated a mosaic or cell structure within the grain. Variations in the severity of the pitting, and the geometric shapes did exist. X-ray diffraction analysis of the crystallographic orientations of these faces is presently being made as a guide for selecting proper final polishing conditions. Preliminary tests have also been made of spark machining as a means for reducing the cross sectional area of a molybdenum single crystal. Whether chemical or electropolishing removes all of the disturbed metal will be determined by Laue diffraction analysis. In addition, the effect of annealing treatments on the as-received single crystal specimens will also be determined. If results show an increase in the perfection of these crystals due to annealing, all crystals will be subjected to such a treatment prior to irradiation.

The first shipment of five-mil molybdenum foil with carbon impurity levels of 100-200 and 400-500 ppm has been received. The vacuum hot stage has been completely dismantled, thoroughly cleaned, and re-assembled. Faster temperature control can now be achieved by virtue of a recently installed Brown Electro Volt 3 mode Controller and a Minneapolis-Honeywell Magnetic Amplifier with a 150-watt capacity.

Crystallographic orientations have been determined for selected crystal rods of medium and high carbon content. Of eight specimens, only two proved to be single crystals. Orientation determinations have been discontinued until the micro tensile specimens have been cut, whereupon orientations will be determined for each individual specimen.

X-ray diffraction experiments on 100 and 110 faces cut on low carbon crystals show that considerable extinction is present. The extinction is apparently of the primary type.

Lattice parameters and x-ray line breadths have been measured for rolled polycrystalline molybdenum foils irradiated to 10^{17} nvt (fast). The lattice parameter for the as-received material is 3.1471 A. Irradiation increases the lattice parameter slightly to 3.1472 A. The breadth of the 400 line is increased from 0.493 to 0.585° 2 θ by irradiation. Annealing of the as-received material does not change the lattice parameter and decreases the line breadth very slightly from 0.493 to 0.490° 2 θ. Irradiation of the annealed material produces no change in lattice parameter and a decrease in breadth, from 0.490 to 0.476° 2 θ. The observed decrease in breadth is unexpected and unexplained.

Twelve capsules containing polycrystalline stored energy, electrical resistivity, macroscopic length, and microhardness specimens have been assembled and will be charged into the reactor at the next shutdown. Additional capsules are being prepared for irradiation. The molybdenum stock used for these irradiations contains less than 200 ppm total impurities, and less than 100 ppm carbon. Future irradiations will involve material with various carbon levels, obtained by doping this material.

Attempts to swage the polycrystalline molybdenum with < 200 ppm impurities at room temperature have been unsuccessful. Experiments are now in progress to plate the molybdenum with copper and nickel, for oxidation protection during hot swaging. Polycrystalline stock with less than 200 ppm total impurities and less than 10 ppm carbon has been successfully swaged to better than 25 percent reduction of area at room temperature.

E. CUSTOMER WORK

Radiometallurgy Service

Thirteen uranium or uranium dioxide samples were dissolved for burnup or mass spectrometer analysis, and nine uranium metal or Pu-Al alloy samples were declad for density measurements. Five samples were vacuum annealed prior to metallographic examination. Densities were determined on ten samples, and microhardness traverses were obtained on nine. Fission gas from eight elements was collected, measured, and submitted for analysis on the mass spectrometer. A Tinius Olsen Cup Tester was installed in E cell and cupping tests were run on 48 samples (RM 511).

Metallographic examination of overbore I&E fuel elements (RM 433) indicated that four missing support rails may have been broken off during the charging operation. Reduced clearance and coolant flow caused by the missing tabs resulted in severe can wall corrosion on that side of the element. The two elements which showed a slight hot spot did not suffer any significant loss of can wall by corrosion. Examination of a side-other rupture from 1581 H has shown that the male weld was solid and without visible flaw (RM 434).

A Tinius Olsen Materials Testing Machine and a 1650 C vacuum furnace have been ordered to replace the old equipment in the high temperature tensile testing cell.

Metallography Service

Continued investigation was conducted of the platelets resembling zirconium hydride at the Zircaloy-uranium interface of pressure-bonded fuel elements. These platelets have now been found not only on specimens which have been through the pressure-bonding process but also on specimens subjected to the time-temperature cycle of the bonding process without pressure, and to a very slight degree on coextruded specimens. They have not been located on beryllium alloy brazed specimens, heat treated specimens, or on those subjected to the steam autoclave. It has not yet been determined whether the presence of these platelets has any deleterious effect on the integrity of the bond.

Samples of carbon steel pipe for the NPR primary piping system are currently being examined. Some defects have been found in the form of slag-type inclusions in the weld, as well as an occasional cold shut between weld passes.

The failure of a stainless steel water monitor sample line from 105-KE was determined to be caused by stress-corrosion cracking.

In conjunction with some routine electron microscopy work, UO_2 and germanium were individually evaporated through a small aperture in an attempt to improve shadow contrast on the replica. Results to date show that shadow edges are sharper than those obtained without using this technique.

Samples Processed During the Month

Total samples	689
Replicas	30

Photographs

Micrographs	501
Macrographs	144
Electron Micrographs	80
	725

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NPR Charging Machine

Wiring of the panels, consoles, valves, switches, and photocells is complete. This does not include modifications which have been incorporated since the electrical drawings were issued for construction. Checkout of the electrical system was started and is 40% complete. Installation of the 440 volt feed to the hydraulic power package is not complete. Fabrication of the electrical portion of the machine is estimated 99% complete.

All major functions, with the exception of the hydraulic connector assemblies, are now operable from the consoles on the regular electrical system (no jumpers). The entire hydraulic system including the high pressure water system is estimated to be 99% complete. Mechanical modification work continued during the month, primarily to the end thrust stabilizer assemblies and the plug conveyor assemblies. All significant mechanical work, excluding modifications, is complete.

APED-Euratom Loading

Examination of the UO_2-1.5 PuO_2 sintered pellets made for the Euratom recycle program showed local areas of unusually high activity as determined by a gamma spectrometer. The principal peak investigated was the 60 kv gamma from Am_{241}. These areas have been checked with x-ray film wrapped around the suspect pellets. The high gamma spectrometer readings have been confirmed by dark spots on the film from the same area.

Since the pellets showed no significant variation from the desired composition when they were ground up and analyzed chemically, it is assumed that these spots of high gamma activity must be either surface contamination from handling, a migration of PuO_2 during the sintering cycle, or a local inhomogeneity due to insufficient mixing and/or sintering. These possibilities are all being investigated.

Fabrication of Fission Product Transient Capsules

Development work for the fabrication of 72 fission product transient capsules for Phillips Petroleum Company has begun. These elements will be tubes five inches long with a 0.692 inch ID and a 0.812 inch OD. The cladding material will be high purity aluminum 0.020 inch thick. The cores will be three to four inches long and 0.020 inch thick containing alloys of Pu-Al, Pu-Al-Li, U_{235}-Al, U_{235}-Al-Li, U_{233}-Al, and U_{233}-Al-Li of varying compositions.

Since a core-to-clad bond is required, the tubes will be coextruded with integral end caps. Due to the short length of the tube, multiple extrusions will be attempted. These will have three or four cores extruded with aluminum spacers. Preliminary extrusions have been made at ten-to-one reduction in area starting from a 1.5-inch diameter hollow aluminum billet extruded over a floating mandrel.

Fabrication of Physics Test Standards

The zero-boron containing elements were shipped to Bettis Atomic Power Laboratory. The aluminum-boron and aluminum-plutonium-boron alloys were extruded and are being analyzed. The aluminum-uranium-boron alloys have not been cast pending analytical results because only a small excess of enriched uranium is available. In general, the composition of the alloys was known within ± 2 percent, at the 95 percent confidence level.

J. W. Woodfield
For Manager, Reactor and Fuels Research
Research and Development

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

NOVEMBER 1961

FISSIONABLE MATERIALS - 02 PROGRAM

FUELS

Kinetics Calculations for HTR

At the request of personnel in Fuels Preparation Department, some additional calculations have been made of the consequences of postulated step reactivity increments in HTR with all control and safety mechanisms inoperative. In addition to the $1 increment case reported earlier, increments of $2 and $0.304 have been considered. The latter corresponds to the as-loaded excess reactivity of the HTR. The calculations predicted that excursions would be quenched by the negative fuel and moderator temperature coefficients, with peaking at about 3 seconds for the $2 increment, and about 225 seconds for the 30¢ increment. Metal temperatures after 400 seconds were in the 900-1500 C range for the large increment, and in the 150-250 C range for the small increment, the variation representing uncertainties in the coefficients and in assumptions about heat transfer.

REACTOR

Optimization of C-Pile Retubed Lattice

An exponential pile mockup of the C-pile lattice has been built to help establish the safety of the over-bored C-Reactor during a flooding accident. The material buckling has been measured with wet C-II-N fuel elements loaded in standard C-Pile process tubes. The buckling is $82 \pm 2 \times 10^{-6}$ cm^{-2}. The measured extrapolation lengths were 0.9 inches perpendicular to the tubes and 0.9 inches parallel to the tubes.

FPD now has enough C-IV-N reject fuel elements for the exponential pile loading. The bumpers that center the fuel elements in the process tubes are being welded on the fuel elements.

Effectiveness of Internal Surfaces

Preliminary values for the lattice parameters k_∞ and f have been deduced for the concentric tube fuel in a 14.5-inch lattice described in the Monthly Report - October, 1961. The measurements were made to check the unusual shape of the buckling curve for this fuel and to find whether a lattice this large could be studied in the Physical Constants Test Reactor (PCTR). The large lattice made the normal flux matching procedure impractical. The criterion used, therefore, was that the adjoint ratios were matched. The deduced adjoint ratios and the associated masses of poison are shown in Table I. The measured values of k_∞ and f are listed in Table II.

TABLE I

Lattice	Central Cell (m_1/m_2)	Buffer m_1/m_2	$\frac{\Delta(m_1/m_2)}{(m_1/m_2)}$	M_o grams
Wet	0.890	0.814	0.085	-378.5
Wet	0.895	0.846	0.055	-391.6
Wet	0.882	0.865	0.019	-400.8
Wet	(Extrapolation)		0	-404.5
Dry	0.842	0.816	0.031	303.0
Dry	0.830	0.819	0.013	264.4
Dry	(Extrapolation)		0	235.5

TABLE II

	k_{ex}	f
Wet	-0.076	0.771
Dry	0.034	0.858

Improvement of the 1/v Cadmium Ratio

The measurement of the 1/v activity induced in a foil is dependent upon knowledge of the resonance integral. The difference between the measured cadmium ratio and the 1/v cadmium ratio is an indication of the magnitude of the resonance integral. The cadmium ratios of several detectors have been compared with that of boron, for three different neutron spectra.

The results in Table I show that sodium is closer to being a 1/v detector than is copper for all spectra. The gold and indium data were taken to help determine epithermal flux shape in the region where 1/v activation is significant. Series I represents measurements taken at the center of a 2.5-inch fuel element. Series II and Series III represent measurements taken in graphite so that the neutron spectrum approached a Maxwellian with a 1/E tail.

TABLE I

Material	Series I*	Series II*	Series III
BF_3	8.98	22.87	77.20
Gold (5 mil)	2.39	4.01	12.05
Copper (5 mil)	4.22	12.00	42.48
Sodium (2 mil)	7.96	20.20	65.43**
Indium (8 mil)			11.99

* Reported in the Monthly Report - July, 1961.

** Effective thickness, 2.15 mils.

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Exponential Pile Measurements for N Reactor

The N-Reactor is designed with a .075-inch annular steam vent between the process tubes and graphite. In a flooding accident this steam vent could be filled with water which would increase the nuclear hazard. To measure the effect of the water in the steam vents polyethylene sheets were wrapped around the process tubes and the material buckling was measured. The polyethylene has nearly the same absorption and scattering properties as water. The buckling has been measured with .040 inches of polyethylene around the tubes to similate half-flooding of the process tube steam vents. The measured buckling with half-flooding is $135 \pm 3 \times 10^{-6}$ cm^{-2} compared to $116 \pm 3 \times 10^{-6}$ for N-Reactor with no flooding. Experiments will continue to establish the amount of flooding which produces the largest increase in buckling.

Theoretical Analysis of the Cadmium Shutter Method in Exponential Experiments

A Green's function analysis of the cadmium shutter method has been completed for exponential assemblies. Since the flux obtained with a shutter in the assembly can arise only from thermal source neutrons above the shutter and background, subtracting this flux from the no shutter flux not only eliminates the effect of background, but also the effect of thermal source neutrons in the measurement region. Consequently, the resulting expression for the flux difference in the measurement region is not only simpler than the no shutter case but has less harmonic content so that analysis is considerably simplified. The advantages of this method have been recognized for some time, but the present analysis is the first to include effects arising from a fast source in a finite base and different materials in the base and measurement regions. Provision for use of the above analysis is being incorporated into program VTΘCL, and comparison with experiment will be undertaken shortly.

Lattice Parameter Calculational Methods

In an effort to obtain experience in the use of multi-group, rather than few-group, diffusion theory in the analysis of Hanford-type reactor lattice cells, an 18-group calculation of the cold, clean NPR cell has been made with program HFN. The resulting k_∞ proved to be inadequate (some 30% low), due principally to the inadequate treatment of the U-238 absorption in the resonance region.

These cross sections were obtained from the 9-ZOOM library tape, and were designed for highly enriched homogeneous systems. While some inaccuracy was expected because of the inadequate self-shielding in U-238, the result was larger than anticipated. At present, two possible ways of obtaining better U-238 cross sections are being investigated: (a) correction of the present cross sections for self-shielding, and (b) calculation of a more detailed slowing down spectrum, using C-6 or GAM, and deriving new 18-group cross sections from this spectrum.

Computational Programming Services

The reactor kinetics code TRIP002 has operated successfully for two different types of cases. An improvement which will permit the addition of as many as t[redacted]-standard equations has been coded as TRIP003, and is being debugged.

A number of requested options have also been added to TRIPOOL. Some time was spent assisting IPD personnel in the operation of the code.

An improvement to VTOCL, the exponential pile data reduction program, was well received. All vital input and output options are now printed and identified for each case.

Instrumentation

Experimental tests continued on methods for measuring the purity of the NPR graphite stack. A number of local and commercial BF_3 tubes were tested. One special-order commercial tube operated the best with counting-rate drifts of less than 3% per day. A charge-sensitive transistor amplifier was developed and fabricated for use with the BF_3 tubes. A special detector housing was designed to meet the rather unusual dimensional requirements for the actual NPR stack tests. Trial assembly tests were run in the full-scale mockup at White Bluffs.

Considerable technical assistance was rendered to NPR Process Design, and Instrumentation Design, CEUO, concerning the slow-scan, gamma energy analysis portion of the NPR fuel failure monitor.

One set of approval prints was reviewed and corrected for the NPR high level neutron flux monitors. Several items required modification to prevent false reactor scrams.

The Mark II process tube distortion traversing mechanism was completely assembled and is now ready for tests on a full-length ex-reactor tube at F Area. This test has been delayed due to reactor shutdowns at K and B Areas which have kept the Irradiation Testing people busy. They have been unable to take time out to assist in running the tests.

A Mark III traversing mechanism has been designed. The hoped-for advantages of this new model are simplicity of construction, ease of decontamination, reduction of traverse time, and greater accuracy.

NPR Project Section requested technical assistance to: (1) Audit the NPR flow monitor specifications and purchase, (2) Consult regarding design of the integrated Temperature Monitor and Data Logger and develop information needed for reliability studies, and (3) Study and analyze instrumentation for the 109 Building (Heat Exchanger) as it is developed and predict the expected system's reliability. The flow monitor has been studied quite thoroughly and a few late revisions are being evaluated. A trip is planned to Los Angeles in early December to the Temperature Monitor and Data Logger vendor's plant. A start was made on analysis of the 109 Building system.

The proposal being considered by IPD for experimental fuel rupture detection equipment for the PRTR Rupture Loop was extensively revised, and new cost estimates were prepared.

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Systems Studies

A six-node reactor speed-of-control model with reactivity and metal temperature feedback in each node is presently being studied on the GEDA and EASE computers. Valid results were obtained within three days after the problem was placed on the computers. This problem will use about four weeks of computer time.

The VSR withdrawal rate problem, which requires simulation of reactor operation during startup, has been prepared; the problem will be studied on the analog computer as soon as computer time is available.

Production Test IP-439-C, "Rod Position Change Versus Neutron Flux", for experimental reactor dynamics data acquisition has been approved, and installation of the test equipment at 105-KW is planned for the next scheduled shutdown. Some modification to the test equipment arrangement was required due to installation of the in-core monitor instrumentation at the 50-foot level, rather than in the control room. Since it is desired to record rod position and flux on the same recorder, it was decided to locate the recorder at the 50-foot level and transmit rod position information to the recorder via a multiconductor cable. The cable installation has been completed and equipment installation is in progress.

A meeting was called by Operational Physics, IPD, to discuss the rod control logic to be used in the forthcoming automatic control tests at 100-D reactor. Control of the half-rods will be in accordance with a method, outlined by C. D. Swanson in HW-69851, which reduces the number of rod movements required under certain conditions. Instrument Development Operation, IPD, has determined that magnetic amplifier control units having the required zero shift stability and resolution are available. A purchase order for these units is being processed (by IPD), and 12-week delivery is expected.

Frequency response tests on the metastable xenon simulation to date indicate that the major effect of changing the relative absorption cross sections of metastable and ground state isomers is to change the system gain. There appears to be very little change in the phase response. Additional frequency response tests are planned before the kinetics and xenon simulations are combined.

A reactor instrumentation study was made to determine the effect of time delays introduced by the instrumentation on the reactor outlet temperature as a function of reactivity. The variable parameters for this study were: "scram" trips set for various percentages of power level and for various outlet temperatures, and instrumentation time delays of 0, 1, and 2 seconds and several combinations of resistance temperature detector time constants. The results were very good. The EASE computer worked extremely well throughout the entire study, which required three weeks of computer time. However, the results did not conform to expectations. Some identical test cases were run on the IBM 7090, and the results obtained there fully confirmed those obtained from the analog. The study was completed in November.

SEPARATIONS

Criticality Experiments With Plutonium Solutions

Criticality studies of plutonium nitrate solutions in a 14-inch diameter sphere were continued. The concentration of plutonium in these solutions was ~ 130 g/ℓ with the acid molarity being ~ six.

An effort was made to correct the measured critical mass values of the nominally reflected sphere (one inch of paraffin) for the effect caused by the thin stainless steel of the vessel. This was done by adding several different layers of thin stainless steel (0.036-inch, and 0.072-inch) to the critical assembly vessel before the addition of the one-inch thick paraffin reflector. The critical mass for the 14-inch sphere, reflected only with paraffin, could then be determined from extrapolation of the curve of critical mass versus stainless steel thickness. The experiments showed the effectiveness of the paraffin reflector to be slightly reduced because of the stainless steel. The critical volume of about 22 liters would have been ~ 0.35 liter less were the stainless steel shell of the vessel to be removed.

From previous measurements with the sphere bare, it was noted that stainless steel in small thicknesses was equivalent to solution volume; the critical volume was reduced by the volume of stainless steel added to the vessel.

In one case the reflector consisted of a 0.030-inch layer of cadmium plus one-inch of paraffin.

The results of the criticality experiments completed during November are summarized in the following table.

There were some inconsistencies in the data because of the fact that the paraffin was distorted from its original shape when being positioned over the slightly larger sphere with the added layers of stainless steel, i.e., the critical volume with only the paraffin reflector in place was slightly different before and after the experiments with the stainless steel. For this reason, another paraffin reflector was made and used to further check on the effects of the stainless steel shell. Although the absolute value of the critical mass was slightly different (presumably because of our inability to make two like reflectors), an extra layer of stainless steel was observed to produce essentially the same net effect as previously.

There also appear to be some inconsistencies in the results of the chemical analyses pertaining to the acid molarity determinations which need to be resolved.

Period measurements were run in several of the critical assemblies to test the period measurement and level potentiometer instrumentation and to evaluate differential control rod worths. The period and level potentiometer, together with the timing circuits, performed satisfactorily. However, difficulties with the ln N and period amplifier in the safety circuit of channel five (high level) prevented other than a few periods being measured in each case, because of inadvertent scrams caused by line transients activating the period trip. Efforts are currently being made to correct this condition.

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CRITICALITY STUDIES WITH PLUTONIUM SOLUTIONS

IN 14-INCH DIAMETER STAINLESS STEEL SPHERE

(Measured Sphere Volume 23.22 Liter; Wall Thickness, 0.044-inch)

Date	Exp.No.	Reflector Condition	Pu(g/ℓ)	Acid* Molarity	Sp.Gr.	H_2O(g/ℓ)	Total NO_3(g/ℓ)	H/Pu (Atomic Ratio)	Critical Volume (liters)	Critical Mass (Kg Pu)
11- 7-61	1141024	1" Paraffin	126.1	6.04	1.388	750	500	169.3	22.2	2.80
11- 9-61	1141025	0.036" S.S. + 1" Paraffin	126.1	6.04	1.388	750	500	169.3	22.5	2.84
11-14-61	1141026	0.072" S.S. + 1" Paraffin	127.4	6.43	1.391	750	514	168.3	22.6	2.88
11-15-61	1141027	0.030" Cd. + 1" Paraffin	127.4	6.43	1.391	750	514	168.3	25.5**	3.25**
11-16-61	1141028	1" Paraffin	127.4	6.43	1.391	750	514	168.3	22.9	2.92
11-17-61	1141029	SS Bare Sphere	130	5.21	1.394	746	502	161.9	29.0**	3.77**
11-22-61	1141030	1" Paraffin	130	5.21	1.394	746	502	161.9	22.6	2.94
11-27-61	1141031	0.036" S.S. + 1" Paraffin	128.6	5.91	1.393	774	482	170.8	22.8	2.93
11-29-61	1141032	1" Paraffin	128.6	5.91	1.393	774	482	170.8	22.7	2.92

* The values given for acid molarity are somewhat inconsistent when compared with the other properties of the solutions, all being obtained from the results of chemical analyses.

** Estimated value from multiplication curve.

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In subsequent experiments, the 14-inch sphere is to be fully reflected with water and also with layers of concrete in four and ten-inch thicknesses; the pouring of the special concrete pieces needed to form the nesting shells for these units has begun.

On the morning of October 31, a plutonium leak was discovered in the critical assembly hood. The leak was brought to light during a routine shoe check following entry into the hood for instrument repairs. Plutonium nitrate solution at $\sim$ 130 g Pu/l had leaked through a defective valve and dripped onto the floor of the critical assembly hood. Immediate action was taken to decontaminate the floor area in the critical assembly room which had become contaminated after leaving the hood; this cleanup was accomplished during the same day of the occurrence. Three more days were required, however, to obtain a new valve, replace the defective unit, and decontaminate the interior of the hood. Air contamination was kept below fresh air levels during the decontamination process. One case of minor skin contamination occurred during the replacement of the valve when some plutonium solution was spilled on protective clothing. Immediate and commendable action by RMO and CMP personnel kept this contamination to a minimum. Air samples in the critical assembly hood are now back to normal with the overnight samples running below mask level.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

1. Criticality of Plutonium Nitrate Solutions

While nuclear safety calculations are normally based upon idealized solutions of plutonium and water, it is realistic and of considerable interest to compute the critical parameters for actual plutonium nitrate solutions. The availability of some accurate chemical analytical results has made possible the calculation of the critical parameters of such systems, extending well into the range of the present experiments being carried out by the Critical Mass Physics Group.

The method of computing the compositions of the plutonium nitrate systems depends upon combining an acid-water mixture of a given molarity with an appropriate amount of the crystal, $Pu(NO_3)_4 \cdot H_2O$. To form the solution (and compute its composition accurately), a plutonium concentration and acid molarity are assumed. The appropriate amount of the crystal and the acid solution are added volumetrically. A correction to the amount of acid solution added is then made to account for the fact that the volumes of the crystal and the solution, when dissolved, are not strictly additive. The correction is based upon a series of accurate measurements of the concentration of Pu, $(NO_3)^-$, H^+, H_2O, and the specific gravity of some trial solutions.

The calculation of the critical properties of the assumed solution are therefore the most realistic and probably the most accurate of such calculation extant. Agreement with the critical masses so far measured, and which can be directly compared, has been good. A more detailed comparison is in progress.

The calculated critical masses, volumes, and radii for both bare and reflected spheres, at various acid concentrations and Pu-240 content, are summarized in Tables I through IV. The calculations will be extended in

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TABLE I

CRITICAL PARAMETERS FOR $Pu(NO_3)_4 \cdot H_2O + HNO_3 \cdot H_2O$ BARE SPHERES - 0% Pu-240

H/Pu	Pu(g/ℓ)	H+(Molarity)	Specific Gravity	H_2O(g/ℓ)	NO_3(g/ℓ)	Rc(cm)	Vc(ℓ)	Mc(Kg Pu-239)
836	30	2.00	1.112	926.5	153.0	21.10	39.35	1.18
499	50	2.00	1.146	921.4	173.0	18.87	28.14	1.41
354	70	2.00	1.182	916.7	193.0	17.94	24.19	1.69
274	90	2.00	1.216	911.4	212.8	17.52	22.53	2.03
161	150	2.00	1.316	891.8	271.9	16.92	20.29	3.04
92.6	250	2.00	1.477	855.7	369.9	16.53	18.92	4.73
53.7	400	2.00	1.712	794.7	516.1	16.28	18.07	7.23
31.5	600	2.00	2.009	698.8	708.8	16.35	18.31	10.98
25.1	700	2.00	2.160	650.93	807.8	16.40	18.48	12.93
792	30	4.00	1.167	859.4	273.2	21.86	43.76	1.31
473	50	4.00	1.203	856.5	292.8	19.51	31.11	1.55
335	70	4.00	1.235	850.1	311.4	18.64	27.13	1.90
259	90	4.00	1.268	844.1	330.0	18.14	25.00	2.25
152	150	4.00	1.367	827.2	386.2	17.45	22.26	3.34
87.2	250	4.00	1.520	789.0	477.0	17.07	20.83	5.21
50.2	400	4.00	1.743	727.2	612.1	16.87	20.11	8.04
29.2	600	4.00	2.028	635.7	789.3	16.93	20.33	12.20
23.2	700	4.00	2.172	589.1	880.4	17.04	20.72	14.51
752	30	6.00	1.227	796.6	394.3	22.54	47.97	1.44
448	50	6.00	1.250	785.4	409.3	20.30	35.04	1.75
315	70	6.00	1.283	780.5	427.2	19.35	30.35	2.12
244	90	6.00	1.317	776.3	445.4	18.80	27.83	2.50
143	150	6.00	1.410	757.5	496.9	18.09	24.80	3.72
81.7	250	6.00	1.559	722.4	581.2	17.67	23.11	5.78
46.8	400	6.00	1.772	662.5	704.4	17.48	22.37	8.95
27.0	600	6.00	2.044	575.5	865.0	17.58	22.76	13.65
21.3	700	6.00	2.182	531.1	947.6	17.75	23.42	16.40

TABLE II

CRITICAL PARAMETERS FOR $Pu(NO_3)_4 \cdot H_2O$ + $HNO_3 \cdot H_2O$ REFLECTED SPHERES - 0% Pu-240

H/Pu	Pu(g/ℓ)	H+(Molarity)	Specific Gravity	H_2O(g/ℓ)	NO_3(g/ℓ)	Rc(cm)	Vc(ℓ)	Mc(Kg Pu-239)
836	30	2.00	1.112	926.5	153.0	17.06	20.76	0.623
499	50	2.00	1.146	921.4	173.0	14.80	13.58	0.679
354	70	2.00	1.182	916.7	193.0	13.88	11.20	0.784
274	90	2.00	1.216	911.4	212.8	13.44	10.17	0.915
161	150	2.00	1.316	891.8	271.9	12.80	8.78	1.32
92.6	250	2.00	1.477	855.7	369.9	12.42	8.02	2.01
53.7	400	2.00	1.712	794.7	516.1	12.25	7.69	3.08
31.5	600	2.00	2.009	698.8	708.8	12.27	7.74	4.64
25.1	700	2.00	2.160	650.93	807.8	12.34	7.87	5.51
792	30	4.00	1.167	859.4	273.2	17.68	23.15	0.694
473	50	4.00	1.203	856.5	292.8	15.35	15.15	0.757
335	70	4.00	1.235	850.1	311.4	14.42	12.56	0.879
259	90	4.00	1.268	844.1	330.0	13.93	11.32	1.02
152	150	4.00	1.367	827.2	386.2	13.21	9.66	1.45
87.2	250	4.00	1.520	789.0	477.0	12.85	8.89	2.22
50.2	400	4.00	1.743	727.2	612.1	12.67	8.52	3.41
29.2	600	4.00	2.028	635.7	789.3	12.70	8.58	5.15
23.2	700	4.00	2.172	589.1	880.4	12.79	8.76	6.13
752	30	6.00	1.227	796.6	394.3	18.25	25.46	0.764
448	50	6.00	1.250	785.4	409.3	15.97	17.06	0.853
315	70	6.00	1.283	780.5	427.2	14.98	14.08	0.986
244	90	6.00	1.317	776.3	445.4	14.45	12.64	1.14
143	150	6.00	1.410	757.5	496.9	13.71	10.79	1.62
81.7	250	6.00	1.559	722.4	581.2	13.29	9.83	2.46
46.8	400	6.00	1.772	662.5	704.4	13.10	9.42	3.77
27.0	600	6.00	2.044	575.5	865.0	13.15	9.52	5.71
21.3	700	6.00	2.182	531.1	947.6	13.25	9.74	6.82

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TABLE III

CRITICAL PARAMETERS FOR $Pu(NO_3)_4 \cdot H_2O + HNO_3 \cdot H_2O$ BARE SPHERES - 4.6% Pu-240

H/Pu	Pu(G/ℓ)	H+(Molarity)	Specific Gravity	H_2O(g/ℓ)	NO_3(g/ℓ)	Rc(cm)	Vc(ℓ)	Mc(Kg Pu239)
876	30	2.00	1.112	926.5	153.0	22.17	45.64	1.31
523	50	2.00	1.146	921.4	173.0	19.64	31.73	1.51
371	70	2.00	1.186	916.7	193.0	18.96	28.55	1.91
287	90	2.00	1.216	911.4	212.8	18.56	26.78	2.30
169	150	2.00	1.316	891.8	271.9	18.12	24.92	3.57
101	250	2.00	1.477	855.7	369.9	17.98	24.35	5.81
56.3	400	2.00	1.712	794.7	516.1	17.81	23.66	9.03
33.0	600	2.00	2.009	698.8	708.8	17.95	24.23	13.87
26.3	700	2.00	2.160	650.9	807.8	17.97	24.31	16.23
830	30	4.00	1.167	859.4	273.2	22.95	50.63	1.45
496	50	4.00	1.203	856.5	292.8	20.50	36.09	1.72
352	70	4.00	1.235	850.1	311.4	19.65	31.78	2.12
271	90	4.00	1.268	844.1	330.0	19.26	29.93	2.57
160	150	4.00	1.367	827.2	386.2	18.74	27.57	3.94
95.5	250	4.00	1.520	789.0	477.0	18.61	27.00	6.44
52.6	400	4.00	1.743	727.2	612.1	18.50	26.52	10.12
30.6	600	4.00	2.028	635.7	789.3	18.62	27.04	15.48
24.3	700	4.00	2.172	589.1	880.4	18.69	27.35	18.26
788	30	6.00	1.227	796.6	394.3	23.70	55.76	1.60
466	50	6.00	1.250	785.4	409.3	21.36	40.82	1.95
331	70	6.00	1.283	780.5	427.2	20.48	35.98	2.40
256	90	6.00	1.317	776.3	445.4	20.0	33.51	2.88
150	150	6.00	1.410	757.5	496.9	19.45	30.82	4.41
89.5	250	6.00	1.559	722.4	581.2	19.26	29.93	7.14
49.0	400	6.00	1.772	662.5	704.4	19.18	29.55	11.28
28.3	600	6.00	2.044	575.5	865.0	19.30	30.11	17.24
22.4	700	6.00	2.182	531.1	947.6	19.40	30.58	20.42

TABLE IV

CRITICAL PARAMETERS FOR $Pu(NO_3)_4 \cdot H_2O$ + $HNO_3 \cdot H_2O$ REFLECTED SPHERES - 4.6% Pu-240

H/Pu	Pu(G/ℓ)	H^+(Mol)	Specific Gravity	H_2O(g/ℓ)	NO_3(g/)	Rc(cm)	Vc(ℓ)	Mc(Kg Pu-239)
876	30	2.00	1.112	926.5	153.0	18.05	24.63	0.705
523	50	2.00	1.146	921.4	173.0	15.64	16.02	0.764
371	70	2.00	1.186	916.7	193.0	14.71	13.33	0.890
287	90	2.00	1.216	911.4	212.8	14.30	12.25	1.051
169	150	2.00	1.316	891.8	271.9	13.72	10.82	1.548
101	250	2.00	1.477	855.7	369.9	13.65	10.64	2.639
56.3	400	2.00	1.712	794.7	516.1	13.55	10.42	3.976
33.0	600	2.00	2.009	698.8	708.8	13.66	10.68	6.113
26.3	700	2.00	2.160	650.9	807.8	13.72	10.82	7.225
830	30	4.00	1.167	859.4	273.2	18.60	26.95	0.771
496	50	4.00	1.203	856.5	292.8	16.25	17.97	0.857
352	70	4.00	1.235	850.1	311.4	15.35	15.15	1.011
271	90	4.00	1.268	844.1	330.0	14.90	13.86	1.190
160	150	4.00	1.367	827.2	386.2	14.27	12.17	1.741
95.5	250	4.00	1.520	789.0	477.0	14.10	11.74	2.800
52.6	400	4.00	1.743	727.2	612.1	14.00	11.49	4.384
30.6	600	4.00	2.028	635.7	789.3	14.10	11.74	6.720
24.3	700	4.00	2.172	589.1	880.4	14.21	12.02	8.027
788	30	6.00	1.227	796.6	394.3	19.33	30.25	0.865
466	50	6.00	1.250	785.4	409.3	16.82	19.93	0.950
331	70	6.00	1.283	780.5	427.2	15.95	17.00	1.135
256	90	6.00	1.317	776.3	445.4	15.49	15.57	1.336
150	150	6.00	1.410	757.5	496.9	14.90	13.86	1.983
89.5	250	6.00	1.559	722.4	581.2	14.65	13.17	3.140
49.0	400	6.00	1.772	662.5	704.4	14.55	12.90	4.923
28.3	600	6.00	2.044	575.5	865.0	14.62	13.09	7.493
22.4	700	6.00	2.182	531.1	947.6	14.70	13.30	8.882

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the near future to two more Pu-240 concentrations and to higher Pu-concentrations as more chemical data become available.

2. Quantity of Boron Needed to "Safe" Plutonium Solutions - Reduce k_∞ of Solution to Unity

The amount of Boron-10 needed to reduce k_∞ to unity was recomputed using new Boron-10 cross sections for the epithermal groups.* The correction of some previously undetected errors made the recalculation necessary. The results are summarized in the following table.

CALCULATED VALUES OF THE AMOUNT OF BORON-10 REQUIRED TO REDUCE k_∞ TO UNITY

H/Pu	Atoms Pu (10^{24}/cc)	Pu (gm/cc)	B (gm/cc)	N^B/N^{Pu} (atomic ratio)	Thermal Group Parameters (barns) σ_c^B	σ_f^{239}	σ_a^{239}	σ_{tr}^H
12	5.04 (-3)**	2.0	2.749	.744	1255	317.6	835.6	11.9
25	2.52 (-3)	1.0	.667	.3611	1409	540	889	13.5
32	2.016 (-3)	0.8	.453	.3085	1500	565	902	14.5
43	1.512 (-3)	0.6	.3174	.2864	1620	591	946	15.4
65	1.008 (-3)	0.4	.2038	.2758	1775	633	1010	16.6
131	5.04 (-4)	0.2	.1019	.2758	2150	684	1080	20.4
264	2.52 (-4)	0.1	.05205	.2818	2500	708	1083	24.6
529	1.26 (-4)	0.05	.02507	.2714	2800	709	1061	27.5
872	7.562 (-5)	0.03	.01283	.2314	2960	700	1042	29.5
1270	5.04 (-5)	0.02	.00733	.1984	3200	695	1004	31.7
2652	2.52 (-5)	0.01	.00167	.0984	3365	685	965	33.2
3536	1.89 (-5)	0.0075	.000281	.02026	3383	684	961	33.4

* The results of earlier calculations were first reported in September of this year.

** Quantity in bracket denotes power of ten to which the corresponding number is multiplied.

The data presented in the preceding table are of interest in connection with plans for more extensive use of neutron absorbers (boron impregnated raschig rings) in criticality control at Hanford.

3. Revisions to Reactor Physics Lattice Parameter Code

Two revisions have been made to the reactor physics lattice parameter code - IDIOT. The first revision reduces the amount of data preparation necessary to generate a series of calculations. This revision permits one to change the value of any input parameter in a preceding case by the simple addition of change cards.

The second revision fixes an upper limit on the deviation of the equilibrium neutron flux from a Maxwellian distribution. For tightly packed lattices, in which the moderator-to-fuel ratios are small, the equilibrium neutron spectrum can no longer be considered thermal, i.e., the four factor formula for the infinite multiplication factor will not be valid for these epithermal systems. Any epithermal ratio, which is a measure of the magnitude of the 1/E epithermal flux to the thermal Maxwellian flux, that is greater

than unity, will now be set to a value of one, and the code will proceed with the calculations; however, a message will be written indicating that certain epithermal ratios have exceeded unity and have been assigned a value of unity.

Both revisions have been checked out and will be included in the IDIOT code that is presently on file in the Special Procedures Library.

Interaction of Sub-Critical Systems

Interaction in terms of leakage, albedo, and secondary absorption was extended to a two-group model for single fully reflected slabs. Criticality factors agree fairly well with a two-group diffusion calculation.

An iterative method has been formulated to predict the effect of two interacting systems on k_{eff}. An approximate total solid angle function for slabs was found. Experimental data is being used as a basis of evaluation of the model.

In-Plant Neutron Multiplication Measurements With Plutonium Metal

On November 11 and 12, a series of neutron multiplication measurements were made with plutonium metal in Hood HC-21C of the 234-5 Building.(1)

Seven multiplication experiments were completed during the two days of these tests. Personnel of CPD arranged for the experiments, and performed the measurements with instrumentation borrowed from Critical Mass Physics; E. D. Clayton served as technical director during the conduct of the experiments. The objectives of the tests were primarily to determine reflector efficiencies of various materials, as a function of thicknesses and spacings, so that data would be available for evaluation of future furnace designs.

Of those in-plant experiments completed to date, the current results are the most amenable to theoretical interpretation. A cylindrical array of plutonium was built up from plutonium metal disks, 3.5-inches in diameter. The cylindrical array was reflected with lucite of four different thicknesses ranging from 3/16-inch to 25/32-inch. The smallest critical mass measured was 8.5 Kg Pu for the case of the 25/32-inch lucite reflector; the final loading contained 84% of the estimated mass for criticality.

The data for the nominally reflected plutonium cylinders may be used to obtain an estimate for the unreflected critical mass, and to evaluate the shape factor for the bare plutonium cylinder. The shape factor is the ratio of the critical mass in cylindrical geometry to the value in spherical geometry. The data indicate the critical mass for the unreflected unit to be $\geq$ 11.5 Kg Pu. The shape factor for the height-to-diameter ratio of 1.07 is then $\sim$ 1.11. This is in excellent agreement with the shape factor of $\sim$ 1.12 which is given for U-235 metal cylinders with this H/D ratio.

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(1) Isaacson, R. E. and R. L. Stevenson, Addendum to In-Plant Multiplication Test No. 2, HW-71579.

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Unfortunately, an insufficient quantity of plutonium was available to obtain a good critical mass estimate for the cases of the 3/16-inch reflected unit and the bare unit. Otherwise, an excellent shape factor determination could have been accomplished.

In one of the experiments, the plutonium cylinder was reflected on the sides only, with a 19/32-inch layer of lucite.

During subsequent measurements, it was shown that a 1/8-inch thick copper cylinder of diameter 7½ inches and height six inches, had a negligible effect on the neutron multiplication of the plutonium cylindrical array when centered within the copper cylinder.

In another multiplication measurement involving plutonium metal shells, it was shown that an infinite column of Model 1251 hemi-shells nested together would be subcritical.

Mass Spectrometry

The heavy element mass spectrometer for this program provided isotopic analyses on three uranium samples for Fuels Preparation Department and on ten plutonium samples for Chemical Processing Department.

Some operating difficulties are still being encountered with this mass spectrometer. Measurements of the isotopic ratios of standard uranium samples indicate systematic biases as large as three percent which are not constant from sample to sample. In addition, it has not been possible to maintain ion beam intensities of the proper shape for extended periods of time. The latter problem is under continuing study.

Criticality Hazards Specifications

Evaluation for Nuclear Materials Operation

Nuclear safety approval was given for the shipment of 1300 lb. of 0.95% U-235 enriched uranium in the form of tubular fuel elements to American Machine and Foundry.(1) Under the conditions of the shipment, the uranium represented considerably less than 20% of a critical mass.

Instrumentation and Systems Studies

Study of the CPD tracer lathe problem continued with an effort to evaluate the constants of a three-mode model for analog computer studies. Systems Research Memorandum 61-42 was issued describing the status and results of the study. One result was an indication that a proposed dynamic vibration absorber does some good in improving the control characteristics. One desirable feature would be to design an absorber that can be tuned to two different frequencies. A way of doing this has been suggested and the appropriate equations are being developed.

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(1) Letter from P. F. Gast to F. J. Zelley, Nuclear Safety Approval for 0.95% U-235 Fuel Element Shipment, November 7, 1961.

The most important instrument problem at the Critical Mass Lab involves false trips on the channel five period monitor. The trouble seems to be caused by large, fast transients on the incoming power line. A line voltage recorder has shown a periodic "spike" on the line occurring every ten minutes. Other transients, evidenced by dimming lights, have proved themselves to be present but too fast for the line voltage recorder. A line voltage transient measuring device developed by CPD will be installed in the near future.

Other instrument problems at the Critical Mass Lab include the following:

1. Two transistorized preamplifiers, for use with semiconductor neutron detectors, have been studied. A modification of an amplifier developed at Brookhaven seems to work quite well. It is the charge-sensitive type with independence of input capacity. With an emitter follower output, it will successfully drive a long cable. The output signal drops from 40 to 20 millivolts when 1500 picofarads are connected across the input.

2. A neutron scintillation counter employing a 6810-A phototube is being installed. It will be used in conjunction with a multichannel analyzer and neutron pulser for reactor neutron burst tests.

3. A neutron scintillation detector has been fabricated for use with a new type log n-period meter.

4. Work is progressing on the fabrication of the new control rod drive assembly.

5. Work on a digital criticality predicting instrument has been deferred because of lack of interest on the part of the operating personnel and the excessive cost.

6. The audio monitor now produces an audio "pip" at the frequency of detected events. Additional resolution of radiation level and rate of increase is desired. Brief investigations of simple means of solving this problem have been started.

An attempt is under way to develop a satisfactory mathematical model of a pulse column used in chemical separations. Four possible mathematical models of varying complexity have been derived and the analog computer will be used to determine the chemical constants necessary to give the best fit of each of the models to given experimental data. The results of the analog work will be used to determine which, if any, of the models will most nearly describe the operation of a pulse column. One of the four models was simulated and the constants determined for the best fit to experimental results furnished by the customer. The "fit" obtained was within ± 10% of the actual results. This was quite satisfactory to the customer. This work will continue during December.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Cross Sections

The 105-DR neutron crystal spectrometer was re-aligned and re-calibrated during the month. Further measurements of spectrometer operation and order

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contamination of germanium monochromating crystal reflections are in progress.

Inelastic Neutron Scattering from Water

The series of inelastic scattering experiments for room temperature water at 0.3 ev initial neutron energy, part of which had to be repeated because of beam monitor instability in the original runs, has been completed.

A series of room temperature water runs at 0.4 ev initial energy has been started. Energy analyses have been made for 8 and 40 degree scattering angles; angular distributions have been made for 0.15, 0.175, and 0.2 ev final energy.

The construction of a sample holder for water which has thick, rigid walls has been completed. This sample holder is to be used in measurements in which the water sample thickness is accurately determined in order to determine the absolute value of the differential scattering cross section scale.

A further water sample holder is being designed to be used in the measurement of the differential inelastic scattering of monoenergetic neutrons from water at elevated temperatures. The sample holder is being designed to accommodate the pressure due to water at temperatures up to 150°C.

Fast Neutron Cross Sections

Two successful liquid scintillation cells for use as fast neutron detectors were tested during the month. One detector consisted of liquid scintillator NE-213 contained in a two-inch diameter, two-inch thick stainless steel-walled-cell mounted on a 56AVP photomultiplier. An aluminum foil inside the cell was used to provide efficient light collection. Measurements were made with a pulsed-beam source of neutrons from the $Be^9(d,n)$ reaction to adjust the time resolution of the detector system. Time resolutions of 0.6 ns and 0.9 ns for gamma rays were observed for pulse-height biases corresponding to the rejection of proton-induced pulses below 3 Mev and 0.8 Mev, respectively. This resolution is about as good as can be expected from the photomultiplier and is about twice as good as the best previously obtained even with a very small detector. This detector provides an excellent detector for future measurements on differential scattering cross sections.

The second detector tested was essentially of the same construction as the first but provided a liquid scintillator volume of 5-inch diameter, two inches thick coupled to a 58AVP photomultiplier. This detector was tested without bench testing for optimum operating characteristics. The best time resolution obtained was 1.5 ns, relatively independent of pulse-height bias level.

The experimental arrangement for fast-neutron total cross section measurements by the pulsed polyergic beam time-of-flight was set up and tested at the Van de Graaff building. The 5-inch diameter liquid scintillator neutron detector was mounted in the heavily shielded room provided in 3745-B building, with a water shielding wall providing shielding for the doorway and a mount for the neutron beam collimators. The Be(d,n) and Li(d,n) reactions were both studied for resolution and background effects. Measurements of neutron beam intensities, spectral shape, and sources and levels of backgrounds were investigated. Measurements of total cross section from 3 to 15 Mev with at

least two percent precision and a time resolution of 0.4 ns/m were indicated to be possible for one sample per shift operation.

Work is in progress to fabricate a sample of elemental sodium for total cross section measurements.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Lattice Parameters for Low Exposure Pu-Al Fuels

The ratios of effective cross sections for copper absorption and Pu^{239} fission have been determined in the fuel clusters for each of the three lattices which have been studied in this program. The quantity R, defined in the next equation, is presented as a function of position in the cluster and as a function of lattice spacing in Table I.

$$\frac{\int \sigma_f^{239}(E)\phi(E)dE}{\int \sigma_a^{Cu}(E)\phi(E)dE} = \left(\frac{A_f^{Pu}}{A_a^{Cu}}\right)_{expt} \left(\frac{A_a^{Cu}}{A_f^{Pu}}\right)_{Thermal} \left(\frac{\sigma_f^{Pu}}{\sigma_a^{Cu}}\right)_{Thermal} =$$

$$R \left(\frac{\sigma_f^{Pu}}{\sigma_a^{Cu}}\right)_{Thermal}$$

TABLE I

VALUES OF R

Lattice	Center Rod	1st Ring	Outer Ring	Weighted Average
10-1/2"	1.0870	1.0873	1.1243	1.1107
8-3/8"	1.1154	1.1195	1.1781	1.1563
6-1/2"	1.1273	1.1424	1.2258	1.1943

These results indicate that there is a significant increase in the self-shielding of the plutonium in the fuel cluster as the neutron spectrum is hardened.

Lattice Parameters for High Exposure Pu-Al Fuels

The experiments planned for the 20% Pu^{240} material are similar in nature and scope to those experiments already performed using low exposure plutonium fuel. The plutonium is presently being fabricated by Plutonium Fuels Development Operation into 1/2-inch diameter rods of 2.2 w/o Pu-Al, clad in zirconium.

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Plutonium Fuel Temperature Coefficient

Experiments designed to measure the fuel temperature coefficient of Pu-Al fuel have been in progress for the past several weeks in the PCTR. The fuel is 1.8 w/o Pu-Al in a 19 rod cluster of 1/2" diameter rods. The clusters are arranged in a square, 6-1/2-inch graphite lattice and the lattice array has been poisoned to unit multiplication. Measurements of the change of PCTR reactivity have been made as the fuel in the central test cell was heated from room temperature to ~450°C. The approximate results so far are indicated in Table I.

TABLE I

Expt.	Reactivity Change (¢/°C)
Al dummy fuel, unpoisoned	~ + 0.002
Al dummy fuel, poisoned	~ + 0.002
1.8 w/o LX Pu-Al, unpoisoned	~ 0.000

Measurements using fuel rods containing 16% Pu^{240} in 2.1 w/o Pu-Al will be made in a few days, completing the series of experiments.

Calculation of Lattice Parameters for Pu-Al Foils

In conjunction with the experiments on Pu-Al lattices a series of cell calculations are being made for comparison with the measurements. The goals are 1) to supplement experimental data with calculated results, 2) to point out ways in which the experiments can be improved, and 3) to make some improvements in calculational techniques in order to more accurately predict the characteristics of thermal systems fueled with plutonium. With respect to the last item, calculations of effective values of η and of the resonance escape probability for Pu-240 represent problem areas.

The first system which is being studied is the poisoned case for the 19-rod cluster of 1.8 w/o LX Pu-Al in a 10-1/2" lattice. An equivalent cylindrical model of the unit cell has been obtained. The cluster has been transformed into a rod, tube and tube, in which the inner and outer circumferences of the tubes correspond to circles inscribed and circumscribed about the rods in the first and second ring of tubes in the cluster. The densities of the tubes are adjusted such that the total numbers of Pu and Al atoms are conserved between corresponding rings and tubes.

A preliminary calculation of the thermal flux distribution within the cylindrical model has been made with the IBM 7090 code IDIOT(1). A multigroup calculation using B. H. Duane's SN code(2) is being planned.

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(1) Richey, C. R. IDIOT - A Lattice Parameter Code for the IBM 709, HW-63411. January 7, 1960.

(2) Duane, B. H. Neutron and Photon Transport Plane-Cylinder Sphere GE-ANPD [redacted]ogram S Variational Optimum Formulation, XDC 59-9-118. January 9, 1959.

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PuO_2-UO_2 Lattice Studies

Work on specifications for the fuel elements and on preliminary plans for the lattice experiments is now essentially complete. The detailed physical specifications have been finished, and a design drawing is being prepared.

The study to determine both the amount of Pu enrichment and the most desirable lattice spacing for the initial experiment has been completed. The enrichment selected for the fuel element specifications is 0.85 w/c PuO_2 in depleted (0.22 w/o U-235) UO_2. Square lattice spacings of 8-3/8" or 10-1/2" would be equally satisfactory for the initial experiment with 19-rod clusters. Experiments could be done for lattices with smaller spacings, but a smaller number of rods per cluster would be used in these experiments. The product of the resonance escape probabilities for U-238 and Pu-240 becomes small ($\sim$ 0.55) for a 19-rod cluster of these rods in a 6-1/2" lattice.

The Critical Facility of the PRP

Rough drafts of experiments to calibrate the control and safety rods of the PRP-CF have been written. In addition, second drafts of some of the other experiments to be done at the startup of the facility have been prepared. All of the drafts have been circulated to members of the PRP-CF planning group. A procedure for normal startups has been reviewed.

The PRP-CF program includes experiments which require a reflector and also experiments which require sharply defined boundaries for thermal neutrons, i.e., boundaries of boral or cadmium. Originally, it was thought that these items could be added as the experiments required them. Calculations which have recently been made by Technical Planning Operation result in a value of $\sim$75 mk for an infinite light water reflector. Such a reflector would result if the cell which contains the facility were flooded. This hazardous situation could be removed either by wrapping a poison around the tank or by furnishing the reactor with a reflector.

Therefore, the PRP-CF program has been reviewed with the thought in mind of determining which could be better used initially, a cadmium sheet around the reactor or a reflector. It was decided to wrap the reactor tank with 0.020" cadmium sheets which are held to the tank by bands. This arrangement allows the cadmium to be removed and a reflector fastened to the tank when the experiments require a reflector.

An IBM-704 code for reactivity step calculations has been modified for use on the IBM-7090. The original program was written by C. E. Cohn and B. J. Toppel and is described in ANL-6134. The modifications include an increase in the maximum number of delayed neutron groups which can be considered from 30 to 50 and remove the requirement that all of the input be repeated when more than one case is run.

The program calculates the behavior of the flux in a reactor following a step change in reactivity by solving the one-thermal-group, space-independent, zero-power kinetic equations. The reactor is assumed to be running at constant level before the step is made, either at critical or subcritical conditions, with an external source.

1250522

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The code (RE-126) assumes all delayed-neutron precursors in equilibrium at the time of the step. It will be used to determine the photoneutron effects on reactivity measurements in the PRP-Critical Facility. Two test cases, utilizing a positive and a negative reactivity step change, have been successfully processed to date. In addition, most of the input parameters corresponding to a Critical Facility fuel loading of 25 UO_2 and 30 Pu-Al elements have been assembled for use in the machine calculations for this loading.

Fuel Irradiation Experiments

Three of the six low exposure Pu-Al fuel elements which have been modified by attaching 1/2 wt percent Co-Al wire flux monitors are ready for charging at the next shutdown of the PRTR (first week in December). The remaining three will be charged at the subsequent shutdown. These elements are scheduled for removal at approximately one month intervals, assuming 70 MW power level and 60 percent operation leading to 50 percent burnup in the last element.

The measurements planned for these elements for the purpose of relating fuel burnup and fission product buildup to exposure are, in chronological order:

a. Gamma scanning the outermost rods of the cluster in a gamma scanning facility to be installed in the Fuel Examination Facility.

b. Reactivity measurement in the PRP Critical Facility.

c. Gamma scanning and/or counting of Co-Al monitor wires and pins, as well as Zircaloy wrapping wire.

d. Mass spectrographic determination of plutonium isotopic content from samples at various longitudinal positions in a central, intermediate, and outer rods.

The PRP-CF schedule precludes measuring reactivity of these elements before exposure and will necessitate holding the irradiated elements in the basin until the facility is available. The reactivity of a PRP-CF element will be used as a standard.

Although preliminary planning has been completed for the gamma scanning facility, it is doubtful that it will be available when the first element is removed in January, 1962. A scan of short-lived activity which would characterize the fission rate distribution existing over a short interval prior to end of exposure would require gamma scanning within a few hours after exposure. For a measure of total exposure the longer after exposure the scan is made the better.

In preparation for the irradiations and subsequent measurements, the purity and uniformity of the monitoring wire is being investigated by irradiating samples of the Co-Al wire in F Reactor and counting the resultant activity with the 256 channel analyzer. It has been concluded from the preliminary results that waiting periods of at least 3 weeks should be allowed for impurities to decay before the wire is counted. Also, the wire can be assumed uniform to within ± 0.5% and therefore specific activities can be determined from the weights of pieces of the alloy.

Samples of U-235 and Pu-Al have been irradiated in the sigma pile and counted with the 256 channel analyzer to determine the feasibility of isolating specific short-lived and specific long-lived fission-product activities by counting gamma rays. These measurements have not progressed far enough to reach any definite conclusions.

Neutron Rethermalization in Graphite and Water

Values of the relaxation lengths for neutron rethermalization in graphite have been inferred (HW-68389) from analyses of experiments using the Selengut multithermal group model. These relaxation lengths can be calculated, approximately, with the theoretical results obtained by Kothari and Singwi (JNE 5, 342, 1957) and Kothari and Khubchandani (NSE 7, 240, 1960) in their studies of elastic and one phonon inelastic scattering cross sections of graphite for neutrons near thermal energies. The calculated values of the relaxation lengths are in fair agreement with the measured values. A comparison is given in Table I.

TABLE I

CALCULATION						EXPERIMENT*
T_1	a	D	T_r	τ_r	L_r	L_r
(^oK)	(sec^{-1})	(cm)	(^oK)	(cm^2)	(cm)	(cm)
260	3.4×10^3	.82	285.3	58.2	7.63	5.3
305	4.8×10^3	.81	301.8	42.4	6.52	4.8
350	6.6×10^3	.795	318.4	31.9	5.65	4.5
400	7.7×10^3	.78	336.8	28.1	5.30	4.3
500	8.8×10^3	.775	373.6	26.4	5.14	4.2
600	8.8×10^3	.775	410.4	28.3	5.32	4.2
1200	8.8×10^3	.775	631.1	37.6	6.13	4.9
1500	8.8×10^3	.775	741.5	41.5	6.44	
2000	8.8×10^3	.775	925.5	47.2	6.87	

$T_o = 300^oK$

* Estimated from experiments at T_1 = 144, 523, 690, 820°K.

The calculated values were obtained in an analysis of the Kothari, et al, results using a procedure which closely resembles Fermi age theory. The age for rethermalization of neutrons, initially at an effective temperature T_1, to a temperature T_r in graphite at temperature T_o is defined as

1) $\tau(T_1 \rightarrow T_r, T_o) = \sqrt{\frac{8k}{\pi m}} \int_{T_r}^{T_1} \frac{D}{a} \frac{T^{\frac{1}{2}}\, dT}{(T-T_o)}$

where k is the Boltzmann Constant, m is the neutron mass, D is the diffusion coefficient, and a and T_r are defined in an approximation to Kothari's results given by

2) $T_r = T_1 + (T_1 - T_o) \exp(-at_r)$.

In eq. 2 T_r is the temperature reached in a relaxation time $t_r = 1/a$. The quantity a is the approximate slope of Kothari's plot of

3) $\frac{dT}{dt} = -a(T - T_o)$;

a is a function of T.

The solution of eq. 1 is

4) $\tau_r(T_1 \rightarrow T_r, T_o) = D/a \left\{ 2(V_1 - V_r) + V_o \ln \left[\left(\frac{V_1 - V_o}{V_1 + V_o} \right) \cdot \left(\frac{V_r + V_o}{V_r - V_o} \right) \right] \right\}$

where $V_i = \sqrt{\frac{8k}{\pi m} T_i}$

The relaxation length, L_r, is defined as

$$L_r = \sqrt{\tau_r}\,.$$

Equation 4 appears to be applicable for any value of T_1 and hence should yield values of τ which asymptotically approach the Fermi age of graphite. It does not, however. Further study is being made to clarify this point. This discrepancy in the limit of large T_1 should not invalidate Eq. 4 for small T_1 ($\leq 2000^{\circ}K$).

Neutron Spectrum Studies

In the reduction of bare and cadmium covered activity data to thermal activities one must assume a form for the energy distribution of neutrons in the "joining region" between the thermal and epithermal neutron groups. Justification of the various spectra used is vague. An estimate of the "best" spectrum to use may be obtained from data taken in the rethermalization experiments.

In a system with a uniform physical temperature and constant energy distribution of thermal and epithermal neutrons one can expect that

$A^y_{th}(r) = CA^x_{th}(r)$ where x and y are any isotopes, $A_{th}(r)$

are the spatial values of the thermal activities of a detector and C is a norm-

alizing constant. In general $A_{th} = A_B - \alpha A_{EC}$ where A_B and A_{EC} are the bare and cadmium covered activities and α is the ratio of epithermal to epicadmium resonance integral. The quantity α is dependent upon the energy distribution of epithermal neutrons and is defined as

$$\alpha = \frac{\int_{E_{et}}^{\infty} \sigma(E)\phi(E)\, dE}{\int_{E_{ec}}^{\infty} \sigma(E)\phi(E) dE}$$

For near 1/v detectors $\alpha \rightarrow 2$; for subcadmium resonance detectors it is larger (up to 19 for Lu-177); and for detectors with epicadmium resonances α approaches unity. The first and last classes include Cu and Au, respectively. For Cu the variation of α with spectra is small (± 10% or so) while α^{Lu-177} may vary by 300%. It is possible therefore to find A_{th}^{Cu} accurately if A_{EC}^{Cu} is small (few % of A_B) and one may write

$$A_{th}^{Cu} = C \left[A_B - \alpha A_{EC} \right]^{Lu-177} .$$

Rewriting this as

$$y = a_1 x_1 + a_2 x_2$$

one may consider y as a dependent variable and x_1 and x_2 as independent variables. A multiple-linear least squares analysis of the last equation yields a_1 and a_2 and hence α^{Lu-177}.

This type of analysis of Cu and Lu-177 traverses in the room temperature experiments on rethermalization in water yields an $\alpha(Lu^{177}) = 20$, which is in very good agreement with the Hurwitz spectrum value of 19.5.

Nondestructive Evaluation of PuO_2 Homogeneity in PuO_2-UO_2 Fuel Rods

A description of a differential reactivity method of non-destructively testing the homogeneity of PuO_2 in PuO_2-UO_2 fuel rods was reported last month. A brief attempt was made this month to determine the sensitivity of subcritical methods of evaluation. With multiplication adequate for fast response ($M \approx 50$) the differential ion currents due to effective changes in TTR fuel content were found to be approximately equal to the ion current noise. This problem can be partially overcome by increasing the TTR source strength.

Pu-240 Effective Resonance Integral

The detailed operational procedures have been specified for the experiment to measure the effective resonance integral of Pu-240 relative to the dilute resonance integral as a function of Pu-240 concentration.

The fuel rods for the experiment have been completed by Plutonium Fuels Development Operation and will be delivered early in December.

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Pu Values in Fast Spectrum Reactors

Some test problems using HFN and the sixteen group fast cross section set of Yiftah, Okrent, and Moldauer have been successfully run, so that one-dimensional, fast reactor diffusion calculations can now be carried out.

As a first application of this procedure, the Pu value in a fast oxide breeder reactor is being examined. The model for this fast oxide breeder has the following characteristics:

Power Level:	1000 MWT
Core Volume:	2300 lit
Core Composition:	55 v/o Na
	15 v/o Fe
	30 v/o Fuel

The breeding blanket consists of sodium, iron, and fully depleted UO_2.

A variety of fuels are postulated in this reactor. In addition to U-235, a series of Pu composites are introduced. These Pu compositions are identical with compositions becoming available from a "typical" thermal, water-moderated reactor at various stages of burnup. For each fast reactor composition, critical loadings and breeding ratios have been calculated. The plutonium indifference value is then computed for each case.

The results of the multi-group calculations are presently being analyzed. Preliminary results indicate that in fast spectrum reactors the plutonium value (Pu-239, Pu-241) is considerably higher than the uranium value.

Non-Linear Aspects of Nuclear Analysis

Physics development work directed toward evolving the optimal balance of analysis economy, versatility, and reliability in handling the non-linear aspects of nuclear design work progressed through formulation and machine programming of the innermost loop of an improved fuel-cycle analysis. This innermost loop constructs the complete set of real eigenvalues and dual eigenvectors both for the isotope production and decay matrix and for the neutron production and thermalization matrix, to provide an orthogonal expansion basis suitable for numerical evaluation of the effects of the non-linear coupling between isotope balance and neutron balance.

The method used to construct the complete set of eigenvalues and dual eigenvectors for a matrix of arbitrary symmetry is a variationally optimized generalization of the quasi-singular resonance-separation method originated by Harker(1) at GE-APED and developed further by Wachspress(2) at GE-KAPL in fuel-cycle work

(1) Harker, W. H., "The Calculation of Intermediate Eigenvalues and Eigenfunctions," GE-APED Memo MR-11 (1958).

(2) Wachspress, E. L., "A Numerical Technique for Solving Group Diffusion Equations," Nuclear Science and Engineering 8,2 (1960).

on naval propulsion reactors, and by Fischer[3] at GE-ANPD in power-shaping work on aircraft propulsion reactors. Checkout work has verified both the extremely rapid convergence rate and the surprising numerical stability observed by KAPL. In the largest of a sequence of test cases for which known solutions were available for comparison, the simultaneous generation of fundamental and ten harmonics converged in three iterations, with accuracy ranging smoothly from five figures or better on all intermediate eigenvalues to seven figures or better on both the smallest and largest eigenvalues.

Code Development

RBU

A uranyl-nitrate, critical-mass assembly in spherical geometry was simulated and run on RBU. The results indicated far too much neutron leakage and the cause, although not known definitely yet, has been traced to the random number generator in the Monte-Carlo. Communication with J. P. Burr of Atomics International revealed that strong biases existed in the random number generator and particularly in the calculation of random cosines. Particle traces carried out by Burr indicated too large a neutron age and diffusion length, which could have been caused by such a bias. A new random number generator has been installed in the Monte-Carlo, but no results have yet been obtained to judge its randomness. Additional work is being done on the distance to collision calculation which is the calculation most critical in determining the transport behavior of Monte-Carlo particles.

Specific numerical values of system parameters presented to the Monte-Carlo for execution are being compared with hand calculations, the purpose being to isolate any future troubles to the Monte-Carlo, Diffusion and Burnup programs.

G-2 Nuclear Data Tape

The G-2 data tape was updated during the month by adding cross section records for Pu-239, Pu-240, Pu-241, and Pu-242. Because the energy groups of the G-2 data tape are large, the program which obtained the cross sections from the RBU basic library had to be modified to provide a 1/E weighting. As a result of this particular application, two versions of the basic program for obtaining group cross sections from the RBU basic library now exist; one with unit weighting and the other with 1/E weighting.

HET - Code

Two HET codes now exist using (a) age-diffusion, or (b) two-group diffusion theory. It was found that making a transport theory approximation near boundaries reduced the error in k_{eff} for a Pu PRTR loading to + 2%.

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(3) Fischer, P. G., "Multi-Group, Multi-Region, One Space Dimension Neutron Diffusion Calculation," GE-ANPD XDC 60-3-68 (1960).

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Instrumentation and Systems Studies

The recording of PCTR neutron flux made in October was analyzed to determine the change in the ratio of total delayed fraction, β, to effective neutron lifetime, ℓ, caused by different loadings and lattice structures. The May recording indicated a β/ℓ ratio of 8.5. The October recording indicates a β/ℓ ratio of 6.9. These data have been reported to Experimental Reactors Operation, HLO.

Two new ionization chambers were fabricated and tested for use in the forthcoming PRTR noise test (PRTR Test #12). Small electrode spacings were used to allow voltage saturation with reasonable power supply voltages. Tests made at the TTR reactor indicate that the chambers saturate at less than 300 volts at a flux level of 2.5×10^9 nv. They will be operated at 900 to 1500 volts in the PRTR in a flux estimated to be approximately 1×10^{10} nv. A short duration flux recording was also made during the TTR tests. Analysis of the recording indicates that the chamber efficiency is sufficient to show the required pile noise effects although a definite answer could not be obtained because of the limited recording time.

The new Ampex tape mechanism purchased by Atmospheric Physics Operation has been used with Systems Research Operation electronics (from the analog computer tape delay units) to determine the feasibility of using tape speedup techniques in the analysis of statistical data. The original PCTR recording was re-recorded at 3-3/4 inches per second and then played back at 30 inches per second to obtain a speedup factor of eight. Analysis of the re-recorded data yielded results within one decibel of those obtained from the original recording. Use of this technique makes analysis of low frequency (0.01 cps) data practical.

A new simulation of the PRTR gas balance system was programmed on the GEDA computer. Computer instability prevented any solutions from being obtained. This problem will be simulated on the EASE computer as soon as computer time is available.

The PRTR Critical Facility has been successfully simulated a number of times on the analog computer. It was initially assumed that heat transfer to the moderator was of little consequence, due to the extremely short duration of the power excursions. In accordance with a request by the G. E. Reactor Safeguards Committee, additional analog runs were made which included the heat transfer effect. The runs were completed and forwarded to Reactor and Fuels Development Operation.

Installation of extensive changes recommended for the PRTR Fuel Failure Monitor is nearing completion. The basic probe terminations are changed and the removal of the probe-system terminal board was completed. Modifications are now being made on the gas sampling system, and newly-incorporated gas separator changes have improved the sample gas flow rate and materially decreased the water content of the gas. The over-all system is now in condition for general testing.

Investigation continued on a microwave method for measuring the very small displacements encountered in in-reactor measurements of creep in metallurgy samples. Work this month centered around cavities expected to have only one mode of

oscillation in the region of interest (about 8 mm displacement range and about 5 Gc frequency range). So far the cavities built showed multiresonance problems; apparently multimodes are common problems. Possibility of using a multimode system on a displacement transducer is being investigated.

Methods are being sought for measuring U-235 enrichment in metallic samples of various sizes to aid bookkeeping and nuclear safety auditing procedures in metallurgy laboratory and fuels processing areas. One simple test has been demonstrated that will give an approximate measure of fuel enrichment. The method is based on the ratio of the gamma counting rates at two different gamma energies. Uranium-235 has a strong line at 185 kev, but there are no resolvable and unique lines from the daughters of U-238 near this energy. Instead, the many decay gammas form a continuum which can be made fairly flat in the region of 185 kev. The method demonstrated plots the ratio of the counts in the 185-kev peak to the counts in the nearby continuum, say at 225 kev. The resulting plot is very linear from 0% of U-235 up to the order of 10% U-235. In this range it is possible to measure enrichment to about 5% of the enrichment. The ratio for nearly pure U-235 depends strongly on the detector resolution, and the curve cannot be extrapolated in general up to this region. However, the difference in the ratios is very large, and if necessary, a given instrument (detector) may be calibrated with known samples.

NEUTRON FLUX MONITORS

Reproducibility was obtained for lifetime and sensitivity characteristics for various U-235, Pu-239, and Pu-240 Phoenix (breeder) in-core neutron flux monitors, as determined with the computer. The studies concerned detector placement both in the graphite and adjacent to the fuel elements. The optimal composition of the detector for in-graphite use was determined to be U-235 (60%) and Pu-240 (40%); whereas the location adjacent to a fuel element required a composition of U-235 (50%), Pu-239 (10%), and Pu-240 (40%).

Calculations indicate that a possible physical configuration of the detector between suitable fission-material plates may materially reduce neutron detection sensitivity variations caused by gradual buildup, saturation, and finally, burnout of the fission products.

Necessary instrumentation was obtained for the fabrication of the experimental detectors in the form of a colloidal suspension of fissile material in a carbon foil. Satisfactory thin carbon substrates on stainless steel have been prepared. The planned next step will be to inject plutonium nitrate solutions onto the carbon and then sinter.

NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

Additional measurements were made with the developmental multiple-parameter eddy current nondestructive test device and a simulated test specimen. These measurements revealed a problem area in the effect of small calibration and measurement errors upon the degree of isolation between the individual parameter readouts. The simulated test specimen has served its main functions, which were to provide a ready means to vary parameters and to initially demonstrate the

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principle of operation of the equipment. It will now be replaced by specific actual metal test specimens which will be directly related to nondestructive test problems.

The transformation section of the multiple parameter eddy current device was incorporated in the test equipment in which the test specimen is represented by a four-parameter electric circuit having four inductively-coupled meshes. The simulated test specimen represents a layered metal object having four layers, with the electrical conductivity of each layer being adjustable.

The transformation section performs summations of the expanded eddy current test signal to give individual readout for small individual parameter excursions. This summation has been performed previously by using a desk calculator. Analysis of data obtained by this method shows that, as the number of parameters to be separated increases, small errors in calibration reduce the degree of isolation between read-out channels. The degree of isolation now should be improved by trimming the transformation circuit adjustments under operating conditions to correct for small calibration errors. Tests are now in progress to determine the amount of parameter variation over which the device will separate the parameters of the simulated test specimen. The simulated test specimen will now be replaced with actual metal test specimens having prepared irregularities of various types, and the device will be calibrated to identify and measure these different parameters.

Heat Transfer Testing

A circuit to synchronize the print frequency generator in the Model 1003 heat transfer mapping system, and one to automatically shut the plasma flame off in the event that the scanning lathe stops during a test have been installed and tested.

An invention report on the line-length mapping method now being used has been issued and an article on the heat transfer work has been accepted for publication in Nuclear Science and Engineering.

Seventy-five ultrasonic reject production fuel elements were heat transfer tested for AlSi Product Engineering, FPD. Only one contained a sharp heat transfer defect large enough to give a signal similar to that caused by a 3/8-inch-diameter void. Small differences in over-all heat transfer test signals from several of the fuel elements were detected, but it has not been determined whether or not they were due to differences in surface emissivity. Differences in surface emissivity from point to point on the surfaces of some fuel elements is great enough to cause 30% variation in signal. Such differences mask small variations due to subtle mechanical and metallurgical differences in bonds. Surface emissivity differences have thus proved to be the present limitation of the infrared method of heat transfer testing. However, two methods using reflected infrared compensation schemes, and one using transient surface temperature behavior for minimizing surface emissivity effects are being studied.

Zirconium Hydride Detection

X-ray diffraction analysis of sections of Zircaloy-2 tubing being used in ultrasonic investigations indicated that one sample, which was supposed to have 500 ppm hydrogen content, actually contained much less. Vacuum fusion analysis of

the sample confirmed this result. X-ray analysis of carefully prepared coupons of Zircaloy-2 containing 1000, 980, 700, 400, 100, and 50 ppm hydrogen indicated that standard X-ray diffraction techniques yield qualitative information on hydride content. However, simple measurement of diffraction peak height is not a reliable measure of hydride content due to variations caused by preferred orientation in the present samples; the 111 gamma phase zirconium hydride peak heights for the 1000 ppm and 100 ppm samples were about the same. No gamma hydride peaks were detected in the 50 ppm sample.

Ultrasonic tests made by Testing Methods, FPD, using standard equipment and techniques, have thus far proved insensitive to hydride concentrations of 120 ppm and 70 ppm. Specifications for a laboratory ultrasonic experimentation system have been written. This equipment is to be used as a starting point for development of advanced ultrasonic techniques.

Magnetic field strength measurements were made on electromagnets and permanent magnets for use in the development of a test probe for simultaneous measurement of the Hall coefficient and resistivity by inductive means. Some tentative designs of pickup and driving coils have been completed. When fabricated, these coils will be used for reference Hall coefficient measurements on bismuth. Bismuth has a relatively large Hall coefficient compared to that of hydrided Zircaloy previously measured.

Microwave Techniques

Some exploratory experiments were performed to evaluate the possibility of detecting surface defects in the inside of fuel sheath tubes by microwave methods. Tests on 60 Zircaloy tubes showed sensitivity to tube ellipticity, tube bending, impressed foreign particles in the surface, and variations in surfaced conductance. Some of these factors can be detected directly; others will require further study.

Imaging Methods for Ultrasound

Schlieren image methods have been used for a wide variety of fundamental studies on shock waves, sonic and ultrasonic vibrations, and high velocity gas jets. The method makes visible physical disturbances which cause small changes in the refractive index of a transparent medium. The visible image of the disturbance has then been used for detailed study of pressure distributions in shock waves, ultrasonic mode conversions at interfaces, and density gradients in gas jets, for example. Evidence of applying direct imaging to nondestructive testing problems has not been found. For example, the successful use of ultrasonics for flaw detection relies on complete knowledge of the ultrasound propagation. Such things as beam characteristics, mode conversions, and physical shapes of flaws can cause variations in flaw detection capabilities which may influence the interpretation of the test. These effects are not always well understood, and present methods for their measurement are laborious and often introduce reflecting surfaces or probes which perturb the ultrasonic test being studied. Direct imaging with the Schlieren method does not influence the sound propagation and may be a much faster and more complete way of measuring these phenomena.

Very encouraging results were obtained from a preliminary experiment which made visible an ultrasonic beam from a focused transducer in water. The cone shape of the beam and the characteristic side lobe transmission were clearly

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visible. Photographs of the visible beams from supposedly identical transducers can be measured from beam density and shape, and rapidly compared for differences which may affect their responses.

Other possible uses for the Schlieren image method appear equally attractive. Since ultrasound may be observed in solid transparent media, the direct observation of reflection and through transmission at interfaces and mode propagation and beam shapes within the media should be possible. On the same basis, reflection, mode conversions, and scattering from different types of flaws should be observable. The observations made on transparent materials, by analogy, should be applicable to similar situations in optically opaque solids such as metals. The ability to make direct measurements may represent a significant advancement over presently-used secondary detection methods.

To determine the applicability of this method, the preliminary optical system is being refined and new equipment is being ordered. A power amplifier capable of driving transducers with continuous ultrasound at frequencies and powers which are of interest has been fabricated and checked out. The unit should provide up to 100 watts power at any frequency between 4 and 11 megacycles. Pulsed ultrasonic power is available with equipment on hand.

USAEC-AECL COOPERATIVE PROGRAM

Nondestructive Testing of Sheath Tubing

Investigation of methods for comparing the response of supposedly identical transducers continued. Four possible techniques are being considered:

1. Ultrasonic reflection from smooth ball bearings.

2. Direct imaging utilizing Schlieren techniques.

3. Ultrasonic reflection from a long (compared to beam width), small-diameter wire stretched in a direction normal to beam propagation.

4. Sampling of the beam energy with a probe which is very small compared to the size of the transducer under study.

Some refinements were made to the preliminary Schlieren system to make the beam from a focused transducer more clearly visible. The requirements for an optical system needed to thoroughly evaluate the applicability of the Schlieren method for comparing transducers were determined, and components are being ordered. These will be included as part of a more extensive Schlieren system being developed for general advanced ultrasonic studies as part of the Division of Reactor Development sponsored Nondestructive Testing Research program. The Schlieren imaging studies under way and planned for the AEC-AECL program will be confined to those aspects particularly pertinent to sheath tube testing.

The stretched wire reflection technique was used to measure the beam width of a ten-megacycle point-focused lithium-sulphate transducer. About 80% of the reflected energy was contained within a width of 0.100 inch.

Necessary design changes were completed for the mechanical manipulator developed to study the ultrasonic response to notches in flat and curved plates. Fabrica-

tion of new parts was started.

Adaption of the newly-developed reject circuit to the Immerscope instrument continued. Further refinements are necessary to provide a stable rejection level from signals in the flaw gate. Some instability has been encountered due to false triggering from the transmitter pulses and spurious noise pulses. Electrical shielding which is being developed is expected to eliminate or reduce this problem.

PHYSICAL RESEARCH - 05 PROGRAM

Mechanism of Graphite Damage

The theoretical studies, preparatory to additional experiments, begun last month were continued.

BIOLOGY AND MEDICINE - 06 PROGRAM

Atmospheric Physics

Dispersion data, which heretofore had not stratified according to the customary meteorological variables, were found to separate into two groups according to the presence or absence of wind direction trend, the trend effect diminishing with distance as the scale length of effective eddies increased. The dispersion of the time mean plume generated from a continuous point source, as measured by our experimental technique, is the result of both diffusion and transport of the "instantaneous" plume elements. Whether the dispersion arises primarily from diffusion or from meander depends on the spectrum of eddy size relative to the plume dimensions, i.e., eddies smaller than the plume dimensions cause the diffusion while the larger eddies only contribute to meander.

Earlier analyses of the horizontal growth of the plume for the 1959 data indicated that the growth did not correlate simply with atmospheric stability. It is now evident that the horizontal growth of the plume is more closely related to the wind velocity distribution during the period of the experiment. By grouping the data according to whether the standard deviation of wind direction was greater than or less than six degrees, the data separated distinctly into two groups, the first representing a dominant meander eddy present, and the second representing a nearly steady state diffusion. Within the first two miles of travel, the meander effect became less significant as the distance increased so that the increased plume dimensions embraced larger and larger eddies. The result is that at sixteen miles the difference in the mean width between the plume initially dominated by diffusion and the mean width of the plume initially dominated by meander is very small although within two miles from the source their widths differed by a factor of two.

An investigation is presently being conducted to determine the feasibility of measuring the deposition of zinc sulfide over a surface uniformly covered with cheat grass. Samples taken from the grid after a field experiment have been ashed and counted in the Tri-Carb scintillation counter. It has been established that the quantity of zinc sulfide can be determined in this manner for distances within 200 meters of the source.

A field test was conducted from the elevated source at 200 feet during unstable atmospheric conditions and samples were obtained at 1.5 meters height out to a distance of 1600 meters from the source. The wind during this test often exceeded twenty miles per hour at the source and was characterized by extreme gustiness.

Dosimetry

Radiation Protection Operation was assisted in preparing to handle possible I-131 and Th-232 cases at the whole body counter.

Studies of proportional counters were resumed with application to plutonium counting being the goal. Methyl bromide was studied. It would not count by itself. There are indications that drying, purification, and mixture with other gases might result in a usable counter gas.

The positive ion accelerator operated satisfactorily during the month but at less than rated energy. Some sparking is still occurring at the highest energies.

A series of reproducibility tests was partially completed of several cores in the new precision long counter and of different BF_3 tubes used in inverse square measurements in one of the old ones. Measurements were made of the angular asymmetry of neutron emission from a source borrowed from Mound Laboratory. Analysis of our data from three neutron sources that had been calibrated at the National Bureau of Standards gave agreement to within 1.5%. Much of this remaining disagreement is attributed to changes in neutron emission with time.

At the request of Operations Research, work was begun on the measurement of neutron fluxes at near background levels.

A LiI neutron spectrometer was assembled. Difficulty is being encountered in maintaining a vacuum in the apparatus while cycling from room temperature to liquid nitrogen temperature.

An IBM computer program was written and debugged for use in analysis of double moderator data.

The calorimetric measurement of the half-life of Sb-124 is continuing.

The gamma ray calorimeter was recalibrated. The calibration was essentially unchanged from earlier results. This means that the 10% discrepancy for plutonium reported last month is confirmed. It was learned that the Pu-238 content of our source had been below the detection level of the mass spectrograph. It is planned to determine the Pu-238 content of our source by counting methods to see if it can explain the calorimeter results.

The application of a modified "hit" theory to the analysis of survival curves for haploid and diploid yeasts exposed to ionizing radiations was studied in assistance to Biology Operation.

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Radiation Instruments

Final operating adjustments for the experimental-prototype coincident-count alpha air monitor have been established through continued observation of periodic atmospheric inversions accompanied by buildup of radon and thoron. Operation of the system continued to be satisfactory after minor adjustments were made to secure optimum performance. The proper ratio of alpha count rate to coincidence count rate was firmly established at 8:1. Fabrication of a second, final prototype unit which will incorporate all noted refinements and a more satisfactory assembly method is planned.

A short study was conducted for the Biology Operation in an effort to determine an appropriate detection-monitoring system for hogs containing Sr-90, I-131, Cs-137, etc. as body burdens. These hogs have burden activity levels which preclude measurement in the Biology Total Body Monitor because of possible contamination problems. A suitable method for such measurement was established and will be incorporated.

The final model of the scintillation, transistorized, alpha-beta-gamma hand-and-shoe monitor was completed and evaluation tests to date have been satisfactory. After a short period of test-use in the 329 Building, it will be sent to Redox for demonstration.

Two new miniature alpha monitors, using silicon diode detectors and transistorized circuitry including an aural annunciator, were satisfactorily completed and tested. Correct operation was obtained from 0°F to +135°F, and 500 d/m of Pu-239 was easily detected in a several r/hr gamma field. Use at 234-5 Building is contemplated.

The experimental, background-suppression, beta-gamma, combined hand-and-shoe counter, clothing monitor, and background recording system operated successfully for the month at Purex. All detailed circuitry, probe, and panel drawings were completed for the instrument. Twelve units will be fabricated to the Hanford design by an off-site manufacturer for use at N Reactor.

Continued experiments with the CaF_2:Mn thermoluminescent dosimeters showed reproducibility to ± 10% for successive 200-mr gamma dose irradiations at 34 kev for five dosimeters. Four of the five dosimeters were of a new design, and the fifth was used as a control. A series of energy-dependence tests were performed on the five dosimeters at 16, 34, 58, 78, and 100 kev for total doses of 200 mr. The best unit provided a variation of less than ± 25% around the median response over the stated energy span. Some difficulty in measurement apparatus at Calibrations Operation was noted at 58 kev where the free air ion chamber reading for 200 mr corresponded to only 50 mr for a Victoreen r-meter. Similar difficulties were encountered at other energies. These problems have made the thermoluminescent dosimeter measurements extremely difficult. Calibrations Operation personnel are attempting to resolve the difficulties.

Fabrication specifications were completed for the recently-developed regulators for the Atmospheric Physics Radiotelemetry System battery chargers. A new testing device was devised to determine phase angle, dwell time, and general condition of the choppers used in the 20 remote data stations. Written operational directions and schematics were supplied to the maintenance personnel.

Low temperature problems continue to plague some of the data stations.

Advice and assistance were rendered to Atmospheric Physics personnel concerning a raindrop-size spectrometer instrument.

Prototype fabrication continued on a transistorized instrument, with both count-rate-meter and aural-annunciator indication, for use with air-proportional type alpha detecting probes. These are still favored for plant use where the chances of plutonium contamination of the probes is a great problem.

The prototype, transistorized, scintillation, alpha "poppy" was completed and satisfactorily laboratory tested. Evaluation and field tests were started.

Development was begun on a multichannel pulse height analyzer for the positive ion generator facility. The analyzer design will use, wherever practicable, standard computer plug-in modules; this will provide a means to study the possible advantages of modular design, among which are expected to be greater flexibility and much-reduced maintenance cost. A magnetic core memory for the analyzer was purchased and is expected to be delivered by January.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Program

The mass spectrometer for this program provided isotopic analyses of program samples and standards according to goal schedules during the month. One day each was spent in servicing the spectrometer and in laboratory housekeeping.

Some difficulty has been experienced in maintaining adequate sample sensitivity and precision of analyses. The loss in sample sensitivity is believed to be due in part to a gradual decrease in gain of the electron multiplier of the ion detection system.

A calibration of the range factors of the vibrating reed electrometer was attempted. It appears there may be as much as a 0.4 percent relative error among ratios of range factors. However, a more accurate calibration voltage source than the one used in these tests will have to be procured before a precise calibration can be made. It is also possible that the range switch of the vibrating reed electrometer may be wearing out and contributing to a degeneration of precision of isotopic ratio measurements.

TEST REACTOR OPERATIONS

A thermal column has been constructed on top of the PCTR. A calculation of its reactivity worth to the PCTR has been made using the computer program, FSUPER(1), along with several simplifying assumptions about the geometry of the PCTR and thermal column. The result of this calculation indicates that

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(1) Lilley, J. R. Correlation of Experimental Activity Traverses Using Few Group Neutron Diffusion Theory - Computer Program FIT-1, HW-69871. June 7, 1961.

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the presence of the thermal column adds 56¢ reactivity to the PCTR. A measurement of the worth has been made by determining the difference in reactivity of the PCTR with and without a cadmium shutter under the thermal column. The measured difference is $\Delta\rho$ = 39¢. In view of the approximate nature of the calculation, the agreement is considered good.

Operation of the PCTR continued routinely during the month. There were no unscheduled shutdowns.

The Doppler coefficient measurement of 1.8% Pu-Al fuel, 6% Pu^{240} in a 6-1/2-inch graphite lattice was under way during the month.

Operation of the TTR continued routinely during the month. There were no unscheduled shutdowns. Further tests were made exploring the subcritical reactor method for measuring the uniformity of PuO_2 distribution in PuO_2 PRTR fuel elements.

CUSTOMER WORK

Weather Forecasting and Meteorological Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	84.9
24-Hour General	60	86.0
Special	154	90.3

November averaged considerably colder than normal. However, there were no unusual extremes. Snow and rain beginning on the 23rd raised the monthly precipitation total from 0.02 to 0.49 inch. However, this was still considerably short of the normal amount for November.

Instrumentation and Systems Studies

Field follow-up work was done on the IPD Panellit-Heise Gage Readout Device in response to reports that the device was not working properly. Investigation showed proper equipment operation but faulty operating procedures. A rough draft of a report on this instrument has been written and will be issued as an unclassified document in the near future. All nine drawings on this instrument have been revised to show all recent changes.

An FPD autoclave temperature controller circuit was simulated on the Donner 3500 computer with a time speedup of 1000 to 1. The simulation is being used to study the startup characteristics of the controller with various simulated processes.

The fabrication of a paper tape perforator and programming unit was completed and it will be installed upon receipt of the metal enclosure. The system was developed for HLO Fuel Design Operation to read out digitally the dimensions of NPR fuel elements.

Fuels Development Operation is processing an Appropriation Request for a second tape perforator system similar to the above to punch out stress data from a tensile strength testing machine.

The prototype Automatic Laundry Monitor, for alpha-beta-gamma contamination detection on coveralls and lab coats, was test operated during the month using the initial "test" electronic chassis. Proper mechanical operation was obtained and some circuitry modifications were made to eliminate transient pickup problems in the electronic chassis. Known alpha and beta sources were taped to garments for tests with the alpha and beta probes. A spot beta source of Cl^{36} of 7.5×10^4 d/m caused garment rejection as did a Sr^{90} source of 8.2×10^3 d/m. From 500 to 1000 d/m of Pu^{239} caused garment rejection from the alpha standpoint. These were rejection levels for a conveyor speed of 10 feet/minute. Operation is considered quite satisfactory.

Assistance was rendered to FPD concerning the use of a scintillation detector and multi-channel analyzer to scan normal uranium and 1% enriched (with U^{235}) uranium to attempt to detect differences. Results indicated that the two rods could be distinguished if the geometrical conditions and rod sizes were the same.

Assistance was rendered to Plutonium Fuels Development concerning a shielded collimator scintillation detector and multi-channel analyzer to scan bare plutonium oxide fuel pellets for locations of abnormal spot concentrations. The system is now being run in 308 Building with the measurement of some ten pellets completed to date.

Assistance and tests were rendered and performed for Ceramic Fuels Development concerning a new system proposal for measuring UO_2-PuO_2 fuel rod density by gamma attenuation. It appears that both a complete electronics system and a new mechanical drive system, for moving the rods accurately, will be required.

Calibration of micro-displacement readout systems, to be used by Physical Metallurgy Operation for in-reactor creep measurements, has continued during November. Calibration runs on a 0.030-inch-range transducer (LVDT) were completed during the month. This transducer is typical of the type which are presently in use in the third generation creep capsules. The completion date for the fully automated computer program to analyze transducer calibration data has now been set for early December by Operations Research and Synthesis. Upon completion, the program will be utilized to analyze the data for both the second and third generation transducers, and another reference system calibration scheduled for December. Fabrication is 80% complete on an Invar micrometer support mechanism. When completed, a Boechler micrometer (± 0.000015 inch) will precisely reposition a Cleveland Instrument Company gaging head (± 0.000010 inch) to provide a reference system precision which is expected to be ± 0.000020 inch (or better) over a total range of 0.75 inch.

Optics

Specifications were written for two complete sets of Schlieren equipment. One of these will be used by Testing Methods Engineering, FPD, for imaging ultrasonic beams. The other will be used by Physical Testing, HLO, for studying both ultrasonic beams in water and in thin plastic materials simulating sheath tubing. The specifications for the Physical Testing unit call for components which will permit use of phase contrast microscopy in the study of ultrasonics.

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A study is being made for Plutonium Metallurgy to determine an optimum method of measuring temperatures up to 2000°C in a reactor. The problem has been discussed with Barnes Engineering Company and with W. E. Hill of the General Electric General Engineering Laboratory. This study will lead to a formal Request for Proposal which will be submitted to qualified manufacturers of temperature measurement equipment.

During the five-week period (October 29 to December 3) a total of 536 man-hours of shop work was done. This included:

1. Assembly of the Mark II traverse mechanism.
2. Preparation of six specimens of optical glass for radiography experiments for Ceramic Fuels Development.
3. Repair of four crane periscope heads for Purex and Redox.
4. Fabrication of two silica cylinders.
5. Fabrication of adapters for microwave apparatus.
6. Preparation of a glass scintillator for Chemical Separations (HLO).
7. Fabrication of eight glass bearings for a Johnson X-30 pump at 224-U Building.
8. Fabrication of ten adapters for hand magnifiers for Quality Control (FPD).
9. Coating of one lamp with a semitransparent layer of stainless steel for Structural Materials Development (HLO).
10. Fabrication of metal thickness standards for eddy current testing.

Physical Testing

Service testing work continued at a high level. A total of 11,995 tests were made on 5,661 items, totaling 78,013 feet of material examined. By far the greater part of this footage was represented by tubular products.

Test work included: autoclaving; borescoping; dimensional measurements (micrometric); eddy current (flaw detection and heat treatment); heat transfer (infrared); mechanical tests (bend, impact, and tensile); metallography (macro and micro examination); penetrant (fluorescent O.D. and I.D.); radiography (gamma-ray and X-ray); stress analysis (electric resistance wire strain gages and X-ray diffraction); surface treatment (alkaline cleaning, pickling for autoclaving, steam detergent cleaning, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements). Work was done for 29 organizational components representing most of the operating departments and service organizations at HAPO. Advice was given on 55 different occasions on general testing theory and applications.

Test work on NPR pressure tubes was devoted principally to possible salvage of tubes in a hold status because of surface discontinuities. Many of the tubes have proved to be salvable by removal of the discontinuities and relaxation of wall thickness allowances. A few tubes remain in which wall thickness is now 0.210 inch and in which discontinuities are still evident. A shipment of 17 tubes reworked by the supplier was received. There are only about 50 tubes outstanding on the order that are not on plant. More than 950 tubes are now in final storage ready for reactor installation. Kaiser Engineers reduced their operating force working on the NPR pressure tubes in line with the nearing completion of the test work.

Four PRTR pressure tubes were sent to the straightening operation preparatory to their use as spares for PRTR installation.

One PRTR rupture loop tube was successfully pickled and autoclaved, and will be sent to the 314 Building mockup. This tube had passed all previous integrity tests. The tube was pickled with the new mechanical adapter required to process the rupture loop tubes in the NPR facility. A minimum of interference occurred in NPR work. It was necessary to commit a good tube to test the mechanism, since spare tubes were not available. The autoclave film examination of this first tube demonstrated that satisfactory film formation was achieved and the system should successfully pickle and autoclave the four remaining PRTR rupture facility tubes.

Field activity work utilizing X-ray and gamma-ray equipment was done at 1706-KER, PRTR, 100-D Area, 100-H Area, 200-W Area, and NPR. The fluorescent penetrant testing of over-bore nozzles proceeded routinely. The first phase of stress analysis was completed at 105-C reactor. Ultrasonic thickness measurements were made on two programs. One involved preventive maintenance of oil circuit breakers for the Electric Utility Operation. The other application was part of pressure vessel surveys being conducted at 100-F, 100-D, 200-E, and 200-W.

Zircaloy-2 fuel element sheath tube testing was limited due to the small number of tubes received from the suppliers during the month. Some headway was made on the large backlog of ultrasonic testing. Review of transverse ultrasonic testing by the customer indicated that essentially no discontinuities transverse to the tubing axis appeared to exist. Consequently, the transverse ultrasonic test has been deleted from the current test program.

A new shield, synchronizer, and motor indicator for the infrared heat transfer test system was designed, built, and applied to the system. A preliminary lot of fuel elements were tested and the system appeared to function properly. Test results are currently being evaluated.

Radiographic work on the non-isothermal loop is approximately 80% complete.

Magnetic force welding is being evaluated by Ceramic Fuels Development Operation, HLO, for joining SAP (sintered aluminum powder) closures to SAP tube capsules. A nondestructive test is desirable to assure good quality welds. Work has been initiated to determine if an ultrasonic test is feasible. Several defective weld samples and a number of good weld samples have been obtained for ultrasonic comparison.

After completing (except for formal reporting) the first phase of the special assistance work being done on the NPR primary loop piping, six additional sub-programs were initiated:

1. Physical Testing participated in an audit of the radiographic subcontractor's work (performed by an off-site consultant retained by IPD) to the extent of providing reference field radiographs of the requisite quality.

2. A statistical study was started on Ladish pipe welding procedures. This work was limited to sectioning and metallographic examination. All six welding processes evaluated showed evidence of cracks ranging from micro-[redacted]sures to sizable metal separations.

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3. A pilot order was placed for pipe manufactured by another supplier (Taylor-Forge). Twenty "rings" (from the start and completion of longitudinal weld seams) and one 20-foot section of pipe were sectioned and metallographically examined. Seven of the rings examined and a 6-foot section of the 20-foot piece had cracks in the weldment.

4. A section of seamless pipe was obtained, sectioned, and metallographically examined. The one sample examined was free of discontinuities.

5. Five HUICO welds of circumferential joints were selected. These weldments were angle radiographed, used to obtain mechanical test specimens (including bend, tensile, and impact), and sectioned. Radiography was completed on all joints. Cutting out of the mechanical test specimens is about 50% complete; with the tests completed on about half of those obtained. Sectioning and metallographic examination was completed on three of the samples. Though cracking of the type found in the longitudinally welded pipe was not evident, other discontinuities were found. The limited mechanical tests performed to date confirmed that extensive repair caused damages.

6. A program was initiated to evaluate the results of heat treatment given the primary loop piping. Two conditions are to be examined: over-heating of the pipe with resultant damage to the metallurgical structure; and under-heating to the extent that stress relieving is not achieved. The first problem was attacked utilizing commercially available eddy current and thermoelectric devices to evaluate the metallurgical structure. Results to date have been negative; it is suspected that the effects are being masked by the sand-blasted surface existing on the pipes. The second problem may be susceptible to X-ray diffraction measurements. Samples have been obtained for preliminary laboratory measurements.

ANALOG COMPUTER FACILITY OPERATION

Studies

The major analog computer problems considered during November include:

1. Reactor Speed of Control.
2. VSR Withdrawal Rate.
3. Reactor Xenon Effects.
4. CPD Tracer Lathes.
5. Reactor Instrumentation.
6. CPD "C" Column.
7. PRTR Gas Balance System.
8. PRTR Critical Facility.

Equipment Operation

The GEDA was 78% and the EASE 90% operation during the month. The computer operations were as follows:

GEDA	EASE	
89	129	Hours up
8	8	Hours unscheduled downtime
55	39	Hours scheduled downtime
24	0	Hours idle
176	176	Hours total

Maintenance

The two instrument maintenance men working with the computers are now alternately working days and swing every other week. With one man on swing shift, it is possible to do work that requires the shutting down or use of the computer for long periods of time to properly complete the work. One noticeable result is that all of the function generators on the GEDA are now working.

INSTRUMENT EVALUATION

The original prototype scintillation area monitor with both logarithmic and multi-range linear responses is being altered to use two scintillation probes to cover, on the log range, from about 5 mr/hr to 5,000 r/hr. The second, low-gain, small-detector probe automatically switches into operation, with appropriate warning lights, at 10 r/hr. Thus, the sensitive probe covers from 5 mr/hr to 10 r/hr and the insensitive probe covers from 10 r/hr to 5,000 r/hr. Similar multi-range coverage is obtained on linear scales. This double-probe concept will provide an extremely versatile area monitoring instrument suitable for any plant use. No internal circuit changes are necessary, as the insensitive probe is relay-controlled by the incorporated "normal" high level alarm system.

Acceptance tests on one hundred 0-600 r self-reading pencil dosimeters were unsatisfactory. Sixty-one pencils were out of limits (± 10%) and were returned to the vendor.

Evaluation tests progressed smoothly on the prototype, scintillation, transistorized, combined alpha-beta-gamma hand and shoe monitor. The scaled output reading to background (noise) ratio for the alpha channels exceeded 7:1 for a standard 500 d/m Pu^{239} distributed "wedge" source. This is exceptionally good. The beta-gamma channels also performed correctly, including detection of C^{14} (soft beta). The instrument is now in test-use in the 329 Building and will be moved to either Purex or Redox within a few weeks for field tests and demonstrations.

All purchase specifications were completed for a new order of 50 Model II Scintrans to be purchased by Calibrations Operation for general plant use. The units will be fabricated offsite to Hanford drawings.

Evaluation tests commenced on the new, transistorized, scintillation, alpha portable "poppy" instrument developed by Nucleonic Instrumentation to replace the older vacuum tube models which have been in plant use since 1954.

Assistance was rendered to 306 Building RMO personnel concerning setup, adjustments, and use of a scintillation, transistorized alpha-only hand counter developed by Nucleonic Instrumentation and fabricated in the 328 Building Electronics Shop.

Lack of personnel in the Portable Instrument Shop has precluded getting all 30 of the original order of Model II Scintrans modified, with just minor changes, for field use. Nineteen of 22 units scheduled for alpha use are now modified and performing properly. Eight units are being modified for beta-gamma use, using an extra three-binary circuit, for application in the 100 areas. The eight beta-gamma units are being modified by the 328 Building Electronics Shop. For the forthcoming order of 50 more units, the specifications were considerably tightened in an attempt to insure better quality fabrication.

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Reactor Radioisotope Reduction Studies

A direct evaluation of the effectiveness of water-treatment processes is now being made with a "Zeta-Meter." This instrument measures the zeta potential (z.p.) of colloidal particles in water samples which determines their ability to remain in the colloidal state. Colloid removal from river water was shown to be highly dependent on alum concentration which controls the z.p. of the system. Maximum removal was obtained with 20 ppm alum, which increased the z.p. of water impurity colloids from about -15 mv to +3 mv. At this z.p., the alum floc and primary colloids formed agglomerates which were large enough to settle rapidly or to be readily filterable.

Further studies were made of the effects of chemical additives on the adsorption of materials which act as parents of reactor-effluent radioisotopes. Adsorption of P-32 and As-76 as phosphate and arsenate from process water onto aluminum turnings was studied under conditions of temperature and pH which simulated those of reactor operation. Addition of the surface-active agent, Antaron FC-34, at a concentration of 2 ppm caused a three-fold reduction in this adsorption, while addition of sodium silicate at a concentration of 10 to 50 ppm as silicon reduced the adsorption by three orders of magnitude. So spectacular is the effect of silicate that the surface of the aluminum remains bright in contrast with the visibly-stained surfaces formed in contact with normal process water. The effect of counter-ions other than sodium (which would increase the concentration of the radioactive isotope Na-24 in the reactor effluent) is being examined to find an additive which would not contribute significantly to the radioisotope production.

Soil Sorption of Nuclides from Reactor Effluent

The relative adsorption of zinc, arsenic and chromium by 100 Area soil was determined at 30 C. A 77 cubic centimeter column of soil received a tap water solution of zinc-65 for over 30 days. During this period of operation 418 column volumes of influent were passed without detectable breakthrough. In marked contrast, soil adsorption of arsenic-74 and chromium-51 was characterized by a partial breakthrough within a few column volumes of throughput. These breakthrough curves, however, were relatively flat, reaching 40 percent and 70 percent breakthrough for arsenic-74 and chromium-51, respectively, after 75 column volumes throughput.

Effluent Monitoring

Operation of the arsenic-76 monitor was continuous with no shutdown attributed to component malfunction. Laboratory analytical results on comparison samples were about one-half of the analyses of the monitor; chlorine-38 interference is indicated. Further determinations are being made to resolve this problem.

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Ground Water Temperature Studies

Geologic and hydrologic data are being collected to study the effect on reactor coolant influent of thermally hot water entering the Columbia River in and near the 181 Building forebay. The 100-B Area, where thermally-hot water seeps out of the river bank directly into the 181-B forebay, is of particular interest.

Several large volume water samples, one from a 130 F thermal spring alongside the forebay and the other from a 181-B intake pump, were submitted for radioisotopic analyses. The thermal spring sample contained 1.3×10^{-5} μc Cr^{51}/cc, and the intake pump water contained 1.2×10^{-6} μc Cr^{51}/cc. Several temperature measurements of the influent water show a 5 F increase in the intake water temperature over the 48 F average river temperature. This indicates that the spring water constitutes about 6 percent of the influent compared to about 9 percent as indicated by the Cr-51 results. Temperature measurements of several other points in the influent system showed less of an increase, indicating a possible need for better measurement techniques.

SEPARATION PROCESSES

Purex Diluent Evaluation

Soltrols 130, 140 and 160 (lower boiling point diluents of the same type as Soltrol 170) were compared to Soltrol 170 by the "use test" procedure. No significant differences in fission product extraction or retention by solvents prepared from these four diluents following chemical degradation were observed. These results differ from those observed with diluents obtained directly from petroleum (kerosenes) in which do-bad formation by chemical degradation decreases significantly in lower-boiling fractions.

Purex Water Evaluation

Three runs were made during the month to compare the operating characteristics of the column as a function of the source of the water used in the 1CX stream. Purex demineralized water, Purex sanitary water, and 321 steam condensate were used in the tests. The three runs were identical as to relative flow rates, temperature, pulsing frequency, pulse amplitude and stream composition and varied only in capacity factor. The capacity factor in all cases was maintained at a maximum controlled by the overall column density, which was held constant at a value near flooding for all three of the runs. Essentially no difference in capacity factor was detected when the 1CX was shifted from one source of water to another. Additional runs of this type are planned but with reduced acid concentration in an attempt to reproduce the capacity reducing phenomena that sometimes occur in certain of the plant C-type columns.

Ion Exchange Resin Stress Studies

Equipment for making direct measurement of the vertical stresses in resin-water systems has been installed and is operating very satisfactorily. The apparatus consists of a resin bed supported by a porous piston with the assembly contained in a 4-in. Lucite tube 5-ft. in length. The tube is attached to a rack allowing movement up or down at a selected constant velocity. The piston is suspended from a combination beam balance-load cell arrangement which permits not only measuring the stress but also the recording of the stress fluctuations induced by the stick-slip phenomenon occurring in the resin bed. Liquid can be pumped continuously down through the bed so that countercurrent and cocurrent flows are simulated as the tube is moved down and up respectively.

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To date the equipment has been operated with cocurrent flow only. Results from the first two series of stress measurements, one made at 1.0 and the other at 0.5 inch of water hydraulic pressure drop per centimeter of bed, confirm the assumption (cf. HW-70872 C, p. C-3) that the average stress, $(\sigma_Z)a$, under cocurrent conditions can be approximated by an analytical expression:

$$(\sigma_Z)a = \frac{A\ D_t}{4k_a\mu'}\ [1 - \exp\ (\ -\ \frac{4k_a\mu'}{D_t}\ )]$$

where A is the effective resin density, i.e., the hydraulic pressure drop plus the bulk density of the resin bed in the liquid,

D_t is the tube diameter,

μ' is the coefficient of friction,

k_a is the ratio of radial to vertical stress;

thus, $k_a\mu'$ is the friction parameter.

Plots of the vertical stress versus resin bed height show a maximum or asymptotic vertical stress value at large bed heights (greater than 50 cm). The friction parameters calculated from the asymptotic stresses in both series of experiments with the 10-20 mesh resin gave identical values of 0.16. These data confirm those obtained previously in the earlier pneumatic equipment.

A significant advantage of the new apparatus is its ability to measure the variation of friction parameter with both bed height and vertical stress. As expected, at the low stresses in the cocurrent runs no significant variation in friction parameter with vertical stress was noted. However, data from the pneumatic piston indicated that the ratio of radial to vertical stress increased with vertical stress. The present equipment will permit this point to be checked. In addition, a transducer mounted to measure radial stress independently will yield a means separately determining both the ratio of radial to vertical stress and the coefficient of friction.

Double Bellows Ion Exchange Contactor

Hydraulic and pulsing tests to evaluate the double bellows Jiggler equipment (cf. HW-69822 C, p. C-18) as a semi-continuous contactor appear to be favorable. It was possible to push resin slurry consistently in 4-in. diameter glass columns (2-ft. long adsorption section and 2 ft. long elution section) when the push was programmed alternatively to the flow of simulated process streams with flows up to 4 liters per minute. A 3/4-in. orifice inserted above the elution inlet aided substantially in maintaining a dense bed in the elution section of the apparatus. Maximum pressure during resin movement did not exceed 17 psig even with a pulse frequency as high as 50 cpm.

Dyed process streams confirmed the practical possibility of pumping both feed and elution streams simultaneously without undue mixing of these streams. The test resin was Permutit SK 20-40 mesh and test temperatures were 22 C and 58 C.

WASTE TREATMENT

Solvent Extraction Treatment of Purex IWW

Studies are in progress to adapt the D2EHPA solvent extraction flowsheet used in the Hot Semiworks recovery of strontium to the removal of long-lived radioactive constituents (strontium and rare earths) from formaldehyde-treated Purex IWW waste (FTW). Initial [redacted] experiments attempted to define the stability toward precipitation

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of the FTW solution. Precipitation in synthesized FTW spiked with various radioactive tracers observed versus time. In the period from 18 to 330 hours after preparation the percentage of europium precipitated increased from zero to 13, of cerium from 15 to 43, of strontium from seven to 45, and of zirconium-niobium from 11 to 40. Barium was essentially 100 percent precipitated immediately after make-up.

Further experiments investigated the stability of feed solutions prepared from synthetic FTW. Solids formed immediately during preparation of the FTW were removed by centrifuging. Sodium acetate and HEDTA were added to the centrifugate as buffering and complexing agents. When acetate and HEDTA concentrations were 0.35 M and 0.18 M, respectively, the solutions were essentially stable towards precipitation in the desired pH range (3.1 to 4.7) for a solvent extraction feed.

In batch contact studies the extraction of various radioactive and inert constituents of the above feed solutions by 0.37 M D2EHPA - 0.2 M TBP - Shell Spray base was determined at feed pH's of 4.0 and 4.5. Strontium, cerium and europium distribution ratios were all relatively high. They ranged from three to 300 depending on the ion, the equilibrium aqueous pH and the concentration of HEDTA in the feed. Chromium, iron, sodium, aluminum, zirconium-niobium and ruthenium distribution ratios were all less than 0.1. These data show good promise for the removal of strontium and rare earths from FTW by D2EHPA solvent extraction.

Waste Transfer Program

The mechanics of sludge sluicing by water-jet were studied using 1/8-in. diameter nozzles and submerged plaster of Paris targets. In general, sluicing rates (rate of solids removal) in the system (a) varied by a factor of three for nozzles of differen design and construction but of equal diameter; (b) were not affected significantly by the angle of inclination (jet axis to water surface angle) for angles above 15 degrees; (c) decreased almost exponentially with target submergence (depth of water covering the target), except that for shallow submergence (less than 25 percent of the nozzle to target distance), this effect is small. Sluicing rates were proportional to the square of the mean liquid velocity (fluid kinetic energy). It is expected that the results of the study can be combined with full-scale in-tank studies to design optimum sluicing system for underground waste storage tanks.

In-Tank Solidification

Submerged combustion tests with simulated Purex supernate have been completed and a rough draft of the final report has been prepared.

Batch Calcination

The effect of a draft tube insert on batch calciner operation during the boil-down and calcination steps was further explored in an 8-in. diameter by 2-ft. high annular vessel. The draft tube was 17-1/2 inches high and 7 inches in diameter. A simulated Purex, formaldehyde-treated, high-level waste was chemically adjusted by sodium and alumina sulfate to a solution that would yield a calcine that would melt at a temperature of less than 900 C. The boiling waste circulated through the draft tube during most of the boil-down step and no solids deposition on the pot wall was apparent. No foaming problems were encountered. The circulation ceased only when the boiling slurry became highly viscous. During the calcination step, no adverse effects were noted because of the draft tube.

Since the current program in waste management at Hanford is diverging from an interest in total calcination to one of removal of long-lived heat generators and in-tank solidification, this work will be suspended.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Hot Semiworks Operation

An overall material balance for the recently completed HSW strontium-90 recovery program has been completed and the following data supplant the preliminary information transmitted in last month's report. The data indicate that 745 kilocuries of purified (specification) Sr-90 were prepared from 1180 kilocuries input to HSW with an additional 170 kilocuries held for further rework. Overall run losses averaged 15 percent (175,000 curies total). An additional 90,000 curies is unaccounted for and presumed lost during between-run manipulations.

In the final run, 420 kilocuries of Sr-90 were recovered from an input of 480 kilocuries. Of this, 170 kilocuries has been set aside for further rework. In addition to the Sr-90, about 310 kilocuries of purified Ce-144 were recovered from 660 kilocuries input. An attempt to recover a cerium-free rare earth fraction was abandoned when only 24 kilocuries of Pm-147 were found in the raffinate from the cerium extraction step out of about 120 kilocuries brought in. Material balances were poor indicating only 50 percent of the rare earths were extracted in the first extraction cycle, although only 15 percent were found in the aqueous raffinate wastes.

Solvent Extraction Recovery of Strontium

Effects of radiation on process solutions are being studied in support of the Hot Semiworks strontium recovery program. Solutions simulating DTPA-complexed feed streams, citrate-containing product streams and solvent are being irradiated in the Co-60 facility at 100-KE. An interesting observation is the relatively rapid decomposition of DTPA in simulated feed solutions by gamma radiation. Cerium extraction by D2EHPA-TBP-Shell Spray Base was measured as a function of gamma dose received by the simulated feed. The cerium distribution ratio E_a^o increased from 0.059 at zero dose to 15.3 at a dose of 7.5×10^7R. These results suggest an explanation for the relatively poor cerium decontamination obtained with some HSW feed batches containing DTPA as complexant.

Strontium Carbonate Product Studies

Laboratory bench-scale studies were made to investigate the feasibility of using potassium bicarbonate instead of sodium hydroxide or ammonium hydroxide for neutralization of acidic strontium solutions. The use of potassium bicarbonate would eliminate both the possibility of precipitating strontium as the hydroxide and the potential hazard of ammonium nitrate accumulation.

Four different feed compositions were used: (1) 0.02 M Sr^{++}, (2) 0.02 M Sr^{++}, 1.0 M HNO_3, (3) 0.02 M Sr^{++}, 1.0 M HNO_3, 0.5 M citrate, (4) 0.02 M Sr^{++}, 1.0 M HNO_3, 1.0 M citrate. Acidic samples were neutralized with 2.2 M $KHCO_3$, then all samples were precipitated by the addition of 2.2 moles $KHCO_3$/mole Sr^{++}. After digesting and cooling, the samples were filtered. Filtrates from Samples 1 and 2 were clear and filtration was rapid. Sample 3 produced a gelatinous precipitate which soon totally blinded the filter. Sample 4 filtered rapidly but the yield was visibly poor.

Filtrates from both 3 and 4 were cloudy. In summary, bicarbonate neutralization looks attractive for strontium solutions in nitric acid if no citrate is present.

Bulk Fission Product Packaging

All parts of the prototypical remote loading station have been fabricated and the welding power supply, slope control, and high frequency start were received and installed. Design of the turntable and torch fixtures for remote operation was completed. A welding torch having no gaskets on the gas and water cooling lines was designed to eliminate leakage.

A search has been started to find materials and means for physically binding or cementing dry fission product compounds into a consolidated dust-free mass inside the shipping canister in order to prevent or minimize the atmospheric release of powdery product in the event of a catastrophic accident to the container. The first line of investigation is to seek out materials that can be co-deposited in the shipping container with the fission product intermediate, and then vitrified by heating during the normal fission product calcining step. Inorganic ion-exchange media, when loaded to maximum capacity (e.g., 20,000 curies of radio-cesium product per gallon of media), may be used to carry fission products in the shipping canister. However, the product is difficult to recover after the ion-exchange medium is heated much above 100 C.

An improved design of a capping station for the fission product packaging facility has been completed.

Cerium-144 Shipping Cask Tests

Cerium loading, drying and unloading operations were demonstrated in the HAPO I Fission Product Shipping Cask. A slurry of non-radioactive $Na_2SO_4.Ce_2(SO_4)_3.2H_2O$ and finely divided copper powder was vacuum filtered in the cask filter by means of a ten gallon per minute steam jet. Some of the more important results are as follows:

(1) Capacity of the filter was found to be between 700 and 800 grams of cerium, equivalent to between 0.56×10^6 and 0.64×10^6 curies of Ce-144 versus the design capacity of 0.50×10^6 curies.

(2) Cake dissolution with 4 M HNO_3 was accomplished without pressurizing the cask. Complete dissolution was accomplished in two passes without resorting to backflush technique. Solvent entry through the slurry inlet as well as through the solvent inlet was required.

(3) The cask heater functioned properly during the first drying operation, but was found to have an internal short when connected for the second drying. Cause of the short has not been determined.

(4) A field leak test of the miniature Hanford connectors with metal seals showed a helium leak rate of less than 1×10^{-4} atmosphere-cc per second.

Promethium Recovery

A successful promethium purification run was completed during the month in the A-cell ion exchange equipment, thus demonstrating on a convincing scale a flowsheet originally developed with "cold" stand-ins and tracer levels of activity. A total of 26,600 curies of promethium-147 product was obtained from the run, for an overall recovery of 80 percent. The product was radiochemically pure but contained some (cold) samarium and neodymium.

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The feed was prepared in B-Cell from a Purex crude by batch-wise peroxyacetate precipitations, using decantation for phase separation (since a suitable centrifuge or filter was not available). The Purex crude contained 82 curies/l Pm-147, 185 curies/l Ce-144, and 150 curies/l Y-91. The peroxyacetate product (feed to A-cell) contained 50 curies/l Pm-147, 7-25 curies/l Ce-144, 75 curies/l Y-91 and 18 g/l Na. This feed, initially at pH 4, was acidified to pH 0.85 to 1 (to minimize acetate complexing) and loaded at a fairly high flow rate (5 to 7 ml/min., cm^2) onto the first column in the A-cell series, a 4-in. x 9-ft. column filled with Dowex 50W, X-12 (50-100 mesh) resin in the ammonium cycle. Loading required 33 hours and breakthrough was reached only at the end of the loading cycle. The columns were then connected in series and eluted with a 0.015 M EDTA solution, buffered to pH 8.80 with ammonium hydroxide. "Cold" yttrium was used as barrier ion in the elution columns (which also contained Dowex 50W, X-12 resin) and worked very well. (Thorium or aluminum might also be satisfactorily used as barrier ions. Lead cannot be used since it was reduced by radiation in the presence of EDTA and resin in a manner analogous to that experienced with copper.) During the elution cycle, the columns were heated to 55-60 C. Flow rate was 3.5 to 4.5 ml/min., cm^2, except on the final column where it was reduced to 2 to 3 ml/min., cm^2 to "sharpen" the band. The cerium and most of the yttrium were eluted to waste at the bottom of the first two, 4-in. diameter elution columns. The promethium-rich cut was then eluted through two of the 2-in. diameter columns. (The third 2-in. column could not be used because of a leaking valve or gasket.) Operation was generally quite smooth and there was little evidence of resin damage or troublesome gassing. A decrease in the pH of the elutriant from 8.80 to 8.60 was found to largely eliminate such gassing as was observed.

The profile of the band was determined with the in-cell gamma spectrometer as the promethium was eluted both from the first and the second small columns, and a marked sharpening of the band and increase in purity was noted. Most of the promethium eluted from the last column was radiochemically pure; however, it contained sufficient neodymium and samarium to reduce the chemical purity to about 60 percent. Passage through a third column would undoubtedly have increased the purity further. Use of a larger promethium band (more curies of promethium) would also have improved average product purity through minimizing the relative effect of end effects (overlapping) caused by the short length of the band.

Supporting laboratory and analytical work has been aimed at determining why the Purex crude contained less than the expected amount of promethium. Analysis of samples from a current Purex strontium production run shows that most of the promethium (65 percent) is lost during the sulfate precipitation cycle, compared to only 10 percent of the cerium. The laboratory studies indicate that this is probably due to lower-than-optimum temperatures, which affect promethium more than cerium. (The Purex plant is limited to temperatures less than about 60 C since the transfer jets will not operate at higher temperatures -- while the retrograde solubility of the rare earth sulfates makes a higher temperature very desirable). Both promethium and cerium losses increased with pH, while there was no strong dependence on sulfate, lead, or tartrate concentration. Little yttrium was precipitated under any conditions. Additional experiments (incorporating washing) and analyses of plant samples are in progress aimed at devising means of reducing the promethium loss. Alternately, the sulfate waste may be an attractive potential source of promethium already partially separated from cerium (but heavily contaminated with yttrium).

Cesium Solvent Extraction

Additional solvent extraction experiments with dipicrylamine have revealed an unexpectedly large temperature effect, extraction being favored by low temperatures.

Thus, the extraction coefficient for cesium from synthetic 103-A supernate into 0.0125 M dipicrylamine (in nitrobenzene) increased from a value of 0.9 at 50 C to 5.6 at 6 C. From synthetic Purex IWW (neutralized to pH 8.65 and complexed with tartrate) the change was from 1.3 at 50 C to 8.4 at 6 C. Extraction coefficients from a low-salt, pH 11.5, 0.001 M CsCl solution were much higher; 81 at 50 C, 191 at 25 C, and 405 at 6 C.

A series of nine other compounds were tested and found ineffective. These included: picric acid, nitrobarbituric acid, 2,4-dinitro-1-naphthol-7-sulfonic acid, 3,5-dinitrosalicylic acid, 2,4-dinitroresorcinol, 6-chloro-5-nitro-toluene-3 sulfonic acid, 2,4-dinitrophenol, 2,4,6-trinitro-resorcinol, and 2,4,6-tri-nitro-m-cresol (all tested with nitrobenzene as diluent). Most of these were selected in the (mistaken) belief that compounds resembling picric acid would be effective agents for cesium. From the results, however, it appears that conjugated amine and nitro groups are responsible for the high extraction by dipicrylamine. Compounds are being procured or synthesized to test this hypothesis. The objective is an effective extractant containing fewer nitro groups than dipicrylamine.

Special Hazards Studies

Additional solubility data were obtained for the sodium cerous sulfate salt to be used for Ce-144 shipments. The tracer methods used gave a solubility at 20 C of 6.6 g/liter, a value considerably higher than the gravimetrically determined value reported last month. No reasonable explanation for the difference could be made.

Release of radioactive elements from the sodium cerous sulfate product of cerium fission product recovery process was investigated at elevated temperatures in oxidizing and inert atmospheres. The maximum measured release of radiocerium was 0.11 percent. This release occurred with air flowing at 2300 cc/min (STP) and with a programmed temperature increase of 10 C/min up to 1450 C. A maximum release of 3 percent Ru and 5.5 percent Zr was obtained with helium flowing at 850 cc/min (STP) and under similar temperature programming. Releases under isothermal conditions at 1350 C for two hours in either helium or air atmospheres were 0.005, 0.6 and 0.1 percent for cerium, ruthenium and zirconium, respectively. Since both radioruthenium and radiozirconium are significant contaminants of the product, their consideration in a shipping hazard analysis is indicated.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Determination of Technetium-99

Argentic oxide, an oxidant capable of separating any persistent ruthenium interference, must be freshly prepared to assure oxidizing power adequate for removing ruthenium. Accordingly, standard practice now is to check the anion exchange column holding the technetium for ruthenium contamination prior to elution of the technetium. If ruthenium is detected, the technetium is eluted and the oxidation-cation exchange cycle is repeated using fresh AgO. Incidentally, technetium, in 0.1 M HCl and in its lower valence state, was observed to plate quantitatively on zinc amalgam, a potential separation technique for technetium, perhaps.

Beta Activity and P-32 Measurements in Duck Samples

The determination of Tβ and P-32 contents of duck heads and muscles samples is proceeding as outlined last month with some changes. The burden of 2300 samples demanded a "screening" method to determine the feasibility of measuring Tβ and P-32. The correlation reported to exist between a gamma emitter and P-32 appeared insufficiently

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sensitive. Instead, this alternate was used: gamma counts in the low energy region (0.1 to 0.3 Mev) exceeding background by more than two standard deviations indicated the presence of beta emitters. Thus, samples which counted below that value were discarded. The screening found 800 samples with enough Tβ and P-32 to to measure. The latter was measured by noting the half-life of the Tβ aliquot and comparing occasional results with chemically separated P-32.

Determination of Fluorescein in River Water

The analysis of fluorescein (sodium salt) in 140 river water samples was completed using the direct fluorescence measurements obtained from a spectrofluorometer, employing essentially the same method as developed earlier for this investigation. Refinements extended the detection limit from 0.5 to 0.1 ppb. The recent work indicated satisfactory results in the lower range using only direct measurements without having to resort to a lengthier concentration method. Effects of the instability of the fluorescein sodium salt in water with time are noticeable but not significant for the present use in tracing river water flow patterns.

EQUIPMENT AND MATERIALS

Corrosion of Titanium by Purex IWW

Titanium samples were exposed to the liquid and vapor phases of boiling solutions simulating estimated future composition of Purex IWW but with fluoride concentrations two to six times that anticipated. All samples showed corrosion rates less than 0.05 mil/mo except those in the vapor phase above solutions having five and six times the expected fluoride concentration. These corroded at 0.07 mil/mo at five and 0.7 mils/mo at five and six times expected fluoride concentration, respectively. A sample of A-55 titanium was exposed under heat transfer conditions (bulk metal temperature 150-160 C) to synthetic current Purex IWW. Corrosion rate throughout 800 hours of exposure was about 0.01 mil/mo with no evidence of crevice corrosion at the gasket-sample contact point.

Materials of Construction for Plutonium Electrolysis Cells

Data were obtained for calculation to break down potential of the 60 percent $BaCl_2$, 40 percent KCl salt under test by 234-5 Development. Carbon rods were used for both anode and cathode. At the conclusion of the test, a hard black solid had deposited on the cathode. This experiment was repeated a second time with similar results. X-ray diffraction studies showed the deposit to be predominately potassium chloride with only a weak indication of potassium, barium or barium chloride.

Several attempts to deposit tungsten on ceramic materials by vapor phase reduction has led to a redesign of the equipment. Two short runs in the redesigned equipment yielded an electrically conductive coating on the ceramic substrate. The ceramic part had increased approximately two grams in weight during these two runs.

PROCESS CONTROL DEVELOPMENT

Recuplex Solvent Extraction Control

A series of runs is underway using the C-column facility with flow ratio control to evaluate various control techniques for use with the Recuplex process. These tests are designed to demonstrate the control characteristics of a C-column under constant ratio control, concentration feedback ratio control, and gradient feedback ratio control.

A prototype air driven pulse generator currently under test in Recuplex required instrumentation for indicating the pulse amplitude. An instrumentation system for performing this task was assembled, tested and transferred to Recuplex.

Neutron Multiplication Monitor

Instrumentation for monitoring approach to criticality in a Purex process tank has been assembled and tested in the laboratory. The system uses both a BF_3 counter and a solid state detector for purpose of comparing reliability and efficiency of the two techniques. Laboratory tests indicate the system incorporating a solid state detector, although considerably less sensitive than the BF_3 counter, may have a sufficiently high neutron count rate for a particular application in Purex. The completed instrumentation package was sent to the Purex plant for installation in N cell.

Work is continuing at the Critical Mass Laboratory, in cooperation with Physics and Instrument R&D personnel, to provide an additional source of data for evaluating this type of criticality monitor.

Gamma Spectrometer

A gamma spectrometer technique for remotely determining fission product concentrations has been effectively utilized in the high level radiochemistry facility. A study was made to determine the feasibility of adapting this method for use in Purex. In-line installation at the E-1 sampler appears feasible and should provide valuable analytical data for control of the various steps in the fission product recovery process. A major advantage is expected to be reduction of personnel exposure associated with current sampling procedures.

Preliminary design of a monitoring system for Purex was completed and a prototype sampler was built. Laboratory testing was initiated to determine optimum size and shape of the sample holder in relation to anticipated sample activity levels and detector sensitivity.

Strain Gauge Specific Gravity Instrument

A device for continuous measurement of specific gravity of flowing process streams is under development. The instrument uses a strain gauge load cell to detect the effective weight of a submerged plummet as it varies with changing specific gravity of the stream. The effect of flow rate is essentially cancelled by a specially designed flow cell. Flow rates up to six gpm result in an error of less than 0.004 specific gravity units. Minor modifications are being made to the instrument to reduce its sensitivity to variations in vertical alignment.

C-Column Test Facility

A satisfactory method of logging the output from the new turbine flowmeters was developed using a voltage signal from a Foxboro converter and a tuned wave trap to reduce interference from a 120 cycle ripple in the circuit. Installation of the split beam photometer signal lines was completed. With the exception of an abnormally high dark current on one of the two phototubes, the instrument appears to be operating satisfactorily.

Mathematical Model Studies

A mathematical model for the C-column which consists of two simultaneous differential equations describing the aqueous phase uranium concentration and the organic phase

1250554

uranium concentration as functions of the distance up the column, has been shown to have the characteristics necessary to adequately represent the experimental profile data. The differential equations were programmed on the analog computer in a way that the coefficients of the equations could be easily varied. Several runs were made on the computer with various values of the coefficients until a reasonably good fit to the profile data from one run was obtained. Correspondence between the observed data and the computer results appear to be sufficiently close so that the objectives of the computer study to determine magnitudes of the parameters can be met.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Separation of Plutonium from Uranium in Molten Chloride Systems - Exploratory work has continued on metathesis techniques for the preparation of plutonium oxide in molten chloride salt solutions of irradiated uranium. In these particular studies, the reactions (with MgO, SnO_2, or Sb_2O_5) were attempted at 550 C in a LiCl-KCl melt, with promethium added as a representative rare earth tracer. As reported last month, the addition of one gram of MgO to the melt precipitated about 40 mg plutonium, a recovery of 80 percent. Analytical results recently obtained for this run, however, have shown that the promethium decontamination factor was only 2.7. Attempted precipitations with SnO_2 and Sb_2O_5 gave much lower recoveries of PuO_2, with as yet undetermined promethium decontamination.

Further work in the same system was done with uranium(IV) as a stand-in for plutonium(IV). It was observed that while SnO_2 gives rapid and complete conversion of uranium(IV) to UO_2 in the presence of 0.1 weight percent uranium(VI), much higher concentrations (2.4 w/o and above) reduce the extent to which the conversion occurs. Attempted precipitation of uranium(IV) as UO_2 with Sb_2O_5 produced two reactions, partial precipitation and partial oxidation to uranium(VI).

Mechanism of Reduction of UO_2Cl_2 to UO_2 - As another approach to determining the mechanism of UO_2Cl_2 reduction in fused chloride salt systems, an impedance bridge has been set up and preliminary measurements made of cathode capacitance as a function of cathode potential. The results thus far have shown a reproducible (although broad, and not very high) peak at about 0.29 to 0.30 volts, and a second peak at about 0.22 to 0.20 volts. Although the interpretation of the data is not yet firm, the results appear to agree with chronopotentiometric data which indicate that the reduction of UO_2Cl_2 to UO_2 occurs at least in part by a two-step mechanism, with uranium(V) as an intermediate.

Crystal Growth Studies - Intensive efforts to develop techniques for controlling the crystal growth of cathodically-deposited UO_2 have continued, with the following observations:

(1) Deposits of 2 to 3 gram crystals can be consistently produced at 550 C in the $PbCl_2$-2.5 KCl salt system. Large crystals have been obtained with impurity levels as low as 20 ppm Pb and 10 ppm K.

(2) The LiCl-KCl system (equimolar) also appears to be suitable for the growth of large, ceramic-grade UO_2 crystals.

(3) Crystal growth characteristics may depend strongly on uranium concentrations in the melt. In an experiment in the course of which the uranium concentration was reduced by deposition from 20 weight percent to one weight percent, crystal growth was good in the early stages, some crystal branching was noted at 10 percent, and the deposit laid down toward the end of the run was comprised of a fine powder.

(4) An attempt was made to deposit uranium metal along with UO_2 by operating with a high potential in a LiCl-KCl melt in which more than 20 percent of the uranium was present as uranium(IV). Product analysis by X-ray diffraction indicated nearly stoichiometric UO_2, with no evidence of metallic uranium. The crystalline form of the deposit was quite different from any seen previously. Columns of UO_2 that had hemispherical surfaces grew in vertically oriented rows giving the deposit the appearance of a striped watermelon.

Rates of Dissolution of UO_2 by Chlorine - Additional data have been obtained on temperature effects in the thallium(III)-catalyzed dissolution of UO_2 by chlorine. It was found that an increase in temperature from 500 to 600 C gave about a 75 percent increase in dissolution rate (for a single crystal) in a KCl-LiCl system, while further increase to 700 C, in either LiCl-KCl or $2MgCl_2$-3KCl gave a 10 percent reduction in rate. These phenomena are attributed at least in part to lower equilibrium thallium(III) concentrations in the Tl(I)-Tl(III)-Cl_2-Cl^- system at the higher temperatures.

LiCl-KCl-UO_2Cl_2 Phase Diagrams - Differential thermal analysis measurements have been made on LiCl-KCl-UO_2Cl_2 systems. Among the points obtained for the phase diagram are the following: (1) Addition of 20 and 40 weight percent UO_2Cl_2 to the LiCl-KCl eutectic (40.9 percent KCl) changed the melting point of the salt from 349 C to 366 C and 419 C, respectively. (2) Addition of 20 and 40 weight percent UO_2Cl_2 to equimolar LiCl-KCl changed the melting point from 435 C to 342 C and 324 C, respectively.

Oxidative Decladding - Initial trials aimed at removal of UO_2 from stainless steel tubes by oxidation to U_3O_8 showed only moderate promise. Using heated oxygen only, rate of removal was disappointingly slow. When external heat was applied, there was an initial increase followed by a falling off of rate, apparently due to migration of oxygen into the UO_2 matrix followed by swelling and packing or plugging of the tube. Future runs will explore preheating of the UO_2 and use of a "cutting torch" technique.

RADIOACTIVE RESIDUE FIXATION

Kinetic Studies of Ion Exchange Materials

Kinetics of cesium-134 loading were studied in the film diffusion region for the inorganic cation exchange materials Decalso, clinoptilolite, erionite, phillipsite, and Type A synthetic zeolite. The same shallow bed technique was used as in the previously reported particle diffusion studies.

The film diffusion region is defined as the region where diffusion across a concentration gradient, or film, surrounding the particle of exchanger becomes rate-determining. Boyd[1] has used the expression "ln (1-F) = -R(t)" to describe the film diffusion kinetics of organic resins, where:

(1) Boyd, G.E., Adamson, A.W., and Myers, L.S., Jr., "The Exchange Adsorption of Ions [redacted]eous Solutions by Organic Zeolites. II. Kinetics." Jour. Am. Chem. Soc., Vol. 69, pp 2836-2848. (1947)

1250556

F = fraction of loading,

R = a constant that includes the liquid diffusion coefficient, particle radius, film thickness and a distribution factor, and

t = time elapsed since loading began.

Boyd's expression was tested for applicability by computing "R" at several points on the same loading curve. The values for "R", which theoretically should be the same at all points on the loading curve, were found to deviate less than those reported by Boyd for several organic resins.

Thus, it appears that Boyd's technique for determining film diffusion rates can be applied to inorganic exchangers as well as organic exchangers. The effects of temperature, flow rate, and competing ions on "R" values will be studied on the inorganic exchangers listed above.

Resin Capacity Studies

The capacity of Duolite C-3 resin for cesium-137 from high salt waste increases with increasing pH. Recent experiments have demonstrated that the buffer capacity of the waste affects resin capacity more than the pH per se. Column runs with cesium-137 in 2 N sodium carbonate (pH 11.8) and 2 N sodium sulfate brought to the same pH with sodium hydroxide exhibited marked differences in breakthrough points. The 50 percent cesium breakthrough points for carbonate and sulfate solutions were 208 and 137 column volumes, respectively.

Extraction of Cesium from Acid Wastes by Clinoptilolite

Equilibrium experiments with clinoptilolite show that cesium is readily extracted from synthetic, formaldehyde-treated IWW waste at a pH as low as 1.0. K_d values of 134 and 137 were observed at pH values of 1.0 and 2.4. Slightly higher K_d values are obtained if heated clinoptilolite is used.

Condensate Wastes

Equilibrium distribution coefficients were determined for trace cesium and strontium ions in dilute solutions of lithium and potassium ions at pH 6. Columns of Decalso, clinoptilolite, Amberlite IR-120, and Duolite C-3 would reach 50 percent cesium breakthrough after passage of 12,000, 20,000, 130 and 450 column volumes, respectively, of a 0.12 M lithium ion solution. With the same lithium ion concentration the 50 percent strontium breakthrough would occur after 150,000, 100,000, 5,000 and 3,000 column volumes, respectively.

In 0.1 M potassium ion solution the 50 percent cesium breakthrough would occur after passage of 200, 200, 20 and 50 column volumes, whereas with strontium the breakthrough would occur after 2500, 10, 1500 and 400 column volumes, respectively. The distribution coefficient for strontium on clinoptilolite in 0.12 M acid is the same as observed for 0.12 M potassium ion. Thus, neutralization of 0.12 M acid solutions with lithium hydroxide would increase the strontium capacity of clinoptilolite 10,000 times.

A Micro Pilot Plant run was completed in which the decontamination performance of a cation resin (Amberlite IR-120) followed in series by a mineral (clinoptilolite) was evaluated. Both exchange materials were originally in the hydrogen form. The first 2000 liters of feed, Purex tank farm condensate waste, were adjusted continuously with nitric acid to about a pH 2.4. Then, acid addition was stopped and

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the pH gradually rose to a pH 6.5 while 1800 liters were treated. The final 3000 liters were treated at about pH 6.5. Although the efficiency of the materials for removing cesium and strontium varied with the pH, the optimum removal of these isotopes for this system occurred around pH 4. Cesium was primarily removed by the clinoptilolite, and strontium was primarily removed by the resin.

Ruthenium Tetroxide Studies

Study continued on the chemistry of decomposition of ruthenium tetroxide under simulated waste-calciner off-gas conditions. Information was obtained on (1) vapor pressure of the tetroxide from sulfuric acid solutions, (2) extent of adsorption on silica gel as affected by temperature and a reducing agent (formaldehyde), (3) X-ray diffraction of ruthenium deposits on silica gel as a function of heating, (4) kinetics and auto-catalysis of tetroxide decomposition at elevated temperature, and (5) the ultraviolet absorption spectrum of ruthenium tetroxide. Details will be presented in the Waste Fixation quarterly report.

Fission Product Glasses

Scouting studies on the incorporation of fission product strontium and cesium in glasses -- in behalf of waste storage or heat-source utilization -- have been reported earlier. Many of the glasses prepared had reasonably low water solubility. The suggestion was recently made to use such glasses as high-integrity shipping media, provided the glasses could be dissolved or leached at the destination to make the fission product available for further processing. Semi-quantitative solubility studies showed that the strontium phosphate and cesium phosphate glasses were readily decomposed and largely dissolved by nitric or hydrochloric acid, rendering further processing reasonably convenient. This approach to cheaper shipment will be explored further.

In-Cell Spray Calciner

The in-cell spray calciner is being assembled for thorough "cold" testing prior to moving into the hot cell. Mock-up of the cell with a manipulator-bearing wall will begin as soon as building construction activity in 325-A is completed and the scaffolding removed.

A thermal flow meter, to measure flow rate of pressurized, radioactive feed at flows in the range 50 ml to 2 liters per hour, has been designed and is being tested. The principle of operation is use of a thermistor bridge to measure increase of temperature as the liquid flows past a heater. Although the unit appears promising and possesses the desired sensitivity to small flow variations, problems are presented by sensitivity to solution temperature and dissolved air, and by the unknown effect of radiation on the thermistors.

BIOLOGY AND MEDICINE - 06 PROGRAM

TERRESTRIAL ECOLOGY - EARTH SCIENCES

Geology and Hydrology

Fifteen of the sixteen wells on Project CAH-921 are complete; the final well is being drilled. About 90 percent of the originally estimated footage is drilled.

A two-dimensional, fluid-flow analog model was assembled and tested. The model is a passive resistance network consisting of 288 discrete resistances and simulates

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a previously constructed conducting-paper analog. Individual resistors were calibrated to an accuracy of about one percent while overall system resistance accuracy was better than three percent. Potential values were measured at 144 locations and values compared, through use of a digital computer matrix comparison program, with potential measurements from the conductance-paper analog. Mean difference between the two systems was 0.26 percent which indicates quite good agreement between the systems. The purpose of the resistance network is to test components, methods and techniques of analog simulation prior to attempting design and fabrication of a more sophisticated system representative of the Project.

An aquifer transmissibility test was run on well 699-69-45 after packer studies of the well were completed. The test was made by injecting water into the well and observing the change in well-water elevation. Because the aquifer occurs in the Ringold clay at this location, a low transmissibility was expected. A transmissibility of 113 gpd/ft was indicated. The success of this injection type test shows that this method may be used to obtain hydrologic data where the ground water is in sediments of low to moderate permeability.

Field Apparatus Development

An O-ring shaft seal on the pump for inflating the packing element of the vertical well current meter sealed effectively at depths to 150 ft. The modification should improve the performance of the well current meter.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Analytical Procedures for Meteorological Studies

An analytical procedure to determine zinc sulfide on grass and other types of vegetation ground cover was developed for studies of the distribution patterns of particulate materials released to the environs under different meteorological conditions. The procedure is a modification of that developed for the molecular filters used in air sampling for the same study. The vegetation samples were slowly dry ashed in the counting vials, suspended in the liquid scintillator solution, and counted. Ashed cheat grass exhibited a background phosphorescence which required about 40 seconds delay following excitation by light to decay to insignificance, whereupon the ZnS phosphorescence could be counted. This delay reduced the sensitivity of the procedure to about 2×10^{-7} grams ZnS which, however, is satisfactory for the present study.

Fallout Measurements

Measurements of fallout radioisotopes in the environs due to the recent foreign tests were begun. These include surface as well as upper air (to 12,000 ft.) measurements. Preliminary samples were taken using a "polypore" filter (designed to collect 99 percent of all particles larger than 0.1 μ) backed by about one inch of coconut charcoal. The isotopes Ce-141, Ba-140 - La-140, Ru-103 and Zr-95 - Nb-95 were readily detected on the filter along with some I-131. Up to three-fourths of the I-131 collected was found on the charcoal. The fallout radioisotope concentrations varied with altitude; the highest level in the preliminary tests was found at about 2,000 feet.

Radiation Chemistry

Additional measurements were made on the kinetics of erythrocyte hemolysis in isotonic s[redacted]s following absorption of gamma radiation. In these studies the

erythrocytes are used as a biological prototype for evaluating protective agents. Erioglaucine at a concentration of 5×10^{-6} M and several amino acids each at a concentration of 5×10^{-5} M were found to protect the erythrocytes from radiation-induced hemolysis. Since the rate of hemolysis has not yet been correlated quantitatively with absorbed dose, these protective effects cannot be evaluated in numerical terms. However, it is interesting that the three amino acids, valine, histidine, and tryptophan, with protective indices of 0.1, 0.3 and 0.6, respectively, also produced protective effects increasing in that order.

RADIOISOTOPES AS PARTICLES AND VOLATILES

Aerosol Generation Studies

A LaMer-type aerosol generator was further studied to establish parameters controlling particle sizes and concentrations. Rather narrow size ranges of stearic acid particles were generated of median diameters between 1 and 5 microns. A Royco particle counter was readied for detail studies of size distribution.

Deposition of Particulates in Conduits

A facility was prepared and used to accurately calibrate air-flow meters needed in particle deposition studies. Errors of less than 1 percent in air flow rates up to about 16 cfm are believed attainable with this facility. Highly accurate metering is needed due to the high power dependence of deposition constant on particle transporting media velocity.

W. H. Reas

Manager
Chemical Research and Development

WH Reas:cf

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

Dr. Colbert Cushing from the University of Saskatchewan joined the Radioecology Operation during November as a Biological Scientist.

Dr. E. Tombropoulos from the University of California joined the Pharmacology Operation during November as a Biological Scientist.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 02 PROGRAM

Effect of Reactor Effluent on Aquatic Organisms

The experiment of four months' duration to test the effect of crowding on the incidence of C. columnaris infection in trout was terminated. No mortalities were observed during the late weeks of the test when the water temperatures ranged in the low 50's (F). The summary of the results follows:

Trough No.	Initial No. of Fish	Total Mortality (per cent)	Avg. wt. at end of test (grams)
20	900	11.9	51
21	450	10.2	66
22	150	1.3	86
23	50	0	81

Salmon Survey

A total of 935 salmon nests were observed in the Columbia River between Midway and the mouth of the Yakima. Six hundred of these occurred upstream from the reactors.

C. columnaris

Samples of river fish continued to test negative for columnaris.

Waterfowl

The study of the dispersion of waterfowl from the Hanford environs by analyses of heads from birds harvested by sportsmen was expanded. Waterfowl are now being collected from Washington, Oregon, and California, with more than 2,000 already sampled.

BIOLOGY AND MEDICINE - 06 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Deuterium Studies

The previously reported sigmoidal survival curves have been caused by clumping

of D_2O cells. This clumping is not apparent microscopically, however, by vigorous agitation of D_2O cell suspension, exponential survival curves were obtained. The LD_{50} values for D_2O cells are 2 to 4 times higher than H_2O cells.

Preliminary studies with fish indicate that fish can survive up to 48 hours in 50 per cent D_2O. However, they are not normal acting and will not eat. Fish kept in 25 per cent D_2O were normal in all respects.

Strontium

The influx rate of calcium across the gills of rainbow trout appears to be greater than the influx rate of strontium. Experimental data gave rates of 1.8×10^{-7} cm/sec for calcium and strontium, respectively. The presence of calcium ions (maximum of 50 µg Ca/l) did not change the influx of Sr^{85} in tracer amounts.

Studies of the effects of alkaline earths in the intestinal perfusion fluid on *in vivo* absorption of Sr^{85} and Ca^{45} from the small intestine were continued. Data were obtained on the effects of beryllium and zinc and also the effects of pH and citrate ion. Studies were also initiated to determine the effects of mixtures of calcium and other alkaline earth ions. Of particular interest was the observation that rats perfused with 5 mM zinc in the presence of citrate absorbed 49 per cent of the perfused Sr^{85} and 5.9 per cent of the perfused Ca^{45}; this being the highest ratio of Sr to Ca absorption yet observed.

Marked changes in calcium and Sr^{90} transfer from plasma to milk were observed during the 42-day lactation period of miniature swine. The milk to plasma ratio of stable calcium and of Sr^{90} at three representative test periods is shown below:

Day of Lactation	Milk:Plasma Ratio Stable Calcium	Sr^{90}
1	8	3
10	20	10
42	34	17

The plasma content of both stable calcium and Sr was fairly constant during the entire lactation period. To our knowledge this is the first time that such marked changes in milk:plasma ratio of these elements have been described and further studies are therefore suggested.

Microdensitometric recordings of autoradiographs of the tibia of a one-year-old animal fed 25 uc/day of Sr^{90} showed the following interesting results:

Distance from Proximal End as a Fraction of Tibia Length	Radiation Dose in Tibia: Maximum Dose (rads/day)	Minimum Dose (rads/day)
1/8	3.0	2.4
1/4	4.6	1.8
1/2	6.2	2.2
3/4	5.2	0.6
7/8	4.0	2.2

The average dose rate to the active red marrow may approach 4 rads per day since in the adult or young adult animal the active marrow sites have regressed to the proximal and distal ends of the medullary canal and are adjacent to solid bone or bone spicules. These values agree generally with previously predicted values of 4 rads per day to the skeleton of adults on the 25 μc/day level of Sr^{90}. Representative standards upon which these readings depend will be analyzed for their Sr^{90} content.

The basic data on all miniature swine were prepared and key-punched for IBM storage and processing. Other data on the swine will be submitted during early December.

Data from skeletal analyses of sacrificed miniature swine were updated in preparation for this year's Biology Annual Report. Analyses have been performed on a total of about 220 miniature swine. However, most of these data are on newborn and weanling miniature swine. Preliminary inspection of the data revealed little effect of Sr^{90} feeding level on the calcium and phosphorus content of their skeletons. On the average, slightly greater than 1 per cent of the body mass of the miniature swine is calcium with an average calcium to phosphorus ratio slightly below two.

Cesium

Plants grown in toxic concentrations of cesium recovered when placed in potassium nutrient solutions. The Cs^{137} content of plants grown in carrier-free solutions was double that in plants from carrier-containing solutions.

Plutonium

Studies with triethylenetetramine hexaacetic acid (TTHA) were extended to determine the effect of a lower than maximum-tolerated dose. At a 2.8 mM/kg level, at which only moderate diarrhea was observed, TTHA administered orally one hour following plutonium injection resulted in the removal of all except 13 per cent of the plutonium. At the same dosage level, DTPA in a parallel experiment, left 46 per cent of the injected Pu. The effectiveness of TTHA at this well tolerated dose is about equivalent to that of DTPA at the marginally lethal dose level of 6 mM/kg. These data were obtained from a small number of rats due to limited availability of TTHA.

Experiments were initiated to test the effect of urethane (ethyl carbamate), DTPA, and ultrasonic irradiation on Pu deposition in, and removal from, bone. Data are not yet available from Pu analyses. Some interesting physiological interactions between the urethane and DTPA were noted. The DTPA appeared to extend the effective period of anesthesia produced by the urethane injections.

Radioactive Particles

A group of rats were exposed to $Ce^{144}O_2$ aerosol to test the effectiveness of negative ion inhalation and subcutaneous injection of cyanacethydrazide on increasing the rate of pulmonary clearance of Ce^{144}.

The effectiveness of inhaling stable iodine as a diluent of I^{131} on deposition of I^{131} in thyroid of rats was tested in two experiments. No results are available.

One dog died five months after exposure to $Pu^{239}O_2$. Pulmonary changes leading up to death were easily identified radiographically. Other dogs exposed two years ago to $Pu^{239}O_2$ are showing decreased neutrophil levels in the circulating blood as well as lymphopenia. However, the neutropenia does not appear to correspond exactly with the occurrence of lymphopenia in that it is occurring in dogs having lymphocyte levels in the normal range. The blood data are summarized as follows: the lymphocyte counts of all control dogs are above 3,000 cells/mm^3 blood. Nineteen of 23 dogs exposed to plutonium have lymphocyte counts below 1,700/mm^3 and 10 are below 1,000/mm^3. Nine of the exposed dogs and 3 controls have absolute neutropenia, below 4,700/mm^3. Seventeen exposed dogs and 2 controls have leucopenia, below 8,000 leukocytes/mm^3. The number of dogs with marked lymphopenia, neutropenia or leucopenia have increased 30 per cent since July. Lymphopenia is a consequence of plutonium inhalation since it is seen only in exposed dogs. However, the cause for neutropenia in both control and exposed dogs is not known but may be related to seasonal variations. Also, for some undetermined rason, the circulating leukocyte counts of beagle dogs in our colony average well below those of dogs in other laboratory colonies. The general physical condition of the colony is good.

Basic Radiation Effects

Experiments were performed employing tritiated thymidine, leucine and arginine to study the incorporation of these compounds into cytoplasmic and nuclear components of mouse spleen and bone marrow cells. No interpretable data have yet been obtained.

The effects of X-radiation upon single and mixed species cultures of flour beetles (*Tribolium confusum* and *T. castaneum*) were studied. For both species 2000 r greatly reduced the number of F_1 progeny, 4000 r was near the sterilizing dose and 6000 r produced complete sterility. Four weeks after exposure to 2000 to 4000 r, the number of viable gametes increased.

T. castaneum produces more progeny under control conditions and is slightly more tolerant to radiation than *T. confusum*. The proportion of *T. castaneum* in mixed populations after six weeks culture increased from 70 per cent in the control to 95 per cent in the group exposed to 4000 r.

Fallout Studies

The I^{131} concentrations in thyroids from 37 deer harvested in Colorado during October 28 to November 7 averaged 1×10^{-2} $\mu c/g$ wet weight. A slight decrease in I^{131} levels occurred near the middle of November. Deer from southeastern Washington, including roadkills from the Hanford Reservation, contained comparable amounts.

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C. Lectures

a. Papers Presented at Meetings

P. A. Olson, "Fish Toxicity Studies on Atomic Process Wastes," November 14, 1961, Tenth Pacific Northwest Research Symposium, Portland, Oregon.

L. K. Bustad, "Metabolism of I^{131} in Sheep and Swine," International Atomic Energy Agency Conference on the Use of Radioisotopes in Animal Biology and the Medical Sciences, Mexico City, Mexico, November 27, 1961.

V. G. Horstman, J. W. Cable, W. J. Clarke, M. E. Kerr, R. L. Persing and L. K. Bustad, "Blond Miniature Swine for Radiation Research," 53rd Meeting of the American Society of Animal Production, November 24-5, 1961, Chicago, Ill

Northwest Section of the Society for Experimental Biology and Medicine, November 17-18, 1961, Richland, Washington:

R. O. McClellan, W. J. Clarke, N. L. Dockum, V. G. Horstman, J. R. McKenney, Glenda Vogt and L. K. Bustad, "Biological Effects of Sr^{90} in Miniature Swine".

H. W. Casey, R. O. McClellan, J. W. Cable, and L. K. Bustad, "Transfer of Heavy Radionuclides to Milk".

b. Seminars (Off-Site)

J. F. Cline, "Radioisotopes in Agriculture," University of Montana Experiment Station, Havre, Montana, November 13, 1961.

R. C. Thompson, "Internal Emitters," Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 1, 1961.

c. Seminars (Biology)

R. L. Uhler, "The effects of chloramphenicol on ion uptake," November 7, 1961.

R. E. Nakatani, "The effect of chronic feeding of Sr^{90}, Y^{90} on Rainbow Trout," November 7, 1961.

d. Miscellaneous

L. A. George, "Radiation Biology", November 4, 1961, Spokane High School Science Seminar, Lewis and Clark High School, Spokane, Washington.

D. Publications

a. Documents

None

b. Publications in Open Literature

Sullivan, M. F., "Intestinal vascular permeability changes induced by radiation or nitrogen mustard," Am. J. Physiology 201, 951-954 (1961).

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OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - NOVEMBER, 1961

ORGANIZATION AND PERSONNEL

W. R. Lewis was transferred to the newly formed Test Reactor and Auxiliaries Operation as Supervisor, PRTR Technical Planning.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Model

A second draft of the report summarizing work on the HAPO model was completed.

HAPO Criteria Study

The report describing "Criteria Used for the Direction and Measurement of HAPO Business" was issued.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuel Preparation Department

Fuel Element Performance

Considerable attention is being given the problem of assessing the accuracy and precision of measurements performed on the pre-irradiated fuel element. Results from the Quality Certification Program point out the need for obtaining reliable pre-irradiation data. Data from several runs made on the UT-2 and on the bond tester were analyzed. In this connection, a model was developed which permits estimation of percentage biases between runs in addition to constant biases and precisions. This has been programmed for use on the IBM-7090, and it has been found that some runs have indeed measured on the high side for low values and on the low side for high values. Further work is being done in this general area of tester errors.

The segregation of impurity content and grain size along an ingot is being investigated using data collected at FMPC.

Consultation was given relative to the HAPO requirements for variables UT-2 data at the feed sites.

General

In the heat treating of NPR fuels, an air delay time of a given number of seconds is used prior to quenching. Using data showing variations in cooling

rates, the question of whether or not the specifications put on the temperature at quench were too restrictive was considered. Further testing to evaluate sources of variation was designed and recommended.

Further NPR warp data collected from extrusion runs having different press conditions were analyzed to determine the effects of the particular press conditions being varied.

Data from two more pilot plant tests run to determine favorable cycle times in the canning of six-inch I and E fuel elements were analyzed. One was with standard cores; the other used lead plugs.

Component wettability data were analyzed to estimate the within and between batch variance components, and to test whether there is a change in wettability with time.

A new attack on constructing a mathematical model of the fuel element fabrication and scheduling process has produced a totally linear model fully equivalent to previous models which contained nonlinear restrictions. The new system is now being studied by Manufacturing Studies, Fuels Preparation Department.

Irradiation Processing Department

Reactor Optimization Studies

Monthly charge-discharge rates and tube replacement rates for each reactor from April through September were analyzed to use as a basis in controlling such rates in the future. Types of charts to use in controlling such work rates were formulated. However, in view of the apparent excessive variation in these data, it was suggested that limits be developed synthetically rather than on the basis of existing data. This idea is being pursued by IPD personnel.

Reactor Computer Simulation

All reactor management except D have been informed of the proposed computer simulation of reactor operations. Each area was visited during the month to describe the general scope and information requirements, and to introduce the personnel who will be performing the work.

Arrangements have been made to get the detailed radiation exposure records from each area to serve as the basic data for determining the distribution of exposure among craft task activities and the trends experienced at the present time. A strong interest has been shown by management regarding the development of a control information system as part of the development of the simulation model. A real time craft-hour expenditure and craft-exposure system is now being considered as secondary part of the project and should be capable of delineation and exemplary display in a month or two.

Process Tube Leaks

Primary attention was directed in November at estimating sources of variation in reporting minimum wall thicknesses read from probilog traces. Future efforts

in this area will be concerned with the entire probolog trace to obtain a corrosion profile rather than merely the minimum thickness. Some work has been done in determining how best to machine process R data to characterize temperature distributions around a fuel element charge.

Work continued on the problem of computing probabilities of detecting cracks in welded primary piping for the NPR Project. During November an HW document relating to the problem was issued. ("Estimation of Defect Frequency", HW-71640, by Carl A. Bennett and A. D. Wiggins, November 8, 1961.)

General

Fifteen unirradiated fuel elements were measured for weight and dimensions on both the 300 Area equipment and the C-Basin equipment, with three runs being made at each location. Relative biases and precisions are being estimated using the model and computer program discussed in the Fuel Element Performance paragraph.

Confidence limits on the conversion ratio values obtained in the twelve two-ton batch tests were found assuming a given precision in the exposures assigned the individual fuel element charges.

Chemical Processing Department

Machining Development

Preliminary tests on a routine to produce continuously recorded data on standard IBM-7090 magnetic tape by eliminating the usual sequence of record gaps have been encouraging. The degree of success apparently depends purely upon the quality and condition of the tape being used. The technique is necessary in order to produce an instructional tape for the Gorton lathe which contains timing as well as positional information on it.

General

Attention is being given the measurement requirements to demonstrate conformance to purity specifications for the final product. It appears that part-by-part inspection may have to be discontinued for models having high production rates due to limitations in analytical work loads. Alternate means of assuring acceptable product quality are under investigation.

Work continued on the investigation of the factors contributing to variability in the densities of buttons.

Work continued on a motor pool problem for the Facilities Engineering Operation.

Relations and Occupational Health Operation

General

In connection with the blood count study being performed for the Occupational Medical Operation, the pre-employment control group has been supplemented by a

group of HAPO employees with longer work experience but no exposure to radiation; and by a more complete tabulation of individuals with high exposure. The use of these additional data will provide a new control sample of people with HAPO experience and will provide more information on the high exposure group.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Pulse Column Test Facility

The 1 GX-Rotometer calibration was finished, and the calibration function is being programmed into the IBM data reduction system. A second organic shift experiment was designed and performed in connection with the absorptiometer calibration. The analysis of the resulting data should indicate whether the aqueous uranium solution attenuation coefficient can be applied to the estimation of organic uranium solution concentration. If so, the zero shift from aqueous to organic is estimable, which should complete the absorptiometer calibration.

A numerical integration subroutine is being written to solve the system of partial differential equations which express the column mass transfer dynamics for equilibrium operation. This subroutine will be used with NEMIX to investigate the influence of several controllable variables on the column operation.

Physical Properties Testing

At the request of Physical Metallurgy Operation, a statistical analysis was begun using Zircaloy II hardness data to correlate hardness with irradiation exposure. Similar correlation studies are scheduled for several other physical properties measures. The results of the analyses will be used in conjunction with other information to predict the useful life of NPR core tubing.

General

At the request of Instrument Research and Development Operation, minor revisions and additional features are being incorporated into the IBM-7090 program which evaluates the sensitivity and longevity of a proposed neutron flux monitor as a function of its isotopic constituents.

Assistance was provided in the interpretation of buckling data.

4000 Program

Swelling Studies

Further calculations are underway on pore size distribution data to describe the true pore size distribution in the uranium matrix. A statistical procedure is being programmed to test whether micrograph pore size distributions agree

with a particular theoretical model. Here, the model consists of a theoretical distribution in the uranium matrix plus a transformation function which generates the theoretical distribution on the micrograph from the matrix one.

Plutonium Recycle

Additional analysis of data from a high energy uranium oxide impacting test experiment is underway. A new model which assumes an asymptotic dependence of density on fire pressure is being fitted to the data using NELLY.

A discussion was held with PRTR engineers concerning D_2O inventory procedures. An attempt will be made to assay the precision of hot and cold inventories, both empirically and from the inventory formulas with appropriate propagation of error methods.

General

Recent autoclave corrosion experiments with 360°C deionized water have resulted in six sets of homogeneous corrosion data time series on aluminum lots of similar nominal composition and purity. These data are being fitted to theoretical models in hopes of substantiating or refuting current corrosion mechanism conjectures.

Data from a recent pilot study mineral bed waste column experiment were analyzed for Chemical Effluents Technology Operation. The study considered column optimization as a function of three factors, waste dilution, residence time, and bed particle size. A second experiment was designed to cover factor level combinations which extend the range of the pilot study in the direction of improved column operation.

Work continues on the mathematical circuit analysis model designed to aid Instrument Research and Development Operation evaluate the results of an experiment being performed to test the sensitivity and selectivity of an electronic nondestructive fuel element testing instrument.

5000 Program

Investigation continued on optimum search patterns with some consideration given to rectangular patterns covered by a uniform distribution.

Another IRA run was completed and parity checks are underway. A subroutine is being written so that NELLY can be used as an equal ignorance search mechanism.

Other

Atmospheric Diffusion Studies

The APE data have been processed by the Green Glow Program and the results stored on magnetic tape. An IBM program was written which will select certain records from this tape and prepare them as input data to NELLY.

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METHODS DEVELOPMENT

Numerical

NELLY, the Hanford modification of a Los Alamos nonlinear least squares routine has been completed and its numerous iteration choices extensively checked out on a battery of test problems. SPEC, a computer code for quantitative resolution of time dependent gamma energy spectra, also has been completed. Several test cases have been resolved successfully.

Wesley L. Nicholson

Acting for Carl A. Bennett
Manager
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PROGRAMMING OPERATION

NOVEMBER, 1961

I. REACTOR DEVELOPMENT - 04 PROGRAM

A. PLUTONIUM RECYCLE PROGRAM

1. Cross Section Evaluation

A general calibration of the MELEAGER fuel burnup code is being carried out to increase its applicability to broad survey analysis. MELEAGER is normally recalibrated for each reactor being analyzed by someone extremely familiar with the MELEAGER code and the physics of the reactor to be studied. This is a practical approach for specific cycle analysis where the number of reactors to be calibrated is less than ten. The HLO combined cycle analysis must encompass a very large number of reactor cases and thus, it becomes impractical to provide individual attention to MELEAGER code calibration for each run.

The work is being accomplished in several phases: the first, is to examine the suitability of a modified Westcott representation of flux and cross sections. This work is being done in cooperation with HLO physics groups. The General Atomics' "Spectrum" code is being used as a standard to examine the validity of the modified Westcott flux patterns. Methods have been derived (see October report) for comparing the neutron temperature with the moderator temperature. The investigation has demonstrated that the relationship is:

$$T_n \cong T_m \left(1 + C \frac{Y_a \ \sigma_{oa} \sqrt{\frac{273.2}{T_m}}}{\xi \ \Sigma_s}\right)$$

where,

T_n = Neutron temperature °K

T_m = Moderator temperature °K

C = A constant derived for each absorber

σ_{oa} = 2200 meter/second absorption cross section

$\xi \Sigma_s$ = Cell averaged slowing-down power

Values of C derived for several absorbers are:

Absorber	Number of Cases Used to Obtain "C"	"C"
U-235	64	0.67
Pu-239	48	0.44
Pu-240	52	0.52

It appears extremely desirable to place this temperature correction in the MELEAGER Code.

Where several absorbers are present, one must use an averaged or an approximate value for "C", or use the following expression:

$$T_n \cong T_m \left(1 + \frac{\sum_i C_i \; N_i \; \sigma_{aoi}}{\xi \sum_s \sqrt{\frac{T_m}{293}}} \right)$$

Additional "C's" are needed for every absorber present using this approach. A logical assumption is that the value "C" is related to the shape of the cross section profile. One measure of this is the Westcott "g" factor. A rough correlation was demonstrated. Additional work is needed before a generalization can be made.

It has been anticipated that, if the neutron temperature correction formula is introduced into MELEAGER, it will likely be necessary to reformulate the expression in MELEAGER presently supplying the spectral index term β. β's have been calculated for Pu-240, Pu-239, and U-235. These β's will be compared with those arising from the current MELEAGER formulation. MELEAGER uses averaged Westcott cross sections as follows:

$$\hat{\sigma} = \sigma_{oa} \; (g + rs)$$

$\hat{\sigma}$ = Averaged effective cross section including resonance terms

σ_{oa} = 2200 meters/second absorption cross section

g = Correction for non 1/V absorption in the thermal portion

r = Spectral index = $B/1 + B\beta$ (B is a function of the delta formulation)

s = Correction for non 1/V absorption in the epithermal region

NOTE: B and S and, therefore, r and s, will be dependent upon the delta formulation. Part of this study involves identification of the most appropriate delta function and r evaluation in view of the foregoing suggested temperature correction. The different delta functions permit discretionary selection of the epithermal weighting somewhat independent of the thermal and fast portions of the flux formulation.

Reaction rate ratios are being derived from SPECTRUM code to compare with those that would arise from use of the modified Westcott model. Comparison is made difficult because the SPECTRUM code does not presently account for reactions occurring above 4.2 electron volt energies with satisfactory accuracy. Westcott codes were written to produce Westcott type cross section relations below 4.2 ev. These have been named Westcott 4, 3, 2, and 1 as each code uses different formulations of the delta term as identified by Westcott as Delta 4, 3, 2, and 1. The cross sections are not directly comparable but relative absolute reaction rates can be developed for comparison with those from SPECTRUM.

An error analysis will be carried out with MELEAGER and QUICK codes to determine the impact on fuel costs of any significant differences between the reaction rates described above.

2. Fuel Geometry and MELEAGER

The MELEAGER computer code does not directly recognize fuel geometry, but certain input parameters do reflect the effect. The second phase of the general calibration of MELEAGER is to calibrate these input parameters. By this means, fuel costs that are available for a variety of parameterized reactor characterizations using MELEAGER can be conveniently related to specific fuel element geometries. The Hanford code, IDIOT, is being used as a standard for this work because it is a geometry code that has been calibrated against a variety of physical measurements. IDIOT is a transport code using the P-3 approximation that handles the "idiot" work associated with fuel geometry homogenization. The calibration method being used is based on the fact that SDPV and SCA, the MELEAGER input parameters reflecting geometry, primarily affect the resonance escape probability, "p", and the ratio of neutrons released in the fuel to the neutrons absorbed in the fuel (η). Thus, ηp response surfaces are compared between MELEAGER and the reference. The SDPV is normally the cell averaged slowing-down power, and SCA is a fuel scattering term reflecting the fuel element surface-to-mass ratio. Initially, the ηp products differed considerably between MELEAGER and the reference. Two approaches were successfully used to get better correlation of the "ηp" products, and further evaluation is under way.

3. Zoned Spectrum Reactor

Reactivity lifetime computations are continuing for the Zoned Spectrum Reactor concept which has different amounts of moderator in various zones to provide for absorption of excess neutrons in fertile fuel rather than in control systems. In this respect such reactors are similar to the Edlund Spectral Shift Reactor under study by the Babcock & Wilcox Company, wherein H_2O is introduced in D_2O to adjust the moderating power. Like the Edlund machine, the Zoned Spectrum Reactor appears to improve the reactivity limited fuel lifetime from 50 to 100 percent over conventional batch cycle techniques. This gain is essentially the same as that achieved by the continuous or graded cycles in which the "freshest" fuel is put in appropriate proximity of the highest irradiated fuel. As distinguished from the Edlund Spectral Shift concept, both the Zoned Spectrum Reactor and the continuous cycle type of operation involve physical shifting of the fuel to attain the purported reactivity lifetime. Hence, these methods also involve unusual startup and shutdown charges incurred because of premature discharge of fuel to establish the equilibrium cycle, and the fuel fabrication and jacketing charges simply do not "go the distance." Upon permanent reactor shutdown, a similar circumstance exists. In the case of startup, lower enrichments can be used for the fuel to be discharged early, which minimizes the premature discharge penalty associated with enrichment. This is not the case upon permanent shutdown and higher than usual burnup charges are incurred as normally enriched material is prematurely discharged. The graded fueling system has a special consideration by virtue of the fact that the reactor flux level is constant to maintain constant reactor power. However, the fissile concentrations vary from the initial to final value, which leads to a variation in specific fuel power throughout the reactor. (In the case of coutercurrent charge-discharge, such as CANDU, there is no variation in total process tube power as is characteristic of other graded systems.) HLO calculations of graded cycles involved identification of the maximum and minimum heat transfer. In some cases heat transfer variations of twelve-to-one have been observed in graded cycles. The computer codes have been arranged and debugged to enable comparison of batch, graded, and zoned spectrum cycles. The Zoned Spectrum cycle is also analyzed without unusual startup charges which approximates the Edlund Spectral Shift reactor cycle. Preliminary results, so far, indicate that combinations of plutonium, U-238 and thorium display more flexibility with spectral shifting than do combinations of U-233, U-235, U-238 and thorium.

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4. Salt Cycle Reprocessing Economics

The salt cycle computer program work was concerned principally with the material balance routine for the salt cycle economics code. The problem is to investigate the important parameters relating to the various ways of utilizing a salt cycle process in a plutonium recycle fuel cycle.

The basic concept assumes a zoned reactor with part of the fuel containing plutonium and the balance using UO_2-only, with the same total enrichment in both types of fuel. The relative amount of PuO_2-UO_2 fuel to be recycled depends on the amount of plutonium recovered from a particular recycle step (the number of steps being the number of times the plutonium is recycled) and the enrichment of the uranium recovered with the plutonium. In turn, the enrichment of the uranium recovered with the plutonium is a function of the salt cycle operating procedure and, of course, burnup in the reactor.

The salt cycle process concept under consideration consists of a fused salt bath into which spent UO_2-only fuel or spent PuO_2-UO_2 (both of which contain plutonium) can be charged either separately or together. Either of two products can then be removed by electrolytic deposition: (1) deposition of UO_2-only, defined as a by-product operation, or (2) deposition of PuO_2-UO_2, defined as a product operation. To obtain maximum flexibility in the program, the limiting process parameters are established as input variables. These include such items as maximum uranium charge, and minimum by-product and product heels.

Four basic salt cycle operating procedures have been defined for evaluation, as follows:

a. The amount of PuO_2-UO_2 fuel produced is minimized by first charging the higher enrichment uranium from the spent UO_2-only fuel and removing some of the uranium as by-product; then charging the lower enrichment uranium from the spent PuO_2-UO_2 fuel and removing additional uranium as necessary to adjust the final enrichment; and finally removing all (except for a residual heel) of the remaining plutonium and uranium as PuO_2-UO_2 product.

b. The same procedure as in (a) is followed, except that additional by-product uranium is removed and fresh depleted uranium of lowest available enrichment (0.22%) is added to further reduce the relative amount of PuO_2-UO_2 product.

c. The amount of PuO_2-UO_2 fuel produced is maximized by first charging the lower enrichment uranium from the spent PuO_2-UO_2 fuel and removing some of the uranium as by-product; then charging the higher enrichment uranium from the spent UO_2-only fuel and removing additional uranium if necessary to adjust the final enrichment; and finally removing all (except for a residual heel) of the remaining plutonium and uranium as PuO_2-UO_2 product.

d. A similar procedure as in (c) is followed, except that none of the higher enrichment uranium is removed as by-product and fresh enriched uranium of varying enrichments can be added to increase the relative amount of PuO_2-UO_2 product up to the limiting condition where all of the fuel for the subsequent plutonium recycle step is mixed oxide fuel.

It is planned that the computer program will examine a sufficient number of cases for each procedure to ensure finding the economic optimum method of operating for any particular set of economic parameters. It is expected that procedures (a) and (b) will be important when the incremental fuel fabrication cost for low D.F. mixed oxide is high relative to fuel fabrication cost for high D.F. mixed oxide fuel. Procedures (c) and (d) will be more important in most other situations.

A comparable computer program for the evaluation of recycle via conventional solvent extraction processing has already been set up and demonstrated for a limited set of conditions.

B. SPECIFIC FUEL CYCLES

1. U-238 Spatial Concentration

Most of the emphasis is being placed on preparing formal reports of selected material from the August 11, 1961 Compendium of HLO Plutonium Value Computations. At AEC's request, effort is being made to include some results of the APWR using reduced concentrations of U-238 when plutonium enrichment is used. Analysis of reduced U-238 concentrations can involve very large amounts of computer work as an additional dimension is introduced. Fuel cost correlations are being attempted with combinations of reactor burnup terms, such as conversion ratios and enrichment levels, for selected U-238 spatial concentrations. Since reactor burnup terms can be computed at very low cost on the computer, their use may permit elimination of unpromising uranium concentrations for various plutonium compositions without use of far more costly fuel burnup computations. To date, a simple correlation has not been formulated successfully. The analysis is further complicated, of course, because it cannot be assumed that the uranium enrichment mode will necessarily appear optimum at 100 percent uranium spatial concentration with the HLO computer codes. This is the case, because of simplifications necessarily taken in the HLO codes and because the initial lattice selection was likely made on other bases as is usually necessary in reactor design. As a consequence, it is necessary to normalize the U-235:U-238 case to 100 percent U-238 spatial concentration. For example, detailed examination of one lattice with the HLO codes indicates that U-235:U-238 is optimum at 115 percent U-238 spatial concentration and that Pu:U-238 is optimum

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at 90 percent. When the U-235:U-238 is normalized to 100 percent, the Pu:U-238 appears optimum at roughly 78 percent U-238 spatial concentration. If the HLO computer code is correct, of course, then the U-235:U-238 results at the unnormalized condition must be limited to 100 percent spatial concentration which would further improve plutonium values for that particular reactor. There is no reason to believe that the HLO codes are "on the nose," as all such computer codes involve gross extrapolation of a limited number of facts.

2. Uranium Price Schedules

At AEC's request, 725 different uranium price schedules were computed and printed out in tabular form. Four sets of the computer output (each set required five bound volumes) were supplied. These output tapes were saved so additional copies can be obtained easily.

The output includes the cost components and total uranium cost as a function of U-235 enrichment for all combinations of separative duty and natural uranium costs in 5 percent increments for 50 to 170 percent of the values making up the post-July 1, 1961, uranium price schedule, and a few special cases. As a consequence, the output lists between 350 and 400 thousand numbers. Not being able to check each number, the results have been cross plotted by hand to provide assurance that the input parameters were accurately read into the computer and that the values for 1, 2, 3, and 10 percent of fully enriched uranium are valid. Later, it will be possible to prepare cross plots at high speed on the computer as a plotter code is essentially completed (program ALFPLO-alphabetic plotter). While the plotter results are limited in definition by the machine printer at HLO, additional resolution can be provided in the printout by automatic indication on the plot of the direction and amount of roundoff for each point. For further resolution, the plotter data can be fed to a continuous plotter of the type available at some digital computer installations, or those attached to many analog machines.

3. Code Development

Checks on the MELEAGER data expansion code, PROTEUS, have shown that there is a considerable difference in the accuracy of the polynomial curve fits of the basic MELEAGER data, depending on the number of points supplied. The optimum number was determined by having PROTEUS calculate the same case with different numbers of time steps. Cases which had from 6 to 223 time steps were investigated. The results showed that about 25 points gave the most accurate fits for all of the isotopes. Further, and hopefully final, modifications to the PROTEUS code were begun. These will provide:

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1. Operation with a tape containing the polynomial coefficients as output or input. This will permit calculation of additional end points and permit batch or graded fuel cycle calculations to be done without redoing the entire job. This will also condense the information on the MELEAGER B8 output data tape considerably.

2. Calculation of maximum-to-average and minimum-to-average heat transfer ratios in graded operation.

3. Merge routines for both QUICK fuel costs input tapes and polynomial coefficient tapes.

4. A calculation error check that will print out a warning message if the polynomial fit of the most important isotope is more than three percent in error, or if the average error in the reactor exposure time intervals as a function of k_{∞} is greater than 10 days.

II. OTHER ACTIVITIES

1. Mercury Isotopes

Completion of the first rough draft of the Hg-204 report has afforded a look at the over-all text which indicates that several documents should be prepared rather than a single voluminous offering. In particular, the bibliography, which includes paragraphical abstracts, stands alone very nicely, as does the treatment of fast reactors, phase separation techniques, and reactor concepts.

A preliminary estimate of the cost of producing purified mercury-204 isotope by the monoisotopic photosensitization process was completed. By use of the very limited technical data on this process and appropriate assumptions a figure of about $50 per pound for a plant producing about 2500 kilograms of Hg-204 per year was obtained. Over seventy percent of this cost related to fixed expenses including operating labor. Cost of mercury, chemicals, losses and utilities (mostly electricity) comprised the remaining thirty percent. Although it appears that high concentrations of Hg-204 may be obtained effectively by the indicated process, the problem of separating the interferring and very high cross section Hg-199 isotope to necessarily extremely low levels is unresolved. It is expected that alternate methods can be developed and that such methods should not greatly change the cost as estimated in this case. Although actual process development may disclose means of reducing the estimated production cost, the most significant reductions can only be achieved by development of equipment and process techniques which greatly increase capacity. However, at the production cost as developed here the conception of specialized reactors may be anticipated to utilize economically this unique material particularly when combined

with bismuth and lead to yield a low melting but vaporizable coolant which may be handled in conventional materials of construction. If these costs can be realized for Hg-204 separation even lower costs should be probable for Hg-202 for which the Hg-199 problem does not exist and which may also find economic applications since its cross section is no greater than many common materials of construction used today in reactors and fuel cladding, namely all of the major components of stainless steel.

2. Application of Alternate Solvent Extraction Technology

Study of alternate solvent extraction process routings which utilize volatile solvents essentially without non-volatile salting agents was initiated. It appears quite certain that in the present Redox Plant feasible routings can be proposed which will result in the elimination of the need for almost all of the present salting agent. The actual economic and practical feasibility of such a process has yet to be developed. Concurrently application of such processes in future facilities along with other advantageous techniques indicated by present technology or by technologies in need of only moderate extension continue to be investigated.

3. Hazards Analysis

The Interagency Committee on the Transportation of Radioactive Materials has prepared a discussion draft of "Technical Standards to be Used as a Basis for Preparation of Regulations for the Safe Transport of Radioactive Materials." At the request of the AEC (one of the agencies represented on the Committee), the draft report was reviewed and comments were provided. The draft report follows quite closely regulations adopted by the International Atomic Energy Agency.

for Manager,
Programming

WK Woods:EAE:dde

RADIATION PROTECTION OPERATION
REPORT FOR THE MONTH OF NOVEMBER 1961

A. ORGANIZATION AND PERSONNEL

Transfers within the Radiation Protection Operation included the assignment of Lyle A. Carter to the Staff of RPO and J. Walt Vanderbeek to Environmental Studies and Evaluation, both effective November 1, 1961. Edna D. Britch was placed on ROF status effective November 30, 1961. The work force now totals 131.

B. ACTIVITIES

Occupational Exposure Experience

There were five cases of plutonium deposition confirmed by bioassay analyses during the month. The total number of plutonium deposition cases that have occurred at Hanford is 277 of which 201 are currently employed. The deposition in each of the five cases confirmed this month was estimated as less than 1 percent of the maximum permissible body burden.

Continued investigation of the 1.3 r dose reported last month for an IPD maintenance employee revealed that his film dosimeter was exposed while not being worn to high dose rates during the removal of a test hole facility and associated stringers from the 105-KW reactor. The film dosimeter was left inadvertently in a desk drawer by the employee's supervisor after being exchanged. During the stringer removal, high dose rates at this location accounted for a large fraction of the radiation dose received by the dosimeter.

Regular processing and evaluation of the film badge dosimeters for an HLO Physical Testing technician and a JA Jones construction worker indicated a dose of 1.1 r for each employee. Investigation revealed that the dose received by the construction employee was received uniformly over the four-week period while working in a 100-K effluent basin. Investigation failed to provide a satisfactory explanation for the exposure of the HLO technician. Including these two cases, nine individuals in 1961 have received gamma doses exceeding the operational control which limits the whole body penetrating dose to one rem in a four-week period.

Regular processing and evaluation of the finger ring film dosimeter for a CPD maintenance employee at the 234-5 Building indicated a hand dose of about 9.5 r for a four-week period. No explanation was determined for the exposure through the investigation. Evaluation of the film badge dosimeter for the corresponding period showed a penetrating dose of 0.3 r, indicating no abnormal whole body exposure. Based on the finger ring film dosimeter system, the accumulated hand dose for the calendar year through 10/6/61 was about 17.6 r.

1250581

Autoradiographic examination of a contaminated coverall worn by a Purex process operator indicated a dose rate of about 70 rads/hour to a small area of the ankle. The examination provided an estimated dose of 50 rads to about one square inch of skin area, based on the maximum estimated time of exposure.

A CPD process operator received a slight cut on his hand as he was removing a broken bell jar from a hood in the 234-5 Building. Examination of the injury in the Whole Body Counter indicated only about 2×10^{-4} μc Pu present at the wound site. No medical action was required.

Plutonium floor contamination to 80,000 d/m was detected while four CPD maintenance men and an HLO technician were dismantling equipment in the 231 Building. Personnel surveys, including nasal smears, showed no skin contamination, but analyses of spot urine samples from two of the maintenance employees indicated that minor deposition may have occurred. Additional samples for bioassay were requested from the five employees.

A personal survey of a CPD process operator revealed facial contamination to 3000 c/m with nasal smears of about 1000 c/m after working in the Purex hot shop. Examination in the Whole Body Counter showed 3×10^{-2} μc $Zr\text{-}Nb^{95}$ and 3×10^{-2} μc $Ru^{103-106}$. These measured quantities represent only a fraction of one percent of the permissible body burdens.

Radiological problems associated with the control of particulate contamination were introduced at PRTR coincident with the removal of a primary pump. Particles showing dose rates to 1.5 rads/hour were found in several locations throughout the containment vessel. Air contamination problems decreased during recent operating periods allowing considerable access to B cell by construction forces without the need of respiratory protection. The maximum airborne concentration of noble gas daughters in the process cell was 2×10^{-5} μc/cc. Shutdown maintenance was performed in dose rates up to 35 r/hour for process tube inspection and 25 rads/hour for nozzel cap regasketing. Metallic fines detected after a charge-discharge operation showed a dose rate of 100 r/hour at one inch. Bioassay samples of PRTR personnel revealed a maximum of 11.2 μc T/liter, which corresponds to a whole body exposure of 75 mrem in the following 28 days. Tritium concentrations in the moderator, reflector and primary systems were 288, 245, and 47 μc T/ml, respectively.

The daily feeding of 3.1 millicuries of strontium-90 to three swine was closely followed at the Experimental Animal Farm. Dose rates on fecal material varied from 0.5 rad/hour to 1 rad/hour. Air samples taken during normal feeding and care of the animals were negative. A positive air sample of 5.0×10^{-9} μc/cc Sr^{90} was obtained during cleaning of the pens. Assault masks were required during clean-up and bleeding operations.

Environmental Experience

The highest concentration of filterable beta emitters measured locally in air since the resumption of weapons testing occurred on November 13-14, and was 110 μμc/m^3. Subsequent measurements were in the range of 5 to 10 μμc per cubic meter which is comparable with values throughout the Northwest and about 100 times the pretest level.

1250582

A total of 64 fish were sampled from the Columbia River at Priest Rapids, Hanford, Ringold, and Burbank. Seventy-four tissue samples from these fish were submitted to the laboratory for radiochemical analysis. Sixty-two tissue samples from thirty-one ducks taken at selected locations on the Hanford Reservation were submitted to the laboratory for radiochemical analysis. Thirteen hundred and thirty-four duck and goose heads were received from various locations in southeastern Washington, the Yakima Valley, Oregon and California. The total number received and submitted for radiochemical analysis to date is 2056. This program is being carried out jointly with the Radioecology Operation.

No routine background aerial survey flights were made during the month.

Information concerning the future use of Columbia River water by the City of Richland was provided to AEC-HOO. Recent analytical results were reviewed and the prediction made that the concentration of "total beta" at the Richland intake would be about 160 percent of that at Pasco.

The limited capacity of the 307 retention basins, which intercept low level waste from several of the HLO buildings prior to release to leaching trenches, necessitated expedient trucking of some 40,000 gallons of off-standard waste to the 200 West crib. Administrative practices for the operation of the 307 retention basins were reviewed. An outgrowth of this was the improvement of sampling and release practices, which should reduce the chances of off-standard effluent overflowing to the leaching trenches. Further study of the 300 Area liquid waste system points up the substantial added burden on the 340 "crib waste" system which will result from the operation of the PRTR's Rupture Test Facility.

Studies and Improvements

Preparation of material for the Manual of Emergency Procedures continued. A rough draft of a new emergency plan to cover events involving gross personnel contamination was completed. Seven additional emergency monitoring kits were completed and distributed to field locations with instructions to Radiation Monitoring personnel.

Practice sessions for high level dose evaluation were conducted during the month. A threshold criticality dosimeter was irradiated with both 2 Mev neutrons and 1.25 Mev gamma rays. Both the neutron dose and the gamma ray dose were predetermined with a double moderator neutron dosimeter and a Victoreen "r" meter, respectively. The dose evaluation of the foils was to within 15 percent of the predetermined value and the dose evaluation of the glass rods was to within 10 percent of the predetermined value. No major difficulties were encountered; however, several minor changes and additions necessary for a complete procedures manual were revealed.

Partial shipment of the new Hanford Moderator Foil Neutron Criticality Dosimeters was received. These are being readied for placement in fixed locations throughout the Plant.

1250583

A new temporary badge coding machine was put into routine service. This machine X-rays the payroll number in binary code on the film. Not only does the machine allow the temporary badges to be read on the automatic densitometer but also this coder is much faster than the old perfograph.

The design for the new Hanford personnel film dosimeter was completed and met with the approval of Plant management. A requisition for the new dosimeter was prepared and forwarded to purchasing. The plan to place these dosimeters into routine use is on schedule.

A study of the performance and calibration of rubber finger ring dosimeters with aluminum and with plastic disc film retainers was completed. New plastic disc film retainers were procured and readied for use in the finger dosimeter program. Calibration studies with plutonium metal at the 234-5 Building were completed.

Work started last month to provide necessary remodeling of the mechanical parts of the automatic densitometer was completed. The 100 F Area personnel dosimeters were converted to new payroll identification tapes. The film dosimeters from this area were processed for experimental purposes on the automatic densitometer. Nearly 500 films from this run were processed by the automatic densitometer. Of these, 24 were incorrectly processed by the machine. An examination of the 24 films indicated that only three of these were the direct result of malfunction of the automatic densitometer. A set of automatic densitometer checkout films was designed and exposed. The processing of this set of films will promptly detect any abnormal operation of the densitometer.

Preliminary study of the energy dependency properties of the current Hanford personnel neutron dosimeter were undertaken. Wide disagreement is apparent between Hanford studies and other authorities. Positive ion accelerator time was scheduled to study the NTA film response in the energy range from about 0.5 Mev to 10 Mev.

Neutron dose rates from spontaneous fission of Pu^{240} contained in production plutonium were calculated for certain work areas in and around the storage hoods of the 234-5 Building. The calculated neutron dose rates and those measured with the double moderator instrument were in complete agreement. Calculations and experimental measurements are in progress to develop recommendations to provide improved neutron shielding for the storage hoods.

Comment drafts on consequences of accidental releases of radioactive materials from CPD facilities and NPR were completed. Of special interest in the CPD analysis is that the "worst conceivable accident" would be one involving the shipping cask loaded with Cs^{137} or Sr^{90}. In the NPR case, one of the worst potential modes of exposure could be through the overflow of water from the fog spray system eventually discharged to the river.

The new BF_3 double moderator instrument and moderator performance for monoenergetic neutrons with energies of 1.1, 0.82, 0.64, and 0.36 Mev were studied. The response over this energy region was in good agreement with the published

1250584

data by Radiological Physics for the larger double moderator system. This study has provided the information necessary to select the geometry and size of the double moderator of the BF_3 neutron monitoring instrument.

Work in progress with equations describing dose from reactor accidents indicates that the whole body dose which would result from inhalation during cloud passage is about equally divided between halogens, volatile solids, and non-volatile solids.

Facilities for heating the main intake sampling line and portions of the continuous monitoring system at Redox were installed during the month. A reduction of condensate in the sampling systems was noted following installation of the new heating equipment.

A work order was issued during the month to Technical Shops for fabrication of new stack sampling equipment for the Hot Semiworks. It is expected that this new equipment will result in higher sampling efficiency, improved sensitivity, and easier maintenance.

Temperatures of river water recorded at the Automatic Columbia River Monitoring Station were found to differ substantially from the actual temperature of the water in the river. The temperature recorder was relocated to sense the temperature at the PRTR intake which should be more representative.

The PRTR moving tape continuous stack monitor was set up to sample outside air. The radioactivity concentration peaks observed during periods of high fallout activity corresponded favorably with the activity peaks reported by Environmental Studies and Evaluation. The instrument operated continuously without electrical or mechanical failures during the month. Calibration of the instrument was initiated. A single channel analyzer and NaI crystal for monitoring I^{131} in the PRTR stack was assembled and operated on an experimental basis throughout the month. A few faulty components were replaced requiring recalibration of the instrument. Calibration sources of Ba^{133} and I^{131} were ordered to complete the calibration of this component.

Radiographic pictures taken with the pinhole camera at 271-CR Building were found to be underexposed. Further study indicated that the dose rate to the film can be reduced by a factor as high as 4000 when large area radioactive sources are considered. A method for calculating the exposure to any one spot on the film based on the exposure geometry and the CP reading at the camera position was formulated. An experimental exposure of an instrument access port at the PRTR is in progress to verify the dose rate calculation procedure.

C. VISITORS AND VISITS

The following visitors met with various members of the Radiation Protection Staff during the month:

M. A. Collison)
S. L. Rice) - General Services Administration, Yakima, Washington

1250585

Members of the Radiation Protection Operation visiting off-site during the month included:

R. D. Tillson - University of Washington, Seattle, technical recruiting.

A. R. Keene - Sandia Base, Albuquerque, New Mexico, to attend Nuclear Weapons Medical Symposium.

D. RELATIONS

Seven suggestions were submitted by the personnel of the Radiation Protection Operation during the month; thus, the total submitted in 1961 is fifty-one. Two suggestions were adopted and one was rejected. Sixteen suggestions submitted by RPO personnel are pending evaluation.

There were five medical treatment injuries during the month. No security violations occurred during the month of November.

Radiation protection orientation included lectures to: Graphics Operation, Fuels Development Operation, Purchasing and Stores Operation, Chemical Analysis Operation, Maintenance and Equipment Engineering Operation, and various new employees.

Marked improvement in safety and housekeeping standards throughout the Radiation Protection Operation has been noted. Safety meetings were held throughout the various Subsections during the month; two movies were shown, "As Others See Us" and "It Could Happen to You".

E. SIGNIFICANT REPORTS

HW-71678 - "Summary of Radiological Data for the Month of October, 1961" by R. F. Foster.

HW-71893 - "Monthly Report - November, 1961, Radiation Monitoring Operation" by A. J. Stevens.

"A Method of Linearizing Thermistor Thermometer Data in Calorimetry" by H. V. Larson, I. T. Myers and W. H. LeBlac was published in the Journal of Scientific Instruments, 38, p.400 (1961).

1250586

PERSONNEL DOSIMETRY AND RADIOLOGICAL RECORDS

External Exposures Above Permissible Limits

	Nov.	1961 to Date
Whole Body Penetrating	0	0
Whole Body Skin	0	1
Extremity	0	0

Hanford Pocket Dosimeters

Dosimeters Processed	3,560	43,280
Paired Results - 100-280 mr	16	422
Paired Results - Over 280 mr	1	21
Lost Results	0	0

Hanford Beta-Gamma Film Badge Dosimeters

Film Processed	20,994	123,457
Results - 100-300 mrads	2,199	11,721
Results - 300-500 mrads	392	1,685
Results - Over 500 mrads	62	299
Lost Results	80	387
Average Dose Per Film Packet - mrad (ow)	9.74	8.70
- mr (s)	28.76	23.72

Hanford Neutron Film Badge Dosimeters

Slow Neutron

Film Processed	3,677	18,440
Results - 50 - 100 mrem	0	1
Results - 100-300 mrem	0	0
Results - Over 300 mrem	0	0
Lost Results	20	96

Fast Neutron

Film Processed	1,086	4,874
Results - 50-100 mrem	89	460
Results - 100-300 mrem	129	253
Results - Over 300 mrem	0	0
Lost Results	20	96

Hand Checks

Checks Taken - Alpha	33,900	364,374
- Beta-gamma	40,776	520,956

Skin Contamination

Plutonium	29	334
Fission Products	21	487
Uranium	1	47
Tritium	0	20

Whole Body Counter	Male	Female	Nov.	1961 to Date
GE Employees				
Routine	38	5	43	607
Special	2	0	2	61
Terminal	10	4	14	111
Non-routine	18	5	23	93
Non-employees	3	1	4	74
Pre-employment	0	0	0	38
	71	15	86	984

Bioassay

Confirmed Plutonium Deposition Cases	5	13*
Plutonium - Samples Assayed	305	5,349
- Results Above 2.2×10^{-8} µcPu/Sample	3	128
Fission Products - Samples Assayed	285	5,865
- Results Above 3.1×10^{-5} µcFP/Sample	4	18
Uranium - Samples Assayed	259	2,624
Biological - Samples Assayed	0	196

Uranium Analyses

	Following Exposure Units of 10^{-9} µc U/cc			Following Period of No. Exposure Units of 10^{-9} µc U/cc		
Sample Description	Maximum	Average	Number Samples	Maximum	Average	Number Samples
Fuels Preparation	8.6	2.5	86	5.8	2.1	83
Fuels Preparation**	0	0	0	0	0	0
Hanford Laboratories	7.9	2.5	42	7.2	2.4	41
Hanford Laboratories**	0	0	0	0	0	0
Chemical Processing ..	1.8	1.8	1	3.7	2.3	4
Chemical Processing**	0	0	0	0	0	0
Special Incidents ..	1.7	1.7	2	0	0	0
Random	0	0	0	0	0	0

Tritium Samples	Maximum	Minimum	Count	Nov. Total
Urine Samples				
Routine	4.9 µc/l	<1.0 µc/l	95	
Samples Above 5.0 µc/l	11.2 µc/l	5.0 µc/l	15	
				110
D_2O Samples				
Moderator	288.43 µc/ml	286.5 µc/ml	4	
Primary	46.8 µc/ml	44.5 µc/ml	4	
Reflector	245.4 µc/ml	224. µc/ml	4	
				12
Water Samples	2.25 µc/ml		207	207
				329

* The total number of plutonium deposition cases which have occurred at Hanford is now 277, of which 201 are currently employed.

** Samples taken prior to and after a specific job during work week.

1250588

Calibrations

	Number of Units Calibrated	
	Nov.	1961 to Date
Portable Instruments		
CP Meter	1,020	10,193
Juno	239	2,709
GM	514	5,786
Other	171	1,838
Audits	110	1,147
	2,054	21,673
Personnel Meters		
Badge Film	1,334	15,143
Pencils	0	7,174
Other	234	3,684
	1,568	26,001
Miscellaneous Special Services	437	9,224
Total Number of Calibrations	4,059	56,898

Manager,
RADIATION PROTECTION

AR Keene:ljw

1250589

GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 2.93 for the month and 2.92 for the year-to-date.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 17,104 hours. This includes 12,952 hours performed in the Technical Shops, 3,879 hours assigned to Minor Construction, 16 hours assigned to other project shops and 257 hours assigned to off-site vendors. Total shop backlog is 19,141 hours, of which 60 per cent is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 6.1 per cent (1,286 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	2,154	12.60%
Irradiation Processing Department	1,432	8.37%
Chemical Processing Department	957	5.60%
Hanford Laboratories Operation	12,540	73.31%
Construction Engineering & Utilities	21	.12%

Requests for emergency service increased requiring a 6.1 per cent overtime ratio compared to a 4.8 per cent ratio for the previous period. The majority of the increase was required in the preparation of N.P.R. pipe samples for metallographic examination.

At the close of the reporting period, there were five open requisitions for Machinists. Qualified candidates have been interviewed and are in process.

There were seven medical treatment injuries which is within the forecasted parameters established for this Operation.

CONSTRUCTION OPERATION

There were 84 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $158,640. One hundred and fifty one new orders, 6 supplements and adjustments for underruns amounted to $87,732. Expenditures during the month on HLO work were $92,524. Total J. A. Jones backlog at month's end was $153,848.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	83	$ 157,186	1	$ 1,454
Issued during the month (Inc.Sup. & Adj.)	157	87,732		1,017
J.A. Jones Expenditures during month (Inc. C.O. Costs)		92,524		
Balance at month's end	75	151,377	1	2,471
Orders closed during month	159	Face Value - $ 87,693		

Current Maintenance Work Orders - 5 Face Value - $12,025

FACILITIES ENGINEERING OPERATION

Project Activity

At month's end Facilities Engineering Operation was responsible for 13 projects having total authorized funds in the amount of $2,793,600. The total estimated cost of these projects is $7,607,000. Expenditures on these projects through October 31, 1961 were $652,000.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end	13
Number of new projects authorized in November	0
Projects completed in November CAH-914, Rattlesnake Springs Radioecology Facility CAH-896, Stress Rupture Test Facility	2
New project proposals submitted to AEC in November	0
New projects awaiting AEC approval: CAH-917 - Field Service Center CAH-932 - 300 Area Retention Waste Expansion System	2

Project proposals complete or nearing completion are as follows:
Modifications to the H-1 Loop - 105-H Building
CAH-949 - Critical Mass Lab. - Stage II
AC Column Facility

1250591

Engineering Services

Title	Status
Pressure Vessel and Piping Systems - Engineering & Inspection Service	Gas Loop - Completed Code review and record manual. Rupture Loop - Started code review. Progress depends on completion of various branches by Contractor. Breakaway Corrosion Loop - Complete code review and witness hydrostatic test. Manual completed and issued. Propane piping - 329 building. Specifications for valves, flanges and piping completed. Awaiting draftsman to sketch up piping arrangement. Irradiation Studies Loop - Reviewed and calculated new test section and end closure arrangement.
"Split-Half" Machine for Critical Mass Studies	Design is complete and fabrication will be complete the end of January.
HLO Electrical & Signal Systems	Buildings are routinely metered and records maintained. A lighting level survey is complete in all buildings. Signal systems are being standardized and all systems including criticality annunciator will be centrally monitored.
Monorail Trolley - 326 Building	New insulated electrical conductors will be completed next month.
Power Transfer Switch - 306 Bldg.	A new switch is being installed for transferring electrical loads during emergency power periods. Work is in progress.
Rezoning of "B" System - 325 Bldg.	Work completed.
Room Air Conditioner - Room 21-A 326 Building	Equipment is on order. Duct work has been fabricated.
Room Air Conditioner - Room 10A & 12A, 326 Building	Bids for equipment were received.

1250592

Drafting and Design Services

The work load in the 3706 Building drafting room and in 327, 306, 308, and 1707-D Buildings is steady with no overtime required.

The equivalent of 135 design drawings were completed this month as compared to 163 last month.

Major design and drafting work in progress during the month includes the following:

1. Ultrasonic Development Tank - 13 drawings required - work completed.
2. Fission Product Packaging Equipment - 43 drawings issued for comment.
3. Shim Rod Drive Mechanism - PRTR - 10 drawings required - 50% complete.
4. Tensile Test Holder and Capsule - 4 drawings required - work complete.
5. Hood for Furnace - 5 drawings required - 80% complete.
6. Single Channel Analyzer Wiring Diagram - 14 drawings completed.
7. TF-23 Test Loop - 10 drawings required - 25% complete.
8. Transistorized Scintillation Monitor - 6 drawings - 20% complete.

In addition to the above, approximately 90 minor design jobs of one to two sheet magnitude are being completed during the month.

Plant Maintenance Operation

Ocotober costs were $177,951. FY costs to date are 103% of forecast.

Analysis of Costs

It now appears that there will be essentially no improvement work the last quarter of the year. This month the total expenditures exceed the forecast by almost $27,000.

Analysis of Improvement Maintenance

Item	October
Relocation and Alterations	$ 12,656
Repainting	5,337
Heat & Vent Modifications	6,391
Crane	(570)
Piping Modifications	635
Electrical Modifications	180
Total	$ 24,629

Significant Activities

1. Painting

   a. The interior of 3730 Building was completed.
   b. Laboratory #317 in 325 Building was painted.
   c. The lunchroom of 231-Z was painted.

2. Significant Space Modifications

   a. The reinstallation of laboratory apparatus moved from 234-5 to 231-Z was completed.
   b. The relocation of TC-1 was started.
   c. The test pit in the basement of 325 Building was essentially completed.
   d. The installation of the women's room and the modification of the men's locker room in 327 Building was essentially completed.
   e. Conversion of the ventilation of the arc melt furnace room in 306 Building to forced exhaust was begun.

Waste Disposal and Decontamination Service

Quantities of Waste Removed	October	September
Concrete Barrels	12	24
Loadluggers-Hot Waste	4	3
Milk Pails	32	25
Gattling Gun	0	1
Crib Waste	245,000 gal.	190,000 gal.

The efforts to reduce the volume were not as successful as in September. The quantity increased 55,000 gallons. Continued effort will be made to control the flow volume. This may result in an economical method of volume control procedure.

Report - "An Analysis of 300 Area Waste Disposal Systems" - by P.F.X. Dunnigan and C. F. Gabel was issued 11-15-61, Document No. HW-71599.

On November 8, 1961, a retention basin analysis revealed that the total beta concentration was significantly above allowable disposal limits. About 60,000 gallons of the basin waste was pumped to the crib system to provide holding capacity for incoming waste. Subsequent analyses of later samples indicated no appreciable quantities of strontium or other low maximum permissible concentration isotopes. The basin was drained.

The study of revisions to the decontamination and high level waste disposal facilities continues.

The new 300-North area disposal garden has been staked out and a work review has indicated that construction forces should excavate the trench, build the access road and erect a fence. A construction estimate is being obtained.

The old 300-North burial ground temporary trench has been put into service. As soon as the new garden is built, the old one will be abandoned except for milk pail burial and for disposal of beryllium waste.

A layout of the old 300-North burial ground has been made for permanent demarcation in accordance with RPS and Hanford Standards. It is planned that this work be combined with burial ground demarcing which will be lump sum contracted by FPD.

Plant Engineering and Miscellaneous

Approximately 18,900 square feet of prints were reproduced during the month.

The total estimated value of the eleven requisitions issued during the month was $37,000. This procurement is primarily for approved HL projects.

Plans are in progress to improve the compressed air service in 209-E Building. Procurement and installation of a new separate compressor will be required.

A design is in progress to provide a constant proportional sampler system for the 307 influent line. Estimates for installation are being prepared. Also preliminary design of automatic valve application to 307 lines is being prepared.

A work order has been issued to place a water proof protective floor coating to the floor surface of the air-conditioning unit in 328 Building.

Disassembly of the hydrogen sintering furnace in the 325 Building for removal to excess storage is in progress.

The design of the central criticality alarm system has been redone to use the existing telephone pairs from seven of the buildings involved and to provide telephone signal pair drops to the other four buildings. A new cable will be required between the telephone exchange and Patrol Heatquarters. A plant forces work review will be submitted the week of 12-4-61 for a work determination as a result of the re-design, since a previous review covered new line work from all buildings involved.

A work order has been issued to CE&UO Design for study of the possibilities of using the intercommunication system in the 309 Building for criticality civil, defense, and fire alarm, since that building now does not meet the plant standards.

Standardization of fire and civil defense alarm systems has now been completed in 305-B, 306, 314, 321, 321-A, 325, 326, 327 & 328 and work is in progress in 329.

Manager
Laboratory Auxiliaries

JL Boyd:jw

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71921

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CAH-822	Pressurized Gas Cooled Facility	4141 Operat

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO 11-12-61	$
$ 1,120,000	CONST. $ 1,080,000	GE $ 1,120,000	ESTIMATED TOTAL COST	$ 1,120,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	8-19-59	2-3-61	DESIGN	4-29-60
CONST.	10-17-60	DIR. COMP. DATE 9-30-61	CONST.	5-1-62

ENGINEER

REDO - DP Schively

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	100	100
TITLE I	100	100	100
GE-TIT. II			
AE-TIT. II			
CONST.	100	100	93
PF			
CPFF	17	100	91
FP	7	100	100
Govt. Eq.	76	100	92

SCOPE, PURPOSE, STATUS & PROGRESS

A project proposal revision has been submitted which requests an increase of authorized funds of $50,000 and extension of the project completion date to 6-30-62 to accomplish replacement of the NaK heater.

PROJ. NO.	TITLE	FUNDING
CAH-842	Critical Reactivity Measuring Facility	58-e-15

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO 11-12-61	$ 178,624 (E)
$ 360,000	CONST. $ 315,000	GE $ 212,000	ESTIMATED TOTAL COST	$ 400,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	11-17-59		DESIGN	2-1-61
CONST.	10-3-60	DIR. COMP. DATE 8-15-61	CONST	12-30-61

ENGINEER

REDO - WS Kelly

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	100	100
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	100	92
PF			
CPFF *	57	100	86
FP	43	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

The revised project proposal requesting additional funds and an extension of the scheduled completion date has not yet been acted upon by the AEC. A new schedule will be submitted when it is approved.

*Includes equipment to be installed by CPFF. Plating difficulties have delayed completion of the safety and control rods.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71921

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CGH-857	Physical & Mechanical Properties Testing Cell - 327 Bldg.	0290

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	ESTIMATED TOTAL COST
$ 460,000	57,000	403,000		460,000	11-12-61 $ 49,401	$ 460,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	11-2-59	9-22-61	DESIGN	3-15-61
CONST.	5-15-62	DIR. COMP. DATE 12-15-62	CONST.	12-15-62

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		573
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in the 327 Building.

The bid reviews for viewing plugs, windows and other plugs have been made. Both low bids were under the estimated cost. Solid and service plugs were bid at $17,000 vs $27,000 estimate.

Redesign work associated with remaining purchase requisitions is progressing, utilizing information recently obtained on a vist to prospective vendors by the contact engineer.

PROJ. NO.	TITLE	FUNDING
CGH-858	High Level Utility Cell - 327 Building	0290

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	ESTIMATED TOTAL COST
$ 400,000	50,000	350,000		400,000	11-12-61 $ 323,050	$ 400,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	11-1-59	4-6-61	DESIGN	2-15-61
CONST.	5-15-61	DIR. COMP. DATE 2-28-62	CONST.	2-28-62

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		140
PLANT FORCES		
ARCHITECT - ENGINEER		35
DESIGN ENGINEERING OPERATION		716
GE FIELD ENGINEERING		6

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	95	100	100
AE-TIT. II			
Vendor	5	100	100
CONST.	100	27	13
PF			
CPFF	100	27	13
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to prepare specimens from irradiated materials for use in determining their physical and mechanical properties and involves the installation of a cell in 327 Building.

Cell assembly vendor visited Richland the week of November 20th. Qualified delivery date of this order now appears to be 1-15-62.

Construction start on the next phase is being delayed to correspond with receipt of the cell castings.

1255590

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 7191

DATE 11-30-61

PROJ.NO.	TITLE	FUNDING
CAH-866	Shielded Analytical Laboratory - 325-B Building	61-a-1

AUTHORIZED FUNDS				
$ 700,000	DESIGN $ 60,000 / CONST. $ 640,000	AEC $ 546,500 / GE $ 153,000	COST & COMM. TO 11-12-61	$ 40,045
			ESTIMATED TOTAL COST	$ 700,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	9-5-59	DATE AUTHORIZED 5-31-60	DESIGN	11-14-60
CONST.	6-28-61	DIR. COMP. DATE 6-30-62	CONST.	6-30-62

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	12	971
PLANT FORCES	0	3
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		1

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	1[illegible]
TITLE I			
GE-TIT. II	10	100	1[illegible]
AE-TIT. II	90	100	10
CONST.	100	27	2
PF	3	1	
CPFF	2	0	
FP	95	27	2

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow greater capacity for analytical work involving today's more highly radioactive solutions and consists of adding a shielded laboratory to the 325 Building.

Structural steel is 95% erected, except for monorails. Mechanical and electrical subcontractors are continuing with their work. Mr. M. V. Marrs, of L & F Machine Co. suppliers of all the Meehanite Castings for the contractor visited the site to discuss scheduling and shielding around door frames.

PROJ. NO.	TITLE	FUNDING
CAH-867	Fuel Element Rupture Test Loop	58-e-15

AUTHORIZED FUNDS				
$ 1,500,000	DESIGN $ 130,000 / CONST. $ 1,370,000	AEC $ 770,000 / GE $ 730,000	COST & COMM. TO 10-12-61	$ 512,793
			ESTIMATED TOTAL COST	$ 1,500,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	8-1-60	DATE AUTHORIZED	DESIGN	3-15-61
CONST.	11-2-60	DIR. COMP. DATE 6-30-62	CONST.	6-30-62

ENGINEER

REDO - PC Walkup

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	14	840
COST PLUS FIXED FEE	11	1240
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	1[illegible]
TITLE I			
GE-TIT. II	91	100	1[illegible]
AE-TIT. II	9	100	1[illegible]
CONST.	100	60	5
PF	2	0	
CPFF	57	75	[illegible]
FP (1)	10	100	10
(2)	31	25	1

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Company
(2) Lewis Hopkins Construction Company

1256059

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71921

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-h-1

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO 10-31-61	$
$ 420,000	44,000	400,000		387,617
	CONST. $ 376,000	GE $ 20,000	ESTIMATED TOTAL COST	$ 420,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	8-8-60	DATE AUTHORIZED 9-2-60	DESIGN	3-31-61
CONST.	7-10-61	DIR. COMP. DATE 3-31-62	CONST.	6-15-62

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	8	1120
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	100
TITLE I			
GE-TIT. II	17	NS	100
AE-TIT. II	83	NS	100
CONST.	100	61	42
PF	1	30	30
CPFF			
FP	99	61	42

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides additional space for biological research supporting services, and involves an addition to the 108-F Building.

The four foot thick reinforced concrete floor slab for the equipment room was started at 10:00 A.M. Friday, November 17 and finishing completed at 1:00 AM Saturday, November 18. The 16" diameter stainless steel exhaust line and 2 1/2" steam line from train shed was relocated. Block work was temporarily held up for second floor concrete slab to cure. Block work is now progressing. A considerable part of the electrical roughing in work has been completed.

PROJ. NO.	TITLE	FUNDING
CAH-896	Stress Rupture Test Facility	60-1

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO 11-12-61	$
$ 90,000	7,500	78,500		11,467 (GE)
	CONST. $ 82,500	GE $ 11,500	ESTIMATED TOTAL COST	$ 90,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	7-29-60	DATE AUTHORIZED 3-6-61	DESIGN	12-1-60
CONST.	3-20-61	DIR. COMP. DATE 10-15-61	CONST.	11-3-61

ENGINEER

FEO - H Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		650
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100	100	100
PF	2	100	100
CPFF			
FP	98	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

The sixth accumulator has been shipped, however, there is some question regarding the acceptability of the cap that was shipped with it. This cap had been previously rejected and its status will be clarified when the formal inspection report is received.

Another electric space heater installed in the 330 Building has failed, making a total of three failures out of the four installed. The contractor has contacted the manufacturer to determine the cause of these failures and provide satisfactory replacement.

1250100

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71911

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CGH-902	Uranium Scrap Burning Facility	61-j

AUTHORIZED FUNDS				COST & COMM. TO 11-12-61	$ 5,751 (GE)
$ 36,000	DESIGN $ 5,000	AEC $ 27,500		ESTIMATED TOTAL COST	$ 36,000
	CONST. $ 31,000	GE $ 7,500			

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 5-15-61	DATE AUTHORIZED 12-15-60		DESIGN 7-28-61	
CONST. 9-12-61	DIR. COMP. DATE 12-31-61		CONST 12-31-61	

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		201
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		Through 11-21-61

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	95	75
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a means of making uranium scrap material safer for storage and off-plant shipment by converting this scrap to a stable uranium oxide. The facility will be adjacent to the 333 Building.

Building has been completed and accepted.

Scheduled completion of construction is based on AEC's construction schedule.

PROJ. NO.	TITLE	FUNDING
CAH-914	Rattlesnake Springs Radioecology Facility	61-j

AUTHORIZED FUNDS				COST & COMM. TO 11-12-61	$ 16,760 (GE)
$ 90,000	DESIGN $ 3,400*	AEC $ 71,700		ESTIMATED TOTAL COST	$ 90,000
	CONST. $ 86,600	GE $ 18,300			

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 3-1-61	DATE AUTHORIZED 12-22-60		DESIGN 6-6-61	
CONST. 7-12-61	DIR. COMP. DATE 10-31-61		CONST 11-20-61	

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	7	560
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS*	100
TITLE I			
GE-TIT. II			100
AE-TIT. II	100	NS*	100
CONST.	100	100	100
PF			
CPFF	7	NS	100
FP	93	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow performance of radioecological studies under local environmental conditions. It consists of constructing field facilities for this purpose. Approval signatures for project drawings and specifications were obtained 5-31-61.

*Bovay Engineers. Contractor work started 7-13-61. Initial acceptance of the contractor portion of the work with listed exceptions was done 10-19-61. The contractor AEC, and customer representatives were present.

Final acceptance of the contractor portion of work was made 11-10-61. Installation of G.E. procured instrumentation by the CPFF Contractor is complete. Two items of equipment on order have not arrived. These do not require installation. This project is physically complete and will no longer be reported.

1250601

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71921

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CAH-916	Fuels Recycle Pilot Plant	Funds Avail. to Comm.

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$ 385,000	385,000		11-12-61	103,075
	CONST. $ -0-	GE $ 385,000	ESTIMATED TOTAL COST	$ 5,000,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	3-1-61*	10-27-61	DESIGN	6-15-62
CONST.	9-1-62	DIR. COMP. DATE --	CONST.	7-1-64

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	23	
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	25	22
TITLE I	11	100	100
GE-TIT. II	89	15	15
AE-TIT. II			
CONST.	100	NS	
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

The preliminary key plan which delineates the new building arrangement was approved and will be issued as an addendum to the Design Criteria.

Results of the administration area ventilation study show that a refrigerative type system will be less expensive than an evaporative type system.

Comment sessions have been held to review the architectural and piping schematic prints. An important change was made to the floor plan, reducing the two change rooms to one and centralizing this function at CR&D's request.

PROJ. NO.	TITLE	FUNDING
CAH-917	Field Service Center - Atmospheric Physics	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$				
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 154,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	1-15-62*		DESIGN	5-15-62*
CONST.	7-1-62*	DIR. COMP. DATE	CONST.	3-15-63*

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities necessary to conduct atmospheric physics research and development programs.

*Based on AEC authorization by 12-15-61.

The General Electric Company submitted a letter to the Commission in answer to their request for information on alternate locations. Supplementary information was supplied by the Civilian Reactor Development and Research Division for review and approval.

1250602

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71921

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CAH-919	Air Conditioning - 314 Building	61-j

AUTHORIZED FUNDS				
$ 35,000	DESIGN $ 4,850	AEC $ 30,150	COST & COMM. TO 11-12-61	$ 3,849 (GE)
	CONST. $ 30,150	GE $ 4,850	ESTIMATED TOTAL COST	$ 35,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 5-2-61	DATE AUTHORIZED 3-8-61		DESIGN 6-15-61	
CONST. 6-15-61	DIR. COMP. DATE 9-15-61		CONST. 11-30-61	

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		346
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	100
TITLE I			
GE-TIT. II			
AE-TIT. II		NS	100
CONST.	100	100	99
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

Directive AEC-188, dated March 8, 1961, authorized the project and assigned management to the AEC. Work authority was issued 4-18-61, to the General Electric Company.

J. A. Jones forces started work 10-24-61 on the remaining work to complete the project.

Installation of all units is complete. The AEC has authorized J. A. Jones to install hardware cloth and frame over the cooler air inlets to keep deleterious material from the recirculated water.

PROJ. NO.	TITLE	FUNDING
CAH-921	Geological & Hydrological Wells - FY 61	61-j

AUTHORIZED FUNDS				
$ 79,000	DESIGN $ 1,000	AEC $ 69,500	COST & COMM. TO 10-31-61	$ 62,796
	CONST. $ 78,000	GE $ 9,500	ESTIMATED TOTAL COST	$ 79,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 4-15-61	DATE AUTHORIZED 3-24-61		DESIGN 5-15-61	
CONST. 5-22-61	DIR. COMP. DATE 12-31-61		CONST. 12-31-61	

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	7	888
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	100	92
PF	0		
CPFF	3	100	100
FP	97	100	92

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

Approximately 4,300 feet of hole has been completed. Contractor is working on the 16th and final well.

1250163

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71921

DATE 11-30-61

PROJ.NO.	TITLE	FUNDING
CGH-922	Burst Test Facility for Irradiated Zirconium Tubes	62-k

AUTHORIZED FUNDS				
$ 29,600	DESIGN $ 29,600	AEC $	COST & COMM. TO 11-12-61	$ 29,600
	CONST. $	GE $ 29,600	ESTIMATED TOTAL COST	$ 228,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	11-6-61	DATE AUTHORIZED 10-23-61	DESIGN	5-15-62
CONST.	6-15-62	DIR. COMP. DATE	CONST.	12-1-62

ENGINEER

FEO - H Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	2	2
TITLE I			
GE-TIT. II	30	0	0
AE-TIT. II	70	2	2
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to permit deliberate destructive testing of irradiated zirconium tubing. This will provide operating and tube life data not now available because of the limited operating history of Zircaloy-2 pressure tubing in reactors.

AEC Directive No. AEC-199, dated October 23, 1961 authorizing $29,600 for design has been issued. Work Authority No. CAH-922(1) dated October 25, 1961 was received.

Comment prints of the architectural layout have been submitted by Bovay Engineers. The Design Criteria being prepared by CE&UO is nearing completion in rough draft form for final concurrence by all parties concerned.

PROJ. NO.	TITLE	FUNDING
CAH-924	200 KW Induction Heating System - 306 Building	0290

AUTHORIZED FUNDS				
$ 31,000	DESIGN $ 3,200	AEC $ 24,650	COST & COMM. TO 11-12-61	$ 4,983 (GE)
	CONST. $27,800	GE $ 6,350	ESTIMATED TOTAL COST	$ 31,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	5-1-61	DATE AUTHORIZED 3-27-61	DESIGN	10-15-61
CONST.	10-15-61	DIR. COMP. DATE 2-28-62	CONST.	2-28-62

ENGINEER

FEO - LF Higginson

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		38
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	100
TITLE I			
GE-TIT. II		NS	100
AE-TIT. II			
CONST.	100	NS*	1
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a source of power for induction heating for R&D work in the 306 Building.

The induction heating work stations are now on site. The AEC released funds required by J. A. Jones for installation of work stations and distribution system 11-27-61.

*The AEC is preparing the construction schedule.

1250004

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 719-1

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CAH-927	Additions to the 271-CR Building Waste Treatment Demonstration Facility	61-j

AUTHORIZED FUNDS				
$ 80,000	DESIGN $ 4,000 / CONST. $ 76,000	AEC $ 62,500 / GE $ 17,500	COST & COMM. TO 11-12-61 / ESTIMATED TOTAL COST	$ 10,797 (GE) / $ 80,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 6-15-61	DATE AUTHORIZED 5-16-61		DESIGN 3-1-62	
CONST. 3-15-62	DIR. COMP. DATE 3-31-62*		CONST. 7-1-62	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER - Bovay Engineers		85
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	50
TITLE I			
GE-TIT. II			
AE-TIT. II	100	100	50
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides facilities for pilot plant development of decontamination processes for intermediate level chemical processing plant waste for safe discharge to the plant environs.

*A new directive is being written by HOO-AEC based on project proposal revision 1, which is expected to extend the directive completion date to about 7-1-62.

PROJ. NO.	TITLE	FUNDING
CAE-932	300 Area Retention Waste System Expansion	62-k

AUTHORIZED FUNDS				
$	DESIGN $ / CONST. $	AEC $ / GE $	COST & COMM. TO / ESTIMATED TOTAL COST	$ / $ 70,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 1-15-62	DATE AUTHORIZED		DESIGN 4-1-62*	
CONST. 5-1-62*	DIR. COMP. DATE		CONST. 9-1-62*	

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will increase the basin capacity commensurate with the increased volumes handled. This will permit transfer to crib waste of contaminated waste if required, and still permit adequate sampling time for the normal flow.

The project proposal was submitted to HOO-AEC for authorization on 5-5-61.

The proposal was returned unapproved on September 12, 1961, with a letter suggesting alternate solutions. These were reviewed for feasability and practicability. The project proposal was returned to the Commission for further review and approval.

*Based on AEC authorization by 12-16-61.

1250605

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71921

DATE 11-30-61

PROJ.NO.	TITLE	FUNDING
CAH-936	Coolant Systems Development Laboratory	62-k

AUTHORIZED FUNDS				
$ 93,000	DESIGN $ 12,000	AEC $ 81,000	COST & COMM. TO 11-12-61	$ 13,287
	CONST. $ 81,000	GE $ 12,000	ESTIMATED TOTAL COST	$ 93,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 9-8-61	DATE AUTHORIZED 8-9-61		DESIGN 1-9-62	
CONST. 4-9-62	DIR. COMP. DATE 10-31-62		CONST. 10-31-62	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER - Bovay Engineers		108
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	63	80
TITLE I			
GE-TIT. II			
AE-TIT. II	100	63	80
CONST.	100	NS	NS
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides facilities for the conduct of corrosion and decontamination studies for nuclear reactor coolant systems, by the addition of 2,700 sq. ft. laboratory facility on the west side of the 1706 KE Building.

Completion of design is nearing. Comment review meeting 11-30-61.

1250606

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- [illegible]

DATE 11-30-61

PROJ. NO.	TITLE	FUNDING
CGE-937	Safety Improvements to 231-Z Building	61-3

AUTHORIZED FUNDS				COST & COMM. TO 11-12-61	
$ 45,000	DESIGN $ 5,500	AEC $			$ 39,715
	CONST. $ 39,500	GE $ 45,000		ESTIMATED TOTAL COST	$ 45,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	7-12-61	6-29-61	DESIGN	9-29-61
CONST.	7-10-61	EST. COMP. DATE 5-15-62	CONST	2-1-62

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES	6	302
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	
TITLE I			
GE-TITLE II		NS	100
AE-TITLE II			
CONST.	100	55	50
PF			
CPFF	100	NS	50
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides supplemental ventilation and installation of a fire detection system in the 231-Z Building.

The major pieces of Fire Alarm equipment has not been received. This has prevented further progress on the Fire Alarm system.

The 2 ventilating blowers arrived.

Duct installation is approximately 10% complete.

1250007

TECHNICAL ADMINISTRATION OPERATION

MONTHLY REPORT

PROFESSIONAL PLACEMENT

Advanced Degree - One Ph.D. applicant visited for an employment interview. Two offers were extended, no acceptances occurred, and two rejections were received.

Technical Graduate Program - Six Technical Graduates were placed on permanent assignment and two terminated. One new Technical Graduate was added to the payroll. Current program members total seventy-six.

TECHNICAL INFORMATION

A request was received from the Hanford Operations Office requesting a cessation of referencing, in reports distributed offsite, those documents not publicly available.

Upon request, a review occurred to determine whether any unaccounted for Commission documents existed at HAPO. None were located.

Work Volume Statistics

	October	November
Document Distribution and Files		
Documents routed and discharged (copies)	15,764	18,300
Documents issued (copies)	13,327	18,645
Documents sent offsite (copies)	8,310	9,216
Document reserves filled (copies)	767	656
Documents picked up and delivered	18,038	19,220
Document Accountability		
Holders of classified documents whose files were inventoried	179	255
Documents inventoried in Files (copies)	---	---
Documents destroyed or retired	5,738	4,972
Documents revised (copies)	1,508	1,998
Documents pulled and documents filed (copies)	14,465	14,959
Documents reclassified	54	117
Documents microfilmed	1,182	2,550
Accountable copies of SECRET and DOCUMENTED	198,538	200,340

	October	November
Library Acquisitions and Circulation		
Books ordered (volumes)	345	414
Periodicals ordered	52	1,207
Books circulated (volumes)	1,757	2,275
Periodicals circulated (issues)	3,372	4,586
Inter-Library loans	160	41
Films borrowed or rented	23	23
Industrial film showings	39	107
Bound periodicals added to the collection	80	65
Bound periodicals discarded	22	13

Library Collection

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	32,552	8,721	1,887	2,085	45,245
No. of bound periodicals	15,190	19	1,941	24	17,174
	47,742	8,740	3,828	2,109	62,419

	October	November
Classification and Declassification		
Documents, including drawings and photographs reviewed for downgrading or declassification	38	64
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	34	16
Documents submitted to Declassification Branch, Oak Ridge	3	54

O. E. Boston, Manager
Technical Administration

OEB:lmh

1250609

UNCLASSIFIED

TABLE II. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1961 to November 30, 1961

	Visits to Richland				Offers				
	Cases Considered	No Interest	Invited	Visited	Offered	Rejected	Accepted	Open	On the Roll
PhD	180	57	45	18	15	7	5	3	3
Exp. BS/MS	101	83	3	1	2	1	-	1	-
Prog. BS/MS	95	48	-	-	1	1	-	-	-

B. Technical Recruiting Activity - HL - September 1, 1961 to November 30, 1961

	Visits to Richland				Offers				
	Cases Considered	No Interest	Invited	Visited	Offered	Rejected	Accepted	Open	On the Roll
PhD	180	57	45	18	13	7	4	2	2
Exp. BS/MS	68	54	1	-	-	-	-	-	-

In addition to the above activity, 18 exempt employees have transferred into HL from other HAPO departments and 5 technical graduates have accepted off-program placement in HL to date.

UNCLASSIFIED

1250610

C - Technical Graduate Program
Month ending November 30, 1961

Number Personnel on Assignment	76
(HAPO Tech Grad Program 61	
(Engineering & Science Program 15	

Distribution of Assignments by Departments

IPD	34
HLO	27
CPD	9
FPD	5
C&AO	1
CE&UO	0

Distribution of Assignments by Function

Research & Development or Engineering	58
Other	18

FINANCIAL OPERATION MONTHLY REPORT
NOVEMBER 1961

Personnel

There were no personnel changes in the Financial Operation during the month.

Activities

GENERAL ACCOUNTING OPERATION

Following is the status of approval letters seeking Commission concurrence in proposed actions:

Number	Title	Status
AT-8 Add. 1	Decontamination Coupons for APED	Approved
AT-52	Expanded Use of Whole Body Counter	Still held by Commission
AT-104	Fission Products Dispersal Handbook	In process of being re-written and resubmitted with changes suggested by Commission.
AT-105	Symposium on the Biology of Trans-uranic Elements	Washington AEC still considering.
AT-195	AIBS Medical Education for National Defense Program	Approved 11/22/61.
AT-196	Participation in Standardizing Activities	In hands of Commission.
AT-198	Miniature Swine for Hammersmith Hospital	Held pending further correspondence from England.
AT-205	Sanitary Engineering Advisory Committee-Washington State University	In Process.
AT-206	Delay in Disposition of Residence of Transferred Employee	In Process.

Travel activity in November was considerably above the like month in 1960 in contrast to the trend during the first four months of FY 1962. Total activity, fiscal year to date, however, is still 12% below FY 1961 experience.

Action as indicated occurred on the following projects during the month:

1250612

New Money Authorized HLO

CAH-896	Stress-Rupture Testing Facility	$ 500
CAH-936	Coolant Systems Development Laboratory	15 000

Physical Completion Notices Issued

CGH-923 Spectroscopy Laboratory

Test Reactor and Auxiliaries transferred Title III funds on one project to CE&UO. This transaction concluded HLO's compliance with OPG's 1.6 and 1.12 on all PAC projects not scheduled for completion by January 1, 1962. Nine projects were involved in the transfer with CE&UO issuing work orders to HLO on eight of the projects for Field Engineering on a loaned labor basis.

An Assistance to Hanford authorization was issued to General Engineering Laboratory for research concerning the use of a high power lasser for welding-cutting. The amount of this authorization was $9,800.

A review of HLO's active forms, approximately 600, was initiated to determine the accuracy of existing files preliminary to issuing a revision to the Forms Control Manual.

Action was initiated for the design of fifteen new and revised forms. The request for one new form was satisfied by using an existing form.

A review of all active contracts and agreements was made. The basic need, the scope and relationship between cost and benefits received was critically evaluated for each contract.

The following contracts were processed during the month:

MRO-43	RCA Service Company
DDR-136	Speer Carbon Company
SA-175	Dr. W. E. Welsh
SA-176	Dr. D. R. Marble
SA-177	Dr. W. H. Harris
SA-178	Dr. P. M. Aldrich
SA-181	Dr. L. M. Bodie

New and revised OPGs issued during the month are indicated below:

OPG No.	New	Revised	Title
9.2		X	Procurement of Equipment, Materials, Services, and Supplies
3.8.2		X	Washington State Industrial Insurance and Medical Aid Acts
22.1.12	X		Test Reactor and Auxiliaries Operation Organization

OPG No.	New	Revised	Title
22.1.3		X	Reactor and Fuels Research and Development Operation Organization
7.8		X	Control of Documents Classified Secret and Confidential
55.1.1		X	Weekly Time Cards

Twenty-one AEC Manual Chapter revisions were received in November, details of which were covered in a separate report to Section Managers.

Seven suggestions were received during the month for evaluation. Four were rejected and three were held pending further investigation.

Considerable effort was spent during the month updating records and applying dollars ($699,350) to approximately 300 individual units of property transferred to HLO during October from the University of California Lawrence Radiation Laboratory.

During November Fixed Property valued at $4,219,282 was transferred to CPD in connection with the transfer of custody of the Hot Semiworks. Movable property valued at $158,419 will be transferred to CPD in December.

Seventy-three items valued at $64,331 were received at the Laboratory Pool during the month of November. Thirteen items valued at $2,361 were loaned or transferred in lieu of placement of requisitions and fourteen items valued at $6,171 were withdrawn temporarily by custodians. Graphite valued at $11,000, scheduled for excess, was placed in CPD. There are currently equipment items valued at $453,766 physically located in the Pool of which 195 items valued at $29,309 are uncatalogued type items and 29 items valued at $53,868 are held for the converience of others. Reactor and Other Special Materials on hand at the Pool at month-end totaled $183,717 and materials held for the convenience of others totaled $271,446.

A report of results was issued for the physical inventory of movable catalogued equipment in the custody of Biology Operation. Eight hundred and twenty-eight items valued at $641,729 were physically counted. Analysis of the inventory results and the fact that all items were accounted for indicated excellent control of equipment and the use of proper procedures by the Biology Operation.

Heavy Water losses chargeable to operating cost for the month of November amounted to $45,966.51 representing $1,297.30 scrap material and $44,669.21 BPID loss.

Preliminary unitization work was performed during the month on the following projects and all catalogued equipment was tagged:

CAH-834 189-D Building Heat Transfer Additions
CAH-867 Fuel Element Rupture Test Facility - 309 Bldg.
CAH-896 Stress Rupture Test Facility - 330 Bldg.
CGH-935 Metal Storage Building - 328-B Bldg.

1250614

Unitization reports will be issued on the following CGH projects following receipt of an Accumulative Cost Report and on the CAH projects upon receipts of final billing and reporting from AEC.

CAH-681	Hanford Equipment in the ETR
CAH-870	Facilities for Recovery of Radioactive Materials - 325
CGH-785	In-Reactor Studies Equipment - 105-KW
CGH-907	Strontium-90 Interim Program

The unitization report on Project CAH-747, Plutonium Fabrication Pilot Plant - 308 Bldg., consisting of 165 pages is approximately 85% completed. The report will be issued in December.

COST ACCOUNTING OPERATION

The Hanford Laboratories' control budgets were adjusted for November reporting as follows:

1. Budget recast to provide funds for the newly established Test Reactor and Auxiliaries Operation. This also included reallocation of 04 Program equipment funds.

2. The addition of $800,000 for operation of the Plutonium Recycle Test Reactor as promised by Washington-AEC. Of this amount, $300,000 represents a transfer from the Special Reactor Materials Inventory control balance for June 30, 1962.

A new section in Hanford Laboratories entitled Test Reactor and Auxiliaries Operation was established on November 6, 1961. The section will have the responsibility of operation, maintenance, and engineering connected with the Plutonium Recycle Test Reactor. Fiscal year-to-date costs through October were recast to conform with the new organization. Organization nomenclature and cost codes for the new section are as follows:

7A00	Test Reactor and Auxiliaries Operation
7A10	Plutonium Recycle Test Reactor Operation
7A20	Maintenance Operation
7A21	"A" Shift
7A22	"B" Shift
7A23	"C" Shift
7A24	"D" Shift
7A25	Day Shift
7A30	Maintenance and Equipment Engineering Operation
7A40	Technical Planning Operation

Other changes in cost codes and/or organization titles made during the month were as follows:

7510	PRP Hazards Analysis - cancelled.
7522	Special Studies - cancelled.

1250615

7523	Reactor Technology Development - title changed to Shielding Function
7525	Design Development - title changed to Conceptual Design Function
7526	Hazards Analysis Function - new code and title replacing 7510.
7544	Coatings and Corrosion - title changed to Chemical Metallurgy.

The Hanford Laboratories' cost code booklet was updated during November.

Preparation of all phases of the FY 1962 Midyear Budget Review for Hanford Laboratories was completed during the month and submitted to Contract Accounting for HAPO consolidation.

W Sale:whm
December 11, 1961

1250616

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

PRTR Operation

Production for the month of November totalled 653 MWD for an operating efficiency of 31%. Heavy water loss totalled 3200 pounds despite extensive leak correction efforts. Losses during operation were estimated at about 50 pounds per day. Helium losses continued at high levels. Total loss for the month was approximately 205,000 scf.

There were 9 scrams during the month. Three scrams were from spurious flow monitor trips, three were from operational difficulties, two were from erratic flux monitor instrumentation, and one was planned as part of Power Test No. 6. Significant outage work included removal of the ruptured fuel element in tube 1954, Primary Pump No. 3 seal repair on two occasions, and helium and D_2O leak repairs. Five power tests and a portion of another were completed during the month.

On November 9, an incident occurred which resulted in rapid draining of the pressurizer. The reactor was down and the light water injection circuit by-passed, thereby preventing light water injection. Investigation revealed that the operating primary pump had been vapor locked, causing loss of primary coolant flow. During this time the fuel elements had been covered with water, providing adequate cooling. A separate report has been written on this incident.

Major Equipment Maintenance

Primary Pump No. 3 was removed and overhauled for seal failures on two occasions during the month. For the first time, high radiation readings (20-25 RAD) were encountered which could not be satisfactorily decontaminated in the 309 Bldg. The spare pump in the 314 Building was overhauled, modified for PRTR installation and placed in service. Pump decontamination was performed in CPDs decontamination facility.

The diaphragm, both valves, and the temperature controller were replaced on the north head of low pressure compressor no. 1. A loose part from the suction valve ruptured the diaphragm. An oil leak on this compressor was discovered and repaired later in the month. Cause of the leak was a fault in the head casting.

Valves and diaphragms were replaced on the first stage of high pressure compressor no. 2.

High pressure compressor no. 1 received a major overhaul when a piston ring broke on the first stage cylinder.

Equipment Engineering

Primary Pump No. 2, which was last repaired on July 13, 1961, was operated without flow for an hour or longer on November 9, 1961. This condition occurred following a system depressurization while the pump was on low speed operation. Gas formation was evident in other parts of the primary system requiring the injection pumps to be off most of the time during and following this depressurization. Seal leakage alarms were received on November 24, 1961, during pump operation at low pressure but reset satisfactorily.

Primary Pump No. 3 operated without incident following erratic seal temperatures during the period October 20 to October 23, 1961, until shutdown on October 31, 1961. On November 4, 1961, during startup, the primary seal failed. The spare pump was installed on November 6 and apparently damaged on November 9, 1961, during the initial run-in as shown by a high, erratic, amperage recording. This period was the same as described for Primary Pump No. 2, above. The primary seal failed completely on November 19, 1961, during normal operation. A previous seal failure alarm had reset on November 18 following a scram. The original Primary Pump No. 3 was again installed on November 20, 1961, with a separate gas vent line provided to allow more thorough venting of the primary seal. High motor temperatures and high amperage on pump startup, November 22, 1961, would again indicate some damage to this seal. A total of 12 seal leakage alarms on November 26 and 27 indicates possible trouble with either PP-2 or PP-3 since the alarm lights are too short to identify the pump. Design Change DC-40, Revision 2, "Primary Pump Venting", has been originated to provide separate venting of the primary seal of each pump. Design Change 116 for revising the power connections and conduits of the primary pump was issued for approval.

Design Change DC-53, Revision 3, Boiler Feed Pump Relief, was completed with the installation of Valve, S-51, to prevent complete flow shutoff to the boiler feed pumps.

High pressure compressor no. 1 received a major overhaul when a piston ring broke in the first stage cylinder. Calculations reveal that the head bolts of the high pressure compressor may be yielding during thermal cycles at high pressures. Leak indications around the heads when started cold, while not serious, are approximately three times as great as when hot. New heat bolt material is being considered. Design Change 107, which provides automatic draining of HW-7 condensate to the primary storage tank has been issued.

Design Changes 96 (deaerator level control) and 99 (degasser level control) were completed during the month. Permanently mounted recorder controllers are now provided in the control room for these variables, and new transmitters of a more reliable design have been installed.

Initial work was begun on an in-line gas sampling system for the reactor. The complete system will be described on Design Change 97, soon to be issued. Preliminary work (prior to completion of the entire design change) will permit sampling of the gas feed to the pressurizer by means of a temporary tie-in to the Gas Loop gas chromatograph, and will restore the D_2 analyzer to service.

Design Change 114 (Primary System Low Flow Instrumentation) was issued for approval, and the necessary equipment was placed on order. This change will extend flow measurement in the primary loop into the low flow range where the existing flow transmitter is insensitive. All equipment needed for the change is expected by the middle of December.

Design Change 115 was issued for approval, calling for relocation of the pressurizer level transmitters to a position adjacent to the base of the pressurizer. This change will eliminate long horizontal runs in the sensing lines from the pressurizer, which result in formation of gas bubbles in the sensing lines. In addition, level transmitters of a type less sensitive to changes in static pressure will be installed.

Design Change 109, permanent mounting of the second startup channel, has been written and approved. Design Change 113, permanent panel mounting for the servo-manometer readout, has been written and is awaiting approvals. Design Change 103, permanent mounting for the moderator T/C recorder, was written and approved.

An apparent failure of effluent activity Keithley Channel A has been resolved into two separate problems. The failure of the inverters for both Channels A and B comprised the first problem, with the second being that the calibration source for "A" Channel was moved back away from the chamber.

It was previously reported that the failed UO_2 fuel element in process tube 1954 gave a failure signal using the gas activity rupture monitor both during activity bursts after a startup and then continuously after a period at power. Further confirmation of this was obtained during the subsequent period of operation before the failed element was removed. After removal of the 1954 element, gaseous activity levels were reduced by one-third to one-half those previously experienced for comparable operating periods. The reduction of the activity levels after the failed fuel element's removal indicate that, if any other failed elements are present, their combined effect is less than that of the 1954 failure. After the failed element in tube 1954 was removed, the rupture monitor was set up to monitor the thermocouple fuel element in process tube 1550, two experimental fuel elements in process tubes 1051 and 1954, and the fuel element in process tube 1857 which gave somewhat ambiguous results by the stagnant water sampling technique. No rupture indication was received on any of these channels during subsequent operation. These channels were still being monitored at month end. Operating instructions for the demonstration gas separation system were written.

Specifications for the flow monitor system ground detector and DC system low voltage detector were re-written in functional specification form to obtain competitive bidding on these units. Delivery on these items is expected to be 60 to 90 days after the orders are placed.

Training classes for Operation's personnel continued during the month. Classes on the light water injection system and the automatic controller were conducted for all shifts.

Technical Planning and Process Engineering

The fourth reactor fueling was planned and charged at the beginning of the month. Three additional UO_2 elements were exchanged for plutonium, bringing the core inventory to 39 Pu-Al and 46 UO_2. Three experimental UO_2 elements were charged at this time. These consisted of a nested tubular element, described in PRTR Test No. 5 and two 19 rod clusters, one vibrationally compacted and one hot swaged, described in PRTR Test No. 10.

Irradiation during the month brough the total energy generated to approximately 3600 MWD and the maximum tube exposure to about 50 MWD. This is equivalent to 1013 MWD/T for the uranium and 30 percent burnup for plutonium. The plutonium fueling is being planned to approach a linearly graded burnup to about 50 percent of initial heat output.

The moderator pump failure and helium gas flow over the calandria weir portions of Power Test No. 6 (Planned Malfunctions) were performed during the month. The moderator pump failure test revealed that sufficient time is available to start the spare pump and return the moderator flow to normal without having to shut down the reactor. Raising the moderator level to the top overflow slots induced

helium gas flow over the calandria weir and caused a reactor shutdown due to a reactor period scram. The results of this test showed that sufficient protection is available to shut down the reactor in the event of gas flow over the weir.

The thermocoupled fuel element was re-charged into the reactor under Power Test No. 15 (Thermocoupled Fuel Element) for operation at reactor power levels up to 70 MW. Maximum fuel temperatures recorded were about 1000° C. At month end only three of the six thermocouples had failed. Data obtained during the reactor operating period are being analyzed by members of the Ceramic Fuels Development Operation. The element is scheduled for discharge during the next scheduled reactor outage.

All the data necessary for Power Test No. 10 (Moderator Flow and Temperature) and Power Test No. 9 (Heat Transfer Coefficients--HX-1, 2, 3, 4 and 5) were obtained during the month. Data from these tests is being analyzed.

Data were obtained for Power Test No. 14 (Power Decay) and the remainder of Power Test No. 11 (Photoneutron Flux) at the beginning of the scheduled outage. The only data not obtained was a trace of the "spike" in the observed flux upon scram. It is believed that the high resistances used to prevent loading down the log channels were responsible.

Major revisions of the PRTR Operating Standards were begun. It is anticipated that the revised operating standards will be issued in early January. The first audit of reactor operation to insure that conditions were within the operating standards was completed and a report issued.

PRTR Test No. 3 (Secondary Coolant Water Quality During Outages) was performed. The data obtained is being used to review the Secondary Coolant Quality Operating Standard.

A conceptual evaluation of new experimental equipment for PRTR research and development programs was completed. The estimated cost is on the order of $50,000.

Approximately 60 percent of the final draft of a document presenting all PRTR Critical Test results has been completed. The document is designed to present as much detailed test data as is feasible to provide a single reference for subsequent analysis.

Participation in Critical Facility startup planning was continued. Weekly planning meetings have been held to discuss test descriptions, standards and other problems. Three physics test descriptions have been completed as well as a tentative list of operating standards. Development of an operator's qualification test for the facility was initiated.

Some additional calculations were performed to provide hazards and design data for the Critical Facility. These consisted of analyses of reflector effects, fuel element worth and void effects.

Project Management and Design

PRTR. Performance of fuel element examination facility Design Tests continued during the month. The air balance portion of the test has been completed. Repairs were made to the manipulator and profilometer 5X viewer controls. An

elusive DC ground was located and repaired. A dummy element was successfully placed in the facility and removed using the PRTR charge-discharge machine. Further tests of the wide-angle viewer indicated some minor modifications which would improve the quality of the image. These modifications have been initiated. The installation of the fuel element temperature monitor has been started.

Plutonium Recycle Critical Facility (Project CAH-842). The total project as presently scoped is now 92% complete. The CPFF contractor has completed his phase of the installation work with minor exceptions which are being corrected.

Difficulties in applying a suitable cadmium plating to the control and safety rods have delayed completion of these items. The vendor feels that the problem has now been corrected.

The project proposal revision requesting additional funds of $40,000 and an extension of time to complete the modifications requested by the Technological Hazards Council has been approved by Wash.-AEC. Total funds authorized and the directive completion date are $400,000 and March 15, 1962, respectively.

Fuel Rupture Test Facility (Project CAH-867). A design criteria addendum to include a second rupture monitor sampling system and a basin cleanup facility has been prepared and is being routed for approval.

Overall construction is estimated at 54% complete as compared to 60% scheduled. The CPFF work (equipment installation) is estimated at 69% complete compared to 75% scheduled. Low air activity permitted unlimited access to "B" Cell during the month. Good progress was made on the "B" Cell portion of the work. Construction of the Water Treatment Plant and Hold-Up Tank RLT-2 is estimated to be 15% complete versus a scheduled 15% complete as of November 30, 1961. The filter plant clearwell concreting is complete. The contractor is forming and placing re-steel for pump room walls and filters. The base slab for the filters of the sedimentation basins has been poured. Backfilling around clearwell and under sedimentation basins is essentially complete. The 10" and 12" filtered water line is completed except for tie-in near the condenser facility. This tie-in will be made when the filter plant is ready to produce water. Tie-in is not made at this time so that the raw Columbia River water may be used for reactor operation if required. Chicago Bridge and Iron Co., the sub-contractor for the Rupture Hold-Up Tank RLT-2, has moved on the job-site and started erection of the tank. Material has been shop fabricated and is at the job-site. The contractor has submitted most of the vendor submittal data, which is required for this contractor.

GAS COOLED POWER REACTOR PROGRAM

Gas Loop Project Management and Design (Project CAH-822). Gas Loop construction remains approximately 92% complete at month end. Electrical and instrument design tests are in progress by plant forces. The NaK heater has been returned to the vendor for removal of the NaK. A revised project proposal has been submitted requesting an increase in authorized funds of $50,000 and an extension of project completion date to June 30, 1962, to accomplish replacement of the NaK heater.

After considerable study, it has been decided to completely re-design the gas loop heater rather than attempt to modify the existing heater. The two most

suitable candidate materials to replace the NaK were determined to be nickel or silver. Use of nickel is relatively expensive on the basis of fabrication, and is marginal from heat transfer considerations. Silver is expensive on the basis of initial cost, but appears feasible from heat transfer considerations. Accordingly, preliminary design has been completed on a shell and tube arrangement heating the tubes internally with silicon carbide resistors, insulated electrically with alumina, and passing the gas transverse to the tube bundle. Cost of this heater including detail design is estimated to $22,000.

Construction forces presently are engaged in the installation of the in-reactor test section in the experiment cell. The in-reactor section pressure tube has been delivered to the PRTR site and will be connected to the new piping during the next reactor outage.

Latest report from the blower vendor indicates tests of modifications now being incorporated will be started early in December. This schedule indicates earliest possible delivery is February, 1962.

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
R. G. Wheeler	Displacement Gage
W. J. Bailey and S. H. Woodcock	Remotely Operated, Self-Contained Transport Vehicle for Use in Fluid Media, HW-71672, 11/13/61
S. H. Woodcock and W. J. Bailey	Remotely Operated, Expendable or Non-Expendable, High-Speed Device for Determining Thermal Properties of a Specimen Which is Operating at Elevated Temperature, HW-71673, 11/13/61
S. H. Woodcock and W. J. Bailey	Remotely Operated Device for Measuring and Observing Thermal Properties of an Operating Nuclear Fuel Element or Other Test Specimen, HW-71888, 11/30/61
J. Dunn	Impulse Type Pump
J. Dunn	Aid in Tuning of Musical Instruments
R. T. Allemann and R. L. Moore	An Electrostatic Bubble Scrubber (HW-71534)
L. F. Kocher	An Improved Personnel Film Badge Dosimeter (November 30, 1961)
M. F. Scoggins	An Automatic Impaction Shield
D. R. Green	A Quantitative Method for Mapping and Displaying Values of a Variable, HWIR-1450

F. W. Albaugh / for
Manager, Hanford Laboratories

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