HW-54284

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
DECEMBER, 1957

Compiled By
Operation Managers

January 15, 1958

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

[redacted]

PRELIMINARY REPORT

This report was prepared only for use within General Electric Company in the course of work under Atomic Energy Commission Contract W-31-109-Eng-52. Any views or opinions expressed in the report are those of the authors only.

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TABLE OF CONTENTS

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TABLE I. HLO-FORCE REPORT AND PERSONNEL STATUS CHANGES

Date December 31, 1957

FORCE REPORT

	At close of Month			At beginning of Month			Additions		Separations	
	Exempt	Non-Exempt	Total	Exempt	Non-Exempt	Total	Exempt	Non-Exempt	Exempt	Non-Exempt
Chemical Research and Development	128	97	225	127	97	224	1	0	0	0
Reactor & Fuels Research & Development	153	101	254	153	100	253	1	1	1	0
Physics & Instrument Research & Development	56	25	81	57	25	82	0	0	1	0
Biology Operation	35	43	78	34	43	77	1	0	0	0
Operations Res. & Syn.	15	3	18	14	3	17	1	0	0	0
Radiation Protection	44	153	197	44	154	198	0	5	0	6
Laboratory Auxiliaries	46	182	228	45	184	229	1	2	0	4
Financial	16	34	50	16	34	50	0	0	0	0
Employee Relations	13	11	24	13	11	24	0	0	0	0
General	1	2	3	1	2	3	0	0	0	0
TOTALS	507	651	1158	504	653	1157	5	8	2	10

Composite Separation Rate - 1.036
Separation Rate (based on separations leaving G. E.)- .777
Controllable Separation Rate- .172

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PERSONNEL STATUS CHANGES
TABLE II. PROMOTIONS AND TRANSFERS (1)

Date December 31, 1957

Component	PROMOTIONS			EXEMPT TRANSFERS (2)				NON-EXEMPT TRANSFERS	
		Non-Exempt		To HLO		From HLO			
	Exempt	To Exempt	Non-Exempt	From Other HAPO	From Other G.E.	To Other HAPO	To Other G.E.	To HLO	From HLO
Chemical	0	0	1	0	0	0	0	0	0
Reactor & Fuels	0	0	2	1	0	0	0	1	0
Physics & Instrument	2	0	1	0	0	0	0	0	0
Biology Operation	0	0	2	0	0	0	0	0	0
Operations Res. & Syn.	0	0	0	1	0	0	0	0	0
Radiation Protection	0	0	2	0	0	0	0	4	4
Laboratory Auxiliaries	0	0	0	0	0	0	0	2	0
Financial	0	0	0	0	0	0	0	0	0
Employee Relations	0	0	0	0	0	0	0	0	0
TOTALS	2	0	8	2	0	0	0	7	4

(1) Data through 12/31/57
(2) Transfers within HLO not included

SUMMARY

BUDGETS AND COSTS

Fiscal year to-date costs are $8,208,000 at the end of December or 46% of the $17,759,000 FY 1958 Mid-Year Review Budget. December costs of $1,440,000 showed a slight reduction from November.

Cost-budget relationship of end programs through December are, for the most part, satisfactory. The authorization for FPD Research and Development is 60% spent and reduced spending will be required during the balance of the year.

Plutonium recycle costs are only 37% of the annual budget however, the annual budget is based on $3,500,000 (excludes $500,000 equipment) as compared with $3,000,000 (excludes equipment) contained in the financial plan. Large expenditures for prototypes and off-site services will substantially increase the spending rate for this program during the last half of this fiscal year.

CPD Research and Development - Separations is 62% of the budget; the budget for Separations Processes for Non-Production Fuels is only 6% spent. Combined the two programs are 47% of authorized funds.

Reductions in FPD and IPD Process Technology took place in December as planned. While additional reductions appear necessary, it is planned that costs of these two programs will remain within authorized funds this fiscal year.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

IBM computations indicate that in PRPR operation on steady state fuel cycles without segregation of plutonium according to exposure history, maximum exposures are attained at 3-5% rather than zero processing loss. These maximum exposures, with D_2O reflector, are about 6000 MWD/T for the uniformly enriched reactor and about 3700 MWD/T for the spike enriched reactor.

The PRPR preliminary safeguards analysis was reviewed by the General Electric Company Reactor Safeguards Committee on December 9. Although the committee agreed that the reactor design met all present safety standards, further study of the degree and consequences of metal-water reaction following an incident was recommended and will be done.

The design of PRPR Phase II (service area) and Phase III (reactor and auxiliaries) is 15% complete. Scope changes include removal of the turbo-generator and associated changes, and modification of the wall between the lower face access room and the process cell.

The LeFiell Manufacturing Company (Los Angeles) succeeded in mechanically forming the flanged and tapered sections on short, prototype PRPR Zircaloy-2 process tubes. Although further study is required, the outlook is quite favorable.

Zircaloy-2 end fittings fabricated from bar stock by machining have been a

substantial element in fuel assembly costs. Examination of vacuum cast parts made by an off-site vendor indicates excellent quality at considerably less cost.

Frequent ruptures have occurred in attempting to swage to high density sintered and ground UO_2 powder contained in thin wall, 1" OD, Zircaloy-3 tubing. In a test at a vendor plant this did not occur using a stationary spindle (inverted) swaging machine.

Unsintered UO_2 powder specimens irradiated in the MTR have shown no increase in fission gas release with increasing exposure in the range of hundreds of MWD/T.

Examination of Zircaloy-2 and Zircaloy-3 specimens after prolonged exposure in H-Reactor led to the following conclusions: a) rates of reaction with reactor gas can be predicted from out-of-reactor test data, b) cold worked zirconium, Zircaloy-2, and Zircaloy-3 are annealed and recrystallized in less than three months at 410 C, c) 450 C appears to be the upper temperature limit for prolonged exposure of Zr to reactor atmosphere, and d) aside from the effect of annealing, 1000 days of exposure had little effect on mechanical strength.

Two-tube charges of experimental hot-press canned and vacuum canned I and E fuel elements have been discharged after irradiation to about 800 MWD/T at a power level of about 50 kw/ft. No ruptures occurred and all test elements appeared to be in good condition.

Preliminary corrosion tests of four experimental aluminum alloys prepared by a commercial vendor have given results inferior to those obtained on alloys of the same chemical composition prepared by ANL. Effects of variables associated with metallurgical history are indicated.

Exposure of conventional, asbestos-insulated thermocouple wire for eight hours in an inert atmosphere at 600 C resulted in a 2000-fold reduction in electrical insulation resistance. However, burnout of impregnating material and/or other carburizing substances with oxygen restored the insulation resistance to greater than the old value. A loss of electrical resistance of this magnitude would invalidate the temperature-reading of the thermocouple and explains the premature failure of many asbestos-insulated thermocouples in Hanford reactors.

Near saturation of the physical distortion of CSF graphite caused by irradiation at 30 C has been observed for the first time in samples recently discharged with an accumulated exposure of 5725 MD/T.

In ex-reactor loop tests of two weeks duration employing MIPB coolant at 700 F, fuel elements with nickel or graphite diffusion barriers clad with aluminum, steel and Zircaloy-2 exhibited an absence of the distortion previously observed under similar conditions employing AlSi or no diffusion barrier. Magnesium coupons were found to be extensively attacked by traces of water in MIPB.

2. Chemical Research and Development

In Non-Production Fuels Reprocessing, some 20 different processes are being studied for technical and economic feasibility with reprocessing of plutonium recycle fuels included in the scope. More work on chloride removal from Darex dissolver solution by either solvent extraction or boil-off techniques is reported. Corrosion tests are narrowing down materials suitable for dissolver construction. Haynes 25 alloy looks promising to contain HNO_3-HF solutions potentially capable of dissolving either stainless steel or zirconium.

Continued study of uranium, plutonium, thorium, and cerium oxide solutes in molten potassium-aluminum chloride with subsequent reduction reactions to produce metallic uranium, thorium, or plutonium has brought to light some potentially simple and interesting decontamination or partition processes.

Use of tri-laurylamine as a specific plutonium extractant is reported to be more promising than previous alkylamines tested.

Basic chemical feasibility of plutonium recovery from Purex 1WW wastes by anion exchange looks encouraging although several practical problems are yet to be answered. Absorption desorption kinetic studies are reported for various anion exchange resins.

Economic analysis and laboratory exploration was initiated on "dry" storage methods for Purex wastes. Complete dehydration to stable salts retained in steel pipes is visualized. Methods of stabilizing or calcining gel wastes continue to be studied.

Potential substitution of stainless steel in lieu of platinum for Flurex anodes may be economically attractive.

Two independent mechanisms are reported to account for the effective removal of strontium ion from solution by calcite in the presence of phosphate ion.

3. Physics and Instruments

The reactivity loss which will result from loading I and E slugs in the K reactors was determined by experiment in the PCTR. This difference, 240 inhours, was determined with an estimated error of ± 40 inhours by development of an improved technique for using the PCTR in difference-type measurements.

Work continued on determining the nuclear physics parameters for cluster type fuel elements for the NPR program, and progress was also made in the program to develop improved methods for calculating such information. The calculation of the isotopic composition of plutonium produced in reactors having moderator temperatures up to 1200° C received special attention.

The gathering of experimental information needed in setting critical mass limits for the chemical processing of slightly enriched fuel elements continued. This program has now been broadened to include consideration of enrichments up to 1.4%. Problems will exist in both the dissolvers and the calciners at these concentrations. Data were obtained on randomly stacked,

1% enriched, I and E slugs, and on oxide mixtures of low water content. For the latter the maximum enrichment which will have k less than unity under any conditions has now been established as 1.02 ± 0.02%.

In the Plutonium Recycle Program, PCTR experiments were completed on the Mark II annular fuel element and the data are now being analyzed.

Continued high demand for PCTR time necessitated two-shift operation throughout the month.

The simulation, from an atmospheric physics standpoint, of "slow simmer" reactor disasters continued. Tracer materials emitted from 100-H and 100-B have been measured at distances up to 8 miles from the source and at dilutions of 10^{-8} of the source strength. Since experiments to date have been under only one set of atmospheric conditions, no general conclusions can be drawn.

A body monitor shield has been constructed in 329 Bldg. of 100-pound bags of crushed talc.

The development of the pulse method for reading pencils was completed and extensive field testing by Radiation Protection Operation is under way.

Satisfactory progress was made in the development of instruments for radiation detection use. Satisfactory operation of a scintillation, transistorized alpha hand counter was demonstrated by completion of two months' use without any maintenance or recalibration being required. Progress was also made on the development of nine other instruments or major components.

Work in the basic data field continued on programs mentioned in previous months. A significant increase in beam current of the Van-de-Graaff has been achieved by improved alignment.

4. Biology

P^{32} contamination in whitefish available to fishermen at Ringold increased to a point where the consumption of 0.3 lb/week would furnish the offsite MPC (for drinking water). The same level was also found in the flesh of ducks.

From the standpoint of gross beta emitters picked up by Columbia River fish, there appears to be no advantage in retaining reactor effluent for decay of short-lived isotopes.

Prompt treatment with chel-330 appears to be superior to EDTA for the removal of plutonium from the body.

Three malignant tumors were found in mice after administration of $Pu^{239}O_2$ and one after administration of $Ru^{106}O_2$. The latter is the first reported lung malignancy caused by a beta emitter.

Calcium, phosphate, and carbonate were all effective in reducing deposition of Sr^{89} and Ca^{45}, but in varying degrees for the two isotopes. Sodium increased the deposition. The results attest to the complexity of the

interrelationships involved and point up the inadequacy of the commonly accepted concept that calcium will behave simply as an isotopic diluent of strontium.

Technical and Other Services

Two cases of plutonium deposition were confirmed; one case involving a contaminated minor injury and a small excision of skin. Initial bioassay analyses indicated less than ten per cent MPL in both cases. The total number of cases of plutonium deposition on record is 212, of which 168 are on the active rolls.

An ROF of thirty clerical employees in the Radiation Protection Operation was announced to be effective in January. This was necessary because of earlier than expected gains from improvements in the film badge and pencil programs.

The iodine-131 emission rate averaged seven curies per week which included a single emission of 14 curies from the Redox sand filter.

Statistical and mathematical assistance on 37 separate problems was given to other HAPO components. The following items are typical:

1. Control charts currently maintained for I and E fuel element production were reviewed and changes recommended.

2. Fission product gas activity data from a UO_2 irradiation experiment were analyzed with respect to surface area, packing density, enrichment, neutron flux, and exposure time.

3. Radiation exposure data from different tasks within the "Z" plant are being analyzed with the objective of correlating with processing variables in the reactors and separation plants.

4. Assistance was given in a determination of confidence limits on data for a critical mass study concerning randomly dumped fuel elements.

All projects are proceeding substantially on schedule with the exception of CA-658, Shielded Personnel Monitoring Station; Project CA-681, Hanford Equipment in the ETR; and Project CA-695, Radiotelemetering Network.

Four project proposals were submitted during the month. These were as follows:

CA-760 - Expansion of 3745-B Building $ 195,000
CG-785 - In-Reactor Studies Equipment, 105-KW $15,000*
CA-749 - High Level Radiochemistry Facility $1,070,000
CG-660 - Modification and Additions to the Metallographic Cell (Extension of time)

*Preliminary design only.

Project CA-784 - Alterations to the 327 Building - was returned unapproved by the AEC.

Completion notices were issued on two informal requests: IR-224, Biology Controlled Activity Water System, 100-F Area and IR-232, Repair Damage and Additions to Heating System, 747 Building.

A successful demonstration run was made with the vacuum furnace installed on Project CG-620 which removes the exception to the completion of this project.

The modified IBM system introduced last month for control of classified documents is working very satisfactorily. It is not yet possible to analyze costs since billings so far include conversion costs. Additional savings in Technical Information were obtained by transferring security control of SS accountability data sheets to the SS Accountability Operation.

Information was transmitted to AEC regarding situations where compliance with the existing Hanford Classification Guide will be particularly difficult. Drafts of certain sections of the Hanford Classification Guide have been prepared by the respective product departments.

Supporting Functions

1. Financial

A Financial Plan, dated December 20, 1957, has been received from HOO-AEC for FY 1958. A summation of the contents of this plan which makes comparisons with HLO's needs as forecasted in the Mid-Year Budget Review is being prepared for distribution early in January. Highlights of the new financial plan are as follows:

(a) 2000 Program Research and Development has been increased to provide $1.7 million for NPR work this fiscal year.

(b) 3000 Program Research and Development was increased to $333,000 from $164,000 in the preliminary financial plan.

(c) 4000 Program Research and Development decreased from $4.0 million to $3.5 million, including equipment. A meeting was held with HOO-AEC operating and budget personnel to make a strong bid for the recovery of these funds. HOO-AEC is advising AEC Washington early in January of the serious effects this reduction will have on the plutonium recycle program.

(d) 6000 Program Research and Development increases from $1.8 million to $1.92 million to provide additional funds for radioecology and other necessary work.

Eight patent awards were paid and the stock delivered during December. During the year 1957, 24 awards were granted, 9 of which were to inactive employees.

Listings of equipment, found missing in the current HLO physical inventory of uninstalled cataloged equipment, were prepared and distributed to Level 3 Managers, requesting that the equipment be found or action be taken which will permit the equipment to be written off the books. At present 225 pieces valued at $141,000 were not found during the inventory.

2. Employee Relations

At month's end, the staff of the Hanford Laboratories Operation totalled 1158,

including 507 exempt and 651 non-exempt employees. There were 422 exempt employees possessing technical degrees including 222 BS, 103 MS, and 97 PhD's.

Detailed planning for the AFSWP Training Program was completed during the month. A group of nine medical people will arrive on January 6 for a six-weeks' course.

The proposal for the 1958 Summer Institute has received informal AEC approval and will be offered on a "Q"-cleared basis.

There was one additional PhD acceptance received during December and two new PhD's were placed on the roll. Total PhD acceptances for the recruiting year to date are eight and nine open offers outstanding. Two acceptances were received from experienced BS/MS candidates.

Eighteen suggestions were reviewed and 14 were approved for awards totaling $490 at the December Suggestion Board meeting. During 1957 HLO paid a total of $4,652 in suggestion awards.

Negotiations with the Field Inspectors continued during the month. Differences between the Company and the HAMTC were brought to light but were not resolved.

Three grievances were received during the month of December: one was filed by a Radiation Monitor and involved personnel monitoring; one by a Serviceman regarding transportation; and the other by a Painter in FPD concerning jurisdiction. All three are at the Step II level. During calendar year 1957 there were a total of twenty-three formal grievances processed, including one non-unit grievance.

A coordinated HAPO-wide study of the semi-technical jobs was undertaken during the month following a comprehensive review of the data received from the Northwest area and AEC wage surveys.

At month's end each Level 3 Manager had discussed his salary review with the Manager, Hanford Laboratories. Statistics for the HLO review are currently being prepared.

During the month a total of three million man-hours was completed, qualifying HLO for the National Safety Council Award of Honor. During December Laboratories personnel worked a total of 186,174 hours with no disabling injuries.

There were 33 medical treatment injuries giving a frequency of 1.77 as compared to 1.49 last month. For the total calendar year the total frequency was 1.71.

There were seven security violations bringing the total for the year to 88. For the last four months the total was 15 violations.

An analysis of the scores of 35 selected attitude survey questions was plotted using the scattergram method. These plots will be used in

discussions with HLO managers and supervisors in an attempt to develop a better understanding on their part of attitude survey results and to assist in developing improvements for future surveys and programs directed toward improvements in our operations. Sensitivity survey results have also been analyzed and will be discussed with individual managers and supervisors.

Members of a Columbia Basin College science class visited HLO facilities on December 21 and Richland science students toured the facilities on December 23.

There were no reduction in force notices given during December. Two Servicemen were removed from the payroll due to HAPO bumping, following notices given during November.

Paul F. Gast

Acting Manager
HANFORD LABORATORIES

PF Gast:kss

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Effect of Grain Size. The effect of grain size on the high temperature aqueous corrosion of 1245 alloy has been studied. Samples were exposed at 305 C and 290 C. The samples were rolled and heat treated to produce coupons with grain size varying from about 0.1 mm to 1 cm diameter. There was no observed variation in corrosion rate or intergranular-corrosion induction period with grain size.

Anomalous X-8001 Corrosion. Two coupons of aluminum alloy X-8001 (formerly known by Alcoa's designation: M-388, nominal 1% Ni, 0.5 Fe, 0.2 Si) were exposed for two hours in water at 290 C. These were exposed as control samples along with coupons of alloy 1245, Hanford can stock. Both of the X-8001 coupons developed cone shaped eruptions about 1/8 inch in height. Corrosion penetration into the coupons below these mounds was about 1/32 inch or about half-way through the coupon. Normally this exposure will produce only about 0.02 mil of uniform corrosion penetration. These corroded samples are unique. Efforts to reproduce these results have failed. There has been no explanation made of this anomalous corrosion behavior. Temperature excursions or poor water quality are ruled out because the 1245 alloy coupons which were exposed at the same time corroded in the expected normal manner.

Protective Autoclave Films. The corrosion product film formed on aluminum in distilled water or steam at 170 C provides a considerable amount of corrosion protection during subsequent exposure to water at lower temperatures. In order to determine whether a similar protection occurs at higher temperatures, samples of X-8001 alloy were autoclaved in distilled water at 350 C and were subsequently exposed at 300 C along with fresh samples. Another set of samples were autoclaved at 300 C and were subsequently exposed at 250 C along with fresh samples. In both tests there was no protection provided by the autoclave film formed initially at the higher temperatures. At first, the fresh samples corroded more rapidly than the previously autoclaved samples. After a period of time, when all the samples had corroded the same amount, the corrosion rates for the fresh samples and the previously autoclaved samples became identical. These observations substantiate theories that the uniform corrosion of aluminum in static water systems is entirely controlled by the thickness of the corrosion product film. The fresh samples corroded at an initially faster rate until their corrosion product films attained the same thickness as those on the previously autoclaved samples after which the corrosion rates were the same. Since there is very little dissolution of the

corrosion product in a static system, this state of equivalent rates was reached rather quickly, a few days, in these tests.

Corrosion Product Formed in Water Containing Phosphates. Coolant Systems Development provided samples of X-8001 aluminum which had been exposed in ELMO-6 at 300 C to water adjusted to pH 4.5 with phosphoric acid, and ELMO-2 at 180 C to water adjusted to pH 4.0 with phosphoric acid. X-ray diffraction identified the corrosion product film formed at 180 C as the basic aluminum phosphate, augelite. The x-ray pattern obtained from the 300 C corrosion product film could not be identified as augelite, boehmite, or any of the ASTM standards. Electron micrographs were obtained of the corrosion product films. The 300 C film was similar to boehmite films previously observed. The augelite film formed at 180 C was considerably different from boehmite, the augelite crystals being more elongated and more evenly distributed.

Evaluation of Experimental Aluminum Alloys for NPR Fuel Element Cladding. Caps and cans of four experimental aluminum alloys have been obtained from Hunter-Douglas for testing in the KER facility. Since the KER loadings are scheduled for about January 1, 1958, accelerated comparisons of the four alloys have been required. The laboratory evaluation will depend on the results of three tests: 360 C refreshed water, 1000 psi steam at 350 C, and 500 psi steam at 500 C. The results now available are shown in the table below:

	% Composition						Corrosion Performance	
Alloy	Ni	Fe	Si	Ti	Be	Zr	360 C Water	500 C, 500 psi Steam(c)
A-1	0.80	0.05	0.01	0.14			Failed, 10 da.	Failed in 37 hr (d)
A-2	0.81	0.56	0.02	0.14			0.5 mil, 18 "	" " 80 " (e)
C-1	0.51	0.51	0.18	0.16	0.08		1.2 " 18 "	" " 13 " (f)
C-2	1.83	0.49	0.16	0.14	0.08	0.05	0.5 " 18 "	" " 13 " (g)
X-8001(a,b)	1.0	0.5	0.2				0.5 " 18 "	" " 16 "(400 psi)
M-400(b)	1.0	1.0	0.2				0.5 " 18 "	" " 24 "

Notes:

(a) X-8001 is the new Aluminum Alloy Committee designation for M-388.
(b) These two well characterized alloys are included for comparison purposes only.
(c) This is a destructive test. Time to failure is a qualitative measure of resistance to intergranular attack.
(d) Alloy A-1 was intended to duplicate ANL Alloy 198X, which withstood 500 C steam for 12 days, with blistering.
(e) No previous test for comparison. Alloy A-2 is similar to X-8001 (e.g., M-388) except for the addition of Ti and the lower Si content. Note apparent improvement over X-8001 in 500 C steam.
(f) Similar Chalk River alloy blistered in 10 days in 500 C steam.
(g) Similar Chalk River alloy blistered in one week in 500 C steam.

As noted in the table the alloy A-1 is markedly inferior to samples of the same composition from small Argonne laboratory melts. Alloy macro-composition appears to be satisfactory so the poor behavior is tentatively attributed to metallurgical history. To a lesser degree alloys C-1 and C-2 are also below expectations, presumably for similar reasons. On the basis of autoclave tests alloy A-2 is the most promising. It is the only one of the four alloys which apparently has any advantage over X-8001, based on these laboratory screening tests.

Under some service conditions certain heat treatable aluminum alloys are prone to stress corrosion. Corrosion tests were requested for the alloys A-1, A-2, C-1 and C-2 under bending stress. At 360 C the bending stress was relieved after ten days with no evidence of localized attack. Tests will also be performed at lower temperatures.

Corrosion of Zirconium and Zirconium Alloys. A group of Zircaloy-2 and -3 corrosion coupons which showed the least attack in one-day tests in 360 C water and 400 C, 800 psig steam, also looked best after fourteen days in the same systems. This relation, if found generally true, would make rapid quality testing of Zircaloy practical.

Six of eight scheduled exposure groups have been discharged after 54, 160, and 514 hours in 360 C water, and after 24, 72, and 336 hours (14 days) in 400 C steam at 800 psig. There was a general increase in oxide film weight, but this is occurring at a diminishing rate with time. Replicate samples which appeared sound at 24 and 72 hours have sound counterparts after 336 hours. Those which showed signs of failure after the shorter intervals show progressive failure at the extended exposure.

Hydrogenation and Tensile Testing of Zircaloy-2. Tensile testing of duplicate vacuum-annealed Zircaloy-2 specimens at room temperature, 100, 200, 300 and 400 C is in progress. Four of a first group of twelve specimens having 100 ppm H_2 have been prepared for testing. In the interest of homogeneity it has been found that a maximum of four samples can conveniently be hydrogenated simultaneously in the existing apparatus.

Organic Coolant Studies. A study is under way to determine the solid-liquid-vapor phase diagrams of the binary and ternary mixtures of the candidate organic coolants, biphenyl, ortho-terphenyl, meta-terphenyl, napthalene, and phenanthrene. Six of the binary solid-liquid phase diagrams have been completed. Large regions of solid solution were observed. Listed below are the eutectic mixtures, melting points, and regions of solid solution.

Eutectic Composition (mole percent)	Eutectic Melting Point	Regions of Solid Solution
65% biphenyl - 35% meta-terphenyl	45.5 C	0-45% biphenyl 78-100 "
41% biphenyl - 59% ortho-terphenyl	30.0 C	0-25% " 65-100 "
55% biphenyl - 45% napthalene	40.0 C	0-30% " 70-100 "
77% ortho-terphenyl - 23% meta-terphenyl	39.0 C	0-60% ortho-terphenyl 85-100 " "
65% ortho-terphenyl - 37% napthalene	31.5 C	0-15% " " 76-100 " "
41% meta-terphenyl - 59% napthalene	50.0 C	0-10% meta-terphenyl 56-100 " "

The four remaining binary mixtures and the ternary, biphenyl-ortho-meta-terphenyl, are in progress.

Ceramic Coatings on Uranium. The study of ceramic coatings on uranium slugs has been completed. Several corrosion tests were run on these slugs in 130 C water. These tests indicated that the low melting glaze (lead oxide, silicon dioxide, sodium oxide) had poor resistance to hot water. A formal report on this subject, HW-53666, is being issued.

Radiometallurgy Examinations

Examination of Heavily Corroded 1245 Aluminum Fuel Jacket from IP-39-A (RM 207). A standard eight-inch solid uranium fuel element from production test IP-39-A was submitted by Research and Engineering, IPD, to the Radiometallurgy Laboratory for examination. IP-39-A was a production test to compare the in-reactor corrosion properties of M-388 alloy slug cans to 1245 aluminum cans. The slug, which had a heavily corroded 1245 aluminum jacket, was part of series 99-F and was irradiated in tube 1362-B at a calculated power of 20.5 kw. The calculated surface temperature of the slug was 115 C, and during the 62 days of operation above 100 C, 18.13 gm of jacket metal was lost through corrosion attack.

Diameter measurements at six points along the length showed a maximum of 1.436 inches and a minimum of 1.415 inches. Can wall measurements of a wafer from the minimum diameter region of the slug gave maximum and minimum can wall thickness of 54 and 28 mils including 11 and 13 mils of AlSi. Maximum corrosion of the can wall occurred 180° from one of the rib marks with the least corrosion situated between the rib marks.

Production Test IP-32-A Irradiation of Insulated Slugs (RM 176). Three four-inch cored insulated natural uranium fuel elements were exposed to about 600 MWD/T in the KW Reactor through hole. Sectioning of slug #85 revealed that temperatures above the alpha phase were experienced by the piece and that a molten drop may have formed in the core of the slug. Radial cracks were visible. Large radial grains were visible on section wafers in the as-cut condition. An enlargement of the diameter had

occurred and the core was partially closed up. The core appeared to have shifted off center from its initial axial position. Metallographic examination of wafers from opposite ends of the sample is continuing.

Examination of Two 5/8-Inch Cored Uranium Slugs From IP-30-A (RM 192). One of the 5/8-inch cored uranium slugs from IP-30-A has been sectioned longitudinally and two wafers were removed, one from the center of the slug and the other one inch from the cap end.

In the wafer sectioned from the cap end of the slug the AlSi bond had parted from the uranium over a circumferential distance of 3/4-inch and the uranium under the unbonded area was filled with micro cracks, indicating local heating. Examination of the other two samples is in progress.

Cluster Fuel Test - GEH-4-B (RM 181). The four-rod natural uranium fuel element cluster, clad in 304 stainless steel, was disassembled and the components were measured. Three of the uranium rods decreased 35 mils (0.45%) from the pre-irradiation lengths of 8.000 ± 0.002 inches; the length of the fourth did not change. The outside diameters of each of the clad rods had increased 1 mil (0.18%) and the diameter of one of the uranium rods with the cladding removed had increased 3 mils (0.60%) over the pre-irradiation diameters of 0.562-inch clad and 0.500-inch unclad.

Longitudinal and transverse sections were removed from one rod for metallographic purposes and one sample from each rod was obtained for burnup analysis. No evidence of bonding was seen at the uranium-stainless steel interface as the cladding separated from the rod when the longitudinal section was made.

Examination of GEH-4-14 Wafer Slug (RM 155). Metallographic examination of wafer segments from the GEH-4-14 uranium wafer slug disclosed a reduction in wafer thickness from the nominal unirradiated thickness. The can wall was sound, with no evidence of corrosion. The AlSi bond between the jacket and wafers was also in good condition. The AlSi bond between wafers was somewhat cracked, possibly as a result of the reduction in thickness of the wafers. Analytical results indicated that the U-235 burnup was 0.097 a/o.

Examination of Production Test 105-3N Supplement A (RM 108). Elevated temperature tensile tests were conducted in vacuum at temperatures of 450 C and 600 C on two additional uranium samples with an exposure of 150 MWD/T. Another sample with an exposure of 300 MWD/T was also tested at 300 C. The results of these tests, compared with previous data, disclosed that, at an exposure of 150 MWD/T, ductility decreases with an increase in temperature in the 300 to 600 C range.

M-388 Clad UO_2 I & E Slug GEH-4-6-3B (RM 204). The nine-inch I & E slug from GEH-4-6 was received after irradiation for one cycle at the MTR. The fuel material was UO_2, cold pressed and sintered to 92% of theoretical density. Examination revealed no evidence of corrosion, warp or other damage. Diameter measurements along the slug showed a maximum diameter increase of 4 mils over the original diameter of 1.476". Examination of the as-cut surfaces from a cut made approximately four inches from the

base end of the slug disclosed the usual cracked structure observed in irradiated UO_2. There was no evidence of melting.

Thermocouple Slug from GEH-4-H (RM 211). This test consisted of one I & E thermocouple slug with UO_2 washers as fuel. The slug was discharged from the MTR after a short irradiation upon indication of a possible leak. Examination failed to disclose any leak. Diameter measurements showed the slug had increased a maximum of 36 mils in diameter over the original diameter of 1.476". The slug was then leak tested in a bubble tester in an effort to locate a defect in the can. No leaks were discovered.

Corrosion of Irradiated Uranium in MIPB (RM 171). Metallographic examination to determine extent of corrosion caused by the interaction of monoisopropylbiphenyl on irradiated uranium at elevated temperatures and pressures has been completed. It was determined that a 24 g sample of 1945 MWD/T uranium which had been exposed to MIPB at 400 C and not greater than 300 psi for 9 days had not suffered any internal grain boundary corrosion. Corrosion was limited to the external surfaces of the sample, and there were no corrosion pits extending beyond the usual irregularity of the corroded surfaces.

Basic Metallurgy Studies

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel materials is a direct way of detecting radiation damage in these materials. Two techniques are being used: (1) metallographic examination of polished and etched surfaces, and (2) fractographic studies.

Replicas of fracture surfaces of irradiated uranium are currently under examination in the optical and electron microscope. Two levels of irradiation have been studied, and some comparisons with non-irradiated fractured surfaces can be made on the macro scale. There is an increase in the number and the size of cleavage facets as the irradiation level is increased. On the submicroscopic scale, pores have been found on the surfaces and their number also increases with the level of irradiation. These pores have never been observed on non-irradiated fracture surfaces. This work is continuing with specimens irradiated to higher levels and fractured at varying temperatures.

Effect of Present Pile Atmosphere on Uncooled Process Tubes. Examination of the zirconium, Zircaloy-2 and Zircaloy-3 specimens that were exposed in the 100-H Reactor X-test hole was completed and the following general conclusions were made:

1. The rate of reaction of zirconium and Zircaloy-2 with HAPO reactor atmospheres can be predicted from ex-reactor zirconium-air reaction data as obtained by Kendall, HW-39190.
2. Cold worked zirconium, Zircaloy-2 and 3 are annealed and recrystallized in less than three months of in-reactor exposure at 410 C.
3. 450 C appears to be the upper temperature limit for prolonged exposure of zirconium to reactor atmosphere. Beyond this temperature limit scaling becomes excessive.

4. Aside from the effect of annealing, the 1000 days of exposure had little effect on the mechanical strength of the test specimens.

A comparison between calculated and observed weight gain for zirconium exposed to pile gas showed a reasonably close correlation between calculated and observed values.

Diffusion Studies. A knowledge of the interdiffusion of various uranium/barrier metal/clad metal combinations is essential in the design of fuel elements. Diffusion is being studied in U/Ni/Al, U/M-388, U/Zr, and (U-Zr) alloy/Al couples. The effect of thermal cycling on U/AlSi diffusion is also being determined. Four vacuum furnaces together with a new control panel have been installed for this work. Initial tests indicated that several modifications were necessary; these are now being made.

Two U/Al couples which were irradiated at 200 C (392 F) and two U/Al and two U/AlSi couples which were irradiated at 250 C (482 F) in the MTR are now being cross sectioned by radiometallurgy. Three cross sectional planes perpendicular to the diffusion interface in the U/AlSi couples have been polished and examined. Diffusion has apparently occurred, as indicated by small nodules along the diffusion interface. Examination of these couples is continuing. The temperature of irradiation, which was calculated from heat transfer data, will be recalculated on the basis of integrated flux determinations obtained from burnup measurements.

Hanford Irradiation - PT-3NA. The design of advanced fuel elements depends upon some knowledge of the effects of radiation on the significant mechanical and physical properties of the fissionable material. A program to obtain this information for beta heat treated uranium is under way. During the month two elevated temperature tensile tests were made in the Radiometallurgy facility. The first was performed at 600 C on a specimen exposed to 0.018 a/o burnup, and the elongation was 5.8%. This test duplicated a similar test reported last month and confirmed the marked decrease in ductility observed at 600 C compared with specimens with the same burnup tested at 300 and 450 C. The 600 C specimens developed square, brittle appearing fractures. The second test was performed at 300 C on a specimen exposed to 0.031 a/o burnup. The percent elongation in one inch for this specimen was 2.23 compared to 0.7 and 4.5 at room temperature and 600 C, respectively, showing nearly a linear increase of ductility with testing temperature. Further study is required.

The Effect of Irradiation on the Properties of Thorium. The purpose of this test is to determine the mechanical properties of thorium after exposure in a fast neutron flux. The information obtained will aid in interpreting effects of irradiation damage observed in uranium. Thorium being face centered cubic should not be subject to complicated structure-dependent effects present in dimensionally unstable uranium which is orthorhombic. Six tensile specimens of thorium were canned in Zircaloy-2 capsules with NaK for exposure in the MTR. Capsules 25 and 26 were loaded in the L-52-SE position during the December 9 shutdown. Capsule 27 will be loaded in the same position during the December 30 shutdown, and

capsules 28 through 30 will be loaded in the same position as space becomes available.

Th-U-235 Alloy Fuel Material. The third of six capsules of Th-U-235 alloy fuel material being irradiated at the MTR in 0.5% increments to 3.0% burnup has been received at the HAPO radiometallurgy facility. This third specimen, which is restrained by about 0.120" of zirconium II, has attained a calculated exposure of about 14,000 MWD/T or 1.5% burnup. Two previous specimens of the material at 0.5 and 1.0% burnup have exhibited remarkable dimensional stability but have suffered a severe loss of ductility.

Pre-irradiation Study of Thermocouples. A knowledge of the errors in temperature measurement using thermocouples in a neutron flux is essential for the quantitative evaluation of the effects of neutron irradiation on materials. Due to a lack of such information, a program of measuring thermocouple stability in-reactor is currently in progress.

Due to gas leaks in the panel board, the ex-reactor tests for life and stability of chromel-alumel, copper-constantan and iron-constantan have been temporarily halted. Efforts are being made to correct this condition, but the panel will be by-passed in the event that the leaks remain.

Two sections of electrical lead wire have been fabricated by swaging. These consist of 2S aluminum tubing over two 14 gauge wires. Both copper and aluminum wires are being tested. Magnesia insulation is used in each assembly and no difficulties were encountered during the swaging.

Radiation Damage to Molybdenum. Molybdenum and zirconium are being studied by x-ray diffraction techniques after irradiation to improve the basic understanding of radiation damage in metals. The kinetics of damage recovery at elevated temperatures are also being studied.

As mentioned previously, annealing studies of molybdenum irradiated to various exposures from 6.5×10^{16} to 6.7×10^{13} nvt revealed that radiation damage as measured by shifts in the lattice parameter is removed in two discrete temperature regions. We are now in a position to compare the high and low temperature kinetics.

The "low" temperature mechanism (25 C to 200 C) is a first order reaction with an activation energy of 0.29 ev. In the next temperature range (450 C and above) studies to date indicate that no integral reaction order is evident. It is thought that two or more rate processes may be operating simultaneously. Furthermore, isothermal curves obtained at 500 C show that the initial rate of damage removal is a function of the amount of damage present. More highly damaged samples show larger initial rates of recovery than those samples with less damage. In the low temperature region the reaction rate is independent of the defect concentration.

These studies show that radiation damage is removed by not one mechanism, or by two, but by several. These mechanisms differ in nature and are a result of the nature of the metal, its history and structure, and the nature of the defects present.

A Theory for Neutron Damage to Metals. The purpose of this program is to advance the theory of irradiation damage to metals by neutrons. A series of metals representing the common metal crystal types was irradiated at Brookhaven, Hanford, and the MTR under various exposure and temperature conditions. These metals include copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. Post-irradiation measurements of mechanical and physical properties of these metals were initiated at KAPL and will be completed at HAPO.

The design of a vacuum tube furnace facility for the study of annealing effects on irradiation damage is nearing completion. A design for the apparatus required to determine the effects of neutron damage on electrical resistivity has been completed. The construction of a tube storage facility for "low-level" specimens is nearing completion.

New Fuel Element Development

Insulated Fuel Elements. Radiometallurgical examination of the three cored insulated uranium fuel elements which were irradiated in a K through-hole facility to 620 MWD/T is continuing. It was previously mentioned that the fuel element cladding increased in diameter 0.015-0.024 inch but that the uranium diameter was unchanged. The uranium has been subsequently observed to have increased in diameter 0.018-0.023 inch. This is the first instance of appreciable diametrical growth of the uranium core of irradiated insulated fuel elements. The uranium core of the upstream fuel element has been sectioned and examined. The grain structure indicates that nearly all of the uranium has been in the beta phase (660 C) or higher temperatures. Swelling of the uranium into the axial core has indicated partial gamma phase operation and in one location possible melting. Radial cracking on both the inside and the outside surfaces has been observed. The fuel elements were designed to operate in the alpha phase only (660 C), and it is possible that at initial start-up such conditions prevailed. The fact that metallographic examination reveals beta phase temperature range operation and higher suggests some phenomena associated with the many startup-shutdown cycles of a HAPO type production reactor which has somehow increased the effective insulation between the uranium core and the cladding and resulted in progressively higher operating temperatures in the uranium fuel. Detailed investigation is continuing.

A cored insulated fuel element equipped with an axial thermocouple and an hydraulic rupturing mechanism has been loaded into its basket and shipped to the MTR for in-reactor rupturing during operation. The purpose of the experiment is to demonstrate the rupture behavior of an operating insulated fuel element. The Reactor Safeguards Committee has approved the intentional failure of this fuel element during operation within a few hours after the MTR reaches full power. The calculated maximum temperature in the fuel element at rupture will be about 900 C. Loading of the fuel element and rupturing at full power will be scheduled for about February 14.

Co-axial Tube Fuel Element. The co-axial tube fuel element is of interest because it may offer a better split failure resistance than a corresponding sized cored fuel element. Two co-axial tube fuel elements, one

of which is equipped with an axial thermocouple, have been loaded into the MTR and are presently operating at 67.5 kw/ft average power. An initial stepwise increase to full reactor power at reactor startup resulted in a maximum temperature of 500 C in the thermocouple element. Since that time, the temperature has increased to 625 C in steps as the flux pattern in the GEH-4 test facility is changed. Since the average fuel power is still 67.5 kw/ft, it is doubtful that the full increase in temperature is due to the changing flux pattern, but it may be the result of a decreasing U-U interface thermal conductance. Two additional stepwise power increases from a low to full MTR power are hoped for before completion of the current MTR cycle. The behavior of the axial temperatures may indicate whether any serious ratcheting phenomena or creep effect may be experienced by the co-axial core during power variations or transients.

Cold Closure Jacketing Process. Methods to incorporate the various steps of the cold closure aluminum jacketing process into an efficient mass production procedure have been discussed with three Chicago press manufacturing companies. These companies will submit suggestions as to how this could be achieved, after which evaluation of the different approaches will be made to obtain a basis for further actions.

Post-Irradiation Examination of Experimental I & E Fuel Elements. The last two tubes each of hot-press canned and vacuum canned I & E fuel elements (with their controls) which had been irradiated to approximately 800 MWD/T at about 50 kw/ft, under PT's IP-44-A and IP-45-A, were discharged December 3 on an unscheduled shutdown. Owing to the fact that the experimental basin facilities in 100-C Building were undergoing repairs, it was not possible to apply the differential temperature technique for determining the residual heat-transfer quality of these elements before they had cooled too long. However, on the basis that a region of poor heat transfer would be expected to result in the development of an observable region of accelerated corrosion on the surface of the jacket, it is concluded that the heat transfer properties of all the elements involved (both test and control) remained adequate throughout their entire exposure period.

The only evidence of deterioration observable on any of the elements was with respect to features not associated with fabrication methods:

1. Embedded black particles in the jacket surfaces were frequently surrounded with an accretion of corrosion product which when removed left depressed areas in the jacket wall.
2. There was a pronounced tendency for elements downstream from center (both test and control) to develop calcareous deposits on the side opposite the tube ribs. The appearance of these deposits was typical of that seen on "hot-spot" failures, except much milder. Thus, it appears that the diameter chosen for these elements is too great, resulting in too much constriction of the coolant annulus, with overheating of the element surface.

None of these effects had progressed far enough to jeopardize further service; in fact, no reason was found to indicate that the entire test time might not have been at least doubled, with one exception: a deep corrosion pit near

the mouth of a control element exposed to 600 MWD/T. This pit was small in diameter (1/16 inch) and represented a weight loss of perhaps 100 mg. The outstanding conclusions to be drawn from these two tests are:

1. The superior ability of I & E type elements to withstand irradiation for extended periods is well demonstrated.
2. The OD of I & E elements should be reduced to prevent overheating downstream.
3. Steps should be taken to prevent pickup of embedded particles following fabrication and to eliminate particle-bearing elements at the time of charging.
4. The fact that fuel elements canned by methods radically different from standard methods are able to withstand protracted exposure when adequately inspected and culled is well demonstrated. Confidence in these canning methods is strengthened.

Lead Dip Segmented I & E Fuel Elements. The post MTR irradiation examination of GEH-4-14, I & E AlSi canned segmented fuel element with M-388 aluminum cladding, has been completed. The fuel element was exposed to 830 MWD/T, as determined by burnup analysis, during its five-cycle residence in the MTR. There was no significant change in length, but the diameter increased at individual wafers from 0.012" minimum to 0.048" maximum. A rippled effect was produced on the surface of the fuel element by the variations in diametrical growth, but there appeared to be no mechanical damage or stress type corrosion associated with the ripples, nor was there any indication of incipient failure. An extreme difference in grain size of the M-388 cladding material was observed with fine grains prevailing on the external surface and coarse grains prevailing on the inner surface. This grain size variation was probably induced during canning operations. The dimensional instability displayed by the fuel element probably results from different irradiation growth of different wafers as influenced by wafer fabrication and treatment history. It appears that the problem with wafer fuel elements as presented by this examination is that of variable irradiation growth of individual uranium wafers.

Currently, irradiation performance of the segmented I & E (washer) fuel element is being established by reactor charging of the KER and C-size geometries. Fifty KER-size segmented I & E fuel elements have been fabricated by lead-dip canning. These elements will be closed and tested for metallurgical soundness. Improved design of the canning tongs substantially lengthened the tong life and increased the fabrication yield. Tools and components are being assembled for fabrication of a C-size I & E segmented fuel element production test. Elements are to be ready for charging in February 1958.

Hot-Press KER-Size Segmented I & E Elements. Hot-pressed KER-size, segmented (washer) I & E fuel elements are being developed to jointly evaluate the irradiation performance of the washer concept and various aluminum alloy jackets at 300 C reactor coolant water temperature. The equipment required to assemble and press the 1.8-inch diameter elements has been procured and is operating satisfactorily. Three fuel elements have been

completed and destructively examined. The most serious defect noted was uranium-aluminum diffusion at the corners of the washers. Nickel plating was limited to the washer edges, and misalignment allowed small areas of the bare washer face to contact the aluminum jacket. Plating procedures and equipment are being developed which nickel-plate around the corners of the washer to coat a 0.010 wide band of the washer face.

Rod Cluster Fuel. Rod cluster fuel elements meet many of the requirements for plutonium production in pressurized water tubes operating at 300-350 C bulk outlet temperature. Rupture safety advantages of four- and seven-rod clusters have been tested in the Hanford ELMO loops. Irradiation testing at low exposures and temperatures has been carried out in the Hanford H and K Reactors and in the MTR. To extend this experience to high temperature water, twenty-four-rod cluster fuel elements were charged into the KER Loop 3 in late September. This fifteen feet of charge is operating at a bulk outlet temperature of 235 C. The present exposure is about 900 MWD/T. Goal exposure is presently 1500 MWD/T, since similar fuel rods have been successfully exposed to 1000 MWD/T.

A four-rod cluster element was irradiated to 550 MWD/T in the MTR and discharged in May. This element contained 0.500 inch uranium rods also clad with stainless steel, but was irradiated in 40 C water. Radiometallurgical examination is being completed during December. The beta heat treated uranium cores decreased about 0.035 inch in length and grew in diameter by 0.002-0.003 inch. No warping occurred. The fuel cores in all cases filled the cold clearance gap between the core and clad. Uranium oxide present on the rods before irradiation does not appear after irradiation; however, no core-clad reaction could be detected in metallographic examination.

Nuclear Metals, Inc., has produced 127 feet of coextruded uranium as a part of their development subcontract. This rod is natural uranium clad with 0.030 inch of Zircaloy-2. No end plugs were provided. Ten three-inch samples have been cut from this shipment at ten foot intervals. These will be bored, end plug welded, destructively and non-destructively tested prior to production of 12-inch length elements with welded end plugs. These 12-inch elements will be assembled into four- and seven-rod clusters for operation in the KER Loop 1 with 280 C coolant temperature. The KER Loop 1 test date remains March 1958, and the fuel assembly deadline January 15.

Six Nuclear Metals, Inc., coextruded rods with 0.020-inch Zircaloy-2 clad have been counter-bored, fitted with end plugs, welded, and autoclaved. Some bulging of the clad occurred during machining, but this can be prevented with better tool design. An end clearance of 0.025 inch was used between the cap and core end. No collapse of the can occurred at this point during autoclaving. Autoclave duration was 150 hours in flowing 350 C water. Heliarc welds on three of the specimens were not corrosion resistant. Vacuum electron gun welds on the remaining three were corrosion resistant. Uranium rods with 0.007 inch stainless steel clad suffered clad wrinkling and collapse under the same conditions.

Four seven-rod cluster fuel elements were fabricated for the second KE through-hole irradiation. In one fuel element were installed two

thermocouples to measure the central core temperature of two rods. These fuel elements were made from 1.3% enriched uranium rod 0.500 inch in diameter and clad unbonded in 0.030 inch stainless steel jackets. Goal exposure for this irradiation is 2500 MWD/T. The calculated core temperature is 350-400 C at 85-100 kw/ft specific power.

Restraint of Uranium Swelling by Zirconium Cladding. Data have been reported on the swelling rates of unrestrained uranium irradiated in the 400-500 C and 600-700 C temperature ranges. To date no data are available on the swelling of unalloyed uranium restrained by high strength cladding and irradiated with a 300-350 C cladding surface temperature and a maximum fuel temperature in the range 450-600 C. An experiment planned for irradiation in the MTR was not charged as planned because of the failure of a mechanical water tight seal on the experimental assembly. A second assembly is now being built with the same basic design as the first except for the use of stainless steel instead of Zr-2 for the capsule material. This will enable all seals to be welded, reducing considerably the chances for reactor water coming in contact with the NaK in the capsule. The fuel rod in the capsule will be irradiated with calculated surface temperatures of 300-350 C to an exposure of 2500 MWD/T.

Truline Washers. One of the methods being developed for the fabrication of Truline washers is the upsetting of rod stock. The chief advantages of the method are: (1) scrapless production of washers with accompanying economy, and (2) built-in Truline feature eliminating additional fabrication. An experimental die set was designed and fabricated to test the feasibility of upsetting 11/16 inch diameter rod to KER-size washers (1.696-inch outer diameter). Rod blanks, 0.686 inch diameter, 2 inches long were beta heat treated at 730 C, water quenched, and vacuum annealed at 600 C to produce a fine-grained, stress-free, low-hydrogen material. Alpha rolled, recrystallized stock of the same dimensions was also tried. The blanks were preheated in oil to 350 C, but the die set was not heated. Pressing to 100 tons produced approximately 65 percent height reduction in the as-rolled material and approximately 72 percent in the heat treated stock. The as-rolled stock produced a square upset section due to the orientation of the rod and tensile cracks were present on the flats of this section. The heat treated stock did not completely fill the die cavity with this pressure. It appears necessary to preheat the die set and use higher pressures to produce the desired 84 percent height reduction. Provision is being made to heat the dies with heat lamps.

Thermal Conductance of a Contact Between 2S Aluminum and Zircaloy-2. Preliminary experiments have shown contact conductance of a 2S aluminum - Zircaloy-2 joint to be related to the direction of heat flow through the joint. The contact conductance is greater in the case of heat flow from 2S aluminum to Zircaloy-2 than when the flow is from Zircaloy-2 to 2S aluminum. Conductance values in the former case were similar to those of metallurgically bonded materials. Pressure at the contact surface was maintained at a constant 940 psi. All joints had surface roughnesses of 6.5 microinches root-mean-square. The aluminum specimens, calibrated by the National Bureau of Standards, were used for heat flux meters. Conductivity of Zircaloy-2 was evaluated from measurement of the temperature gradient in the Zircaloy-2 specimen.

Advanced Studies Program for Tritium Production. The increased severity of operating conditions in advanced design reactors requires that a special study be made of the feasibility of producing tritium in these reactors. A proposed design for a tritium-producing element consists of an aluminum clad-Al-3.5% Li alloy rod separated from a concentric fuel bearing tube by an annulus of coolant water. The coolant is expected to be near 300 C. Two aluminum alloys for cladding the tritium-producing inner rod meet the requirements of low neutron cross section and show promise of meeting the requirements of low corrosion rates and low permeability to gases produced in the target material. In the initial phase of the experimental work it is planned to investigate the permeation rates of hydrogen through these alloys. Samples of these alloys have been received and are being rolled to the desired thicknesses preparatory to making gas permeation specimens from them. A device to permit experimental determination of permeation rates has been completed and is being helium leak tested to determine the integrity of its gas seals.

Input data, based on the proposed tube and rod design, is being prepared for the IBM 650 to calculate the ratios of neutron flux in the fuel and target, as compared to those in the K Reactors, for several combinations of target rod diameter, inner and outer coolant annulus thicknesses, and fuel tube thickness. From these flux values calculations will be made to determine the approximate heat generation in the fuel and target and the amounts of tritium generated.

High Temperature - High Pressure Bake Testing of Fuel Elements. As was mentioned in the last monthly report, spectrochemical analysis of the can wall of an AlSi bonded fuel element that was bake tested 1500 hours at 450 C indicated that diffusion had taken place so that 50 ppm U at the surface of the element cladding was observed. The AlSi bonding layer had also disappeared as the Si had homogenized in the aluminum and had perhaps diffused into the uranium. Alpha track autoradiographic techniques have indicated a diffusion of uranium into the cladding, but quantitative measurement has not yet been possible. "Hot spots" were observed in the aluminum cladding by this technique, but it has not been determined as yet whether these were produced by the effect of diffusion or by specimen contamination during sample preparation.

Metallographic examination of the baked specimen verified diffusion into the uranium as evidenced by the formation of a 0.020" thick alloy layer. The AlSi braze layer was also observed to be gone with only remnants of the eutectic structure and "sluffed off" bonding layer particles remaining. Spectrochemical analysis of the exterior surface cladding of a cold pressed Ni plated uranium fuel element baked at 450 C for 212 hours revealed no detectable U or Ni diffusion to the surface. Additional tests and analyses are being made to quantify the effects of time and temperature at the bake test pressures on diffusion in fuel elements.

Bake testing of I & E wafer fuel elements at 240 C and 500 psi and 340 C and 1200 psi is being done to determine the effect of these conditions on dimpling due to AlSi porosity and yielding of the aluminum cladding at or near wafer interfaces or fuel element bulkheads. The only effect noted

after 75 hours at 240 C and 500 psi was a slight indentation in the cladding at one wafer interface or bulkhead. The test is being continued at the second set of conditions, 340 C and 1200 psi.

Lithium-Aluminum Fuel Element Closures. Considerable difficulty is usually encountered in closing lithium-aluminum elements by standard production welding methods; therefore, it was decided to investigate the feasibility of closing them by electron beam vacuum welding. Four elements were closed; three had been sized after assembly and one had not. The internal and external welds were completed and appeared satisfactory although there was some spatter on the element which had not been sized. Radiographic examination showed the welds to be sound. Micro examinations are now in progress. Tentatively, it appears that this is an acceptable method of closing lithium-aluminum fuel elements.

Vacuum Melting Furnace. The induction heating section of the NRC vacuum melting and casting furnace has been placed in operating condition. A melt of uranium metal was made while operating at optimum operating conditions. On the basis of this successful melt, the furnace was considered acceptable. Installation of the centrifugal casting mechanism is now in progress.

Fuel Element Design Handbook. The Fuel Element Design Handbook, which is a handbook intended to describe factors and data used in designing reactor fuel elements, is under preparation. Thus far, only Chapter 700 on Thermal Stresses is ready to be published. A draft of this chapter has been given limited circulation in order to obtain declassification and suggestions in regards to its organization and material content. A first review of Appendices A100, A200, A300, and A400 is completed and revisions are being written. The first rough draft of section 201 on Uranium Fuel Material is almost completed. This particular section is of importance because its form and content will serve as a guide for other sections of Chapter 200 on Fuel and Fertile Materials.

2. REACTOR PROGRAM

Coolant Systems Development

Ex-Reactor High-Temperature Studies. Operation of ELMO-2 continued at 180 C and a pH of 4.0 adjusted with H_3PO_4. This test, to determine the effects of operating at low pH and moderate temperatures, has been in progress for 4-1/2 months. Examination of the sensitized and non-sensitized 304 stainless steel coupons disclosed no intergranular corrosion. After three months, the corrosion rates of M-388, M-400, and M-457 alloys are all 0.09 mil/year. The M-257 and X-2219 alloys have corrosion rates of 0.2 mil/year after the same period.

ELMO-3 is a new loop for testing rupture behavior of fuel elements. This loop when completed will replace the present ELMO-4 which is inadequate and does not meet code requirements. The drawings for the fabrication of the ELMO-3 have been completed. Construction materials that were not on plant were ordered and will be on plant by the end of December 1957. The canned motor pump originally intended for the loop, to permit simulation

of KER flow rates, will not be available for about four months. When this pump does arrive, it may be more desirable to use it in the ELMO-7 loop. However, fabrication of ELMO-3 will proceed and a smaller pump capable of 25 gpm will be used until the larger pump is available.

ELMO-4 was idle during the month. It is planned to use this loop to test rupture behavior of fuel elements until ELMO-3 is ready to operate, probably around the latter part of January.

A test was started in ELMO-5 to determine the effects of operating at high pH. This test will essentially be a pilot test for operation of the carbon steel in-reactor loop (KER-1). The two important variables being studied are corrosion of zirconium, stainless steel, and carbon steel and crud formation. An operating pH of 10 was chosen because this pH is considered to be the optimum for systems containing zirconium and carbon steel. The pH will be adjusted with LiOH. The first test at 290 C has been in operation two weeks. The carbon steel samples (SA 212, 1032, 1051) are all in excellent condition. Sensitized and non-sensitized 304 stainless steel also appear in excellent condition. Previous operation of the loop has been with varying SiO_2 concentration. The concentration has now been decreased to normal. Replacement strip heaters were obtained for the line heater. These heaters will enable the loop water temperature to be maintained more consistently.

Corrosion tests were started in ELMO-6 to determine the corrosion rates of selected aluminum alloys under conditions presently assumed to be ideal. These conditions are: pH = 4.5; concentration of H_3PO_4 = 7 ppm; ratio of aluminum surface to volume of water = 450 cm^2/gal. The alloys being tested are A203X, M-388, X-2219, M-400, M-198, and two alloys based on those developed by the AECL and ALCAN. The present test at 300 C has been in progress two months. The corrosion measurements of all the alloys being tested are within the limits of error of the weighings; accurate rates are not determinable after such a relatively short exposure under these conditions. Coupons of the alloys obtained from the Hunter-Douglas Company (A-1, A-2, C-1, and C-2) were charged into ELMO-6 to obtain corrosion data. The test will run concurrently with the existing test.

ELMO-7 is presently being used for testing behavior of NPR, KER, and PRPR fuel elements and for testing flow characteristics of PRPR fuel elements. After 20 days exposure at 240 C, slight depressions were noted on the Elephant and Cow slugs. Examination showed that the metal was pushed into voids in the AlSi layer. The ELMO-7 45-hp Byron-Jackson canned motor recirculation pump failed in ordinary steady state operation at 240 C. From all electrical tests made, apparently the stator winding has burned out. If this is the case, Byron-Jackson representatives say that from 90 to 120 days will be required for repair. The pump is being removed from the loop for shipment to the Los Angeles Byron-Jackson plant. The pump will be replaced with the small 10 hp Byron-Jackson pump originally intended for use in the ELMO-3 slug rupture test loop. Present plans are to return the ELMO-7 loop to limited service by the end of December 1957.

Several changes in the ELMO-8 instrumentation were approved. A delay in securing high pressure valves for the loop probably will delay shipment of the loop about two months or until September 1, 1958.

The test to determine the effect of operation at low pH and high temperatures was continued in ELMO-9. Operation at 250 C and pH 4.0 with H_3PO_4 was temporarily halted to replace a loop heat exchanger which developed a leak. A crack has been observed in the piping exposed to cooling water. Metallographic examination will be made to determine possibility of stress corrosion cracking.

Preliminary estimates were completed on the cost of setting up the 3706 Loop in 185-D Building and adapting it to test rupture behavior of fuel elements under heat transfer conditions. This estimate totaled $36,000. As soon as funds are approved, the work will be started.

High Temperature In-Reactor Loop Tests. The conversion of KER-1 to test operation as a zirconium-carbon steel loop continued. The Zircaloy-2 process tube is ready to be installed.

The KER-2 loop was operated with Cow slugs at an average outlet temperature of 175C and a pH of 4.5 with H_3PO_4. It was discharged after 96 operating days. The loop was recharged with lead-dip canned Elephant slugs and will operate at 235-240 C at a pH of 4.5 for two months. Examination of the Cow slugs is in progress. The loop was on process water twice during the month, one time for 19-1/2 hours to make alterations in the service water supply line and the other time for discharging and charging of fuel elements.

The KER-3 loop has operated for 61 days at an average outlet temperature of 224 C with stainless clad cluster elements. Exposure to date is 520 MWD/T. The loop was on process water three times during the month for a total time of 35 hours. The periods on process water were caused by (1) a loose fuse connection in the flow transmitter caused a variety of circumstances which caused the loop to dump, (2) alterations to the service water supply line, (3) 105 Operations neglected to reset the flow instrument after a tube pressure test and the loop dumped. This loop caused two reactor scrams during the month. The first incident was caused by the loose fuse connection, and the second occurrence was caused by an instrument mechanic removing a thermocouple without bypassing the trip.

The corrosion measured on the M-388 clad Cow slugs from the KER-4 loop after 62 days exposure at 190 C and a pH of 4.5 with phosphoric acid was too low to be measured with accuracy. The loop remained out-of-operation during the month so the canned motor pumps could be repaired. Impellers in both pumps are to be replaced with the new balanced impellers by the end of December 1957. It is hoped to have some hot-pressed Elephant slugs to charge into the loop the first part of January 1958.

Organic Coolant Studies. ORA-1 was discharged for inspection after two weeks operation at 700 F. Samples of 2S and M-257 aluminum, carbon and stainless steel, and Zircaloy-2, all appeared to be in excellent condition. There was no sign of any distortion on the hot pressed, nickel diffusion

barrier fuel elements or the graphite diffusion barrier element. The magnesium coupons were extensively attacked by the traces of water in the MIPB. A second two-week exposure period will be completed by the end of December 1957.

The Santowax OM run was terminated in ORA-2 and all scheduled testing is completed in this loop. The loop will be dismantled at some as yet undecided date. An improved procedure was devised for analyzing the irradiated eutectic and Santowax OM. The tars are distilled from the mixture, and the distillate is analyzed by infra-red methods.

ORA-3 operated almost continuously throughout the month. There have been no indications of heater coking.

The design scope and cost estimate of ORA-4 using a side test hole has been completed. Three scope drawings, SK-1-2205, SK-1-22063 and SK-1-22064, were issued. The cost estimate using solid coolant is $100,000 and using liquid coolants about $94,000. It was decided to also scope and obtain a cost estimate using a front-to-rear test hole. This has some obvious advantages.

Gamma irradiations of MIPB are now completed up to exposures of 6×10^9 R. The rate constant for gamma decomposition has been determined to be 6×10^{-11} per Roentgen. Tests are continuing to determine if various commercial lots of MIPB all behave similarly.

Low Temperature Corrosion Studies. Production Test 105-550-E, to determine the effect of pH on corrosion of fuel elements and components in present reactors, continued during the month. The metal from four tubes operating at 6.0, 6.5, and 7.0 was discharged for examination. Weighed metal was charged into the tubes for the next phase of the test.

Tube #2943-KE, charged with dummy slugs containing flux-monitoring gold foils, has operated for 40 days at 110 C outlet temperature. The test is scheduled for approximately 90 days exposure. Fifteen foils have been recovered from the first charge. Work is in progress to recover as many as possible of the nine remaining foils. The four-inch dummies from this first charge were inadvertently disposed of in the burial ground.

Under certain conditions in the reactor (high temperature and/or long exposure), excessive pitting of the M-388 has been noticed. The pitting occurs principally on the end piece and appears to be related to some combination of the geometry, pressure, temperature, and corrosive conditions of the reactor. In an attempt to duplicate this pitting out of the reactor, a BDF tube was placed in the 1706 mockup assembly and was charged with alternating M-388 and 1245 clad fuel elements. The tube is being operated at 120 C with an inlet pressure of 250 psi and an outlet pressure of 45 psi. The pieces have been exposed for about 60 days of a total planned 150 days exposure.

A second set of four steel samples was removed from the buoyant sample rack in 107 KE "A" basin. These samples have not yet been weighed. The plastic "float" bottles (which became brittle and cracked, permitting the

rack to sink) were replaced with welded aluminum pontoons. One of the steel chains had broken, but the other chain was still strong enough to support the full weight of the rack. Both chains were replaced. All stainless steel, aluminum, and teflon portions of the rack are still in excellent condition, and polyethlene spacers (which were protected from direct sunlight) are in good condition.

Service Work. One nickel plated slug and one slug with 1/2 inch wide zinc rings on each end were discharged and visually examined. The nickel plated piece showed no adverse effects even though the plating did not cover all of the aluminum surface. However, the zinc rings of the other slug failed due to improper bonding to the aluminum jacket. These pieces are designed for in-reactor studies for controlling reactivity.

Two corroded sensing chambers from K water plant differential pressure cells were received from IPD, with a request for information as to possible causes of the pitting corrosion and recommendations for prevention or control of this attack. These sensing elements are apparently aluminum. Samples of gelatinous material found in these chambers have been analyzed spectrochemically. Results of these analyses show appreciable amounts of silicon present. This indicates that the gelatinous material contained activated silica (sodium detection was not attempted). The damaged elements will be sectioned and pitted areas will be examined. Alloy material and the presence of activated silica will be confirmed by further analyses. No prevention or control recommendations can be made at present.

Testing was continued in ELMO-1 to determine the rate of film build-up on heat exchangers cooled with raw water. After four months operation, a slight build-up of scale was noticed, but no decrease in heat transfer coefficient was observed. The test is scheduled to continue for 12 months.

Decontamination Studies. A test is being started to evaluate corrosive effects of decontaminating solutions which may be used in the present reactors, the PRPR, or the NPR. All tests so far indicated no excessive corrosion from the use of Turco. The tubes are being decontaminated and descaled for closer study.

Thermal Hydraulic Studies

Flow Hazard Studies. Experimental heat transfer studies of the responses of reactor process tube assemblies to imposed hazardous operating conditions continued. Experiments were made simulating the transient response of C-Pile I & E fuel elements in a C-Pile process tube to sudden step reduction in flow of amounts from 20 percent to 85 percent of normal flow. Tube powers for these tests were 1250 KW and 500 KW and the initial bulk outlet water temperature in each case was 125 C. The data indicated that with the 2-1/2 second delay between time of Panellit trip and start of effective power reduction, the surface temperature of the simulated fuel elements did not exceed 350 C, even for the case of an 85 percent flow reduction. In all cases the pressurization within the process tube after flow reduction was not great; this indicates that a high pressure Panellit trip backup in case of sudden and severe cone screen plugging is not present, and a low pressure Panellit trip is essential.

There were a few significant differences between the results obtained with the test section simulating I & E fuel elements and those obtained previously which simulated solid slugs. The initial decrease in Panellit pressure after a flow restriction upstream of the Panellit tap was not as great for the I & E case as for the solid slug case. This was attributed to a greater amount of boiling at the top of annulus resulting from the eccentric position of the I & E element in the process tube. Also different for the I & E case were pressure fluctuations attributed to boiling conditions which varied with recurring heat shifts between hole and annulus. It is thought that as boiling commenced in one flow channel, an increased pressure drop in that channel caused a tendency for a reduction in flow leading to higher temperatures and more boiling. The higher temperatures in turn caused a heat shift to the opposite channel which caused increased boiling in that channel as boiling conditions in the first channel were alleviated. The resulting pressure fluctuations were small in magnitude and fairly rapid.

Reduction of the large magnitude of data associated with the transient experiments was made easier with procurement of an automatic data reducing machine. It appears that time required to read data charts will be reduced 50 percent or more with this new apparatus.

Hydraulic Studies. Laboratory data were obtained of the relationship between pressure drop and flow for undersize I & E slugs for BDF type reactors. The data which were reported in HW-54218, show that these proposed fuel elements have only about 59 percent of the pressure drop of a comparable solid slug charge. However, preliminary approximations show that critical flow conditions in the outlet fittings will restrict the normal tube flow to about 47 gpm with a normal front header pressure.

Data were obtained which extended the critical flow data for BDF type rear fittings from 40 gpm to about 52 gpm. The data indicated that the pressurization in the rear fittings is appreciable at high flow rates. For example, at 120 C it takes a rear header pressure of 79 psig to prevent critical flow at 46 gpm.

Calculations were made to determine the flow split in a special train of I & E slugs in a K tube with a 1/8 inch cable running through the holes. This train, made up to C-type I & E slugs preceded and followed by mint slugs, will be pulled back and forth in the tube for front to rear flux control. Results of the calculations indicated that the annulus to hole flow split would increase from 2.61 to 4.7 for C I & E slugs in a K tube and that boiling within the hole could be prevented by using a shortened slug train.

Work was continued on possible test section designs for studying flow and heat transfer using seven-rod fuel elements. One design which was completed and is being constructed consists of 0.625 inch rods spaced 0.05 inch apart. These rods, 42 inches long, are made out of Hastalloy "C" metal. Thermocouples are to be installed in milled axial slots on the outside of the heater rod. Other designs with different sized rods were made and will allow the spacing between rods to be adjusted. The use of Hastalloy in these test sections is new and, although the material is difficult

to machine, it has a high electrical resistance that changes very little with temperature.

Operation of the high pressure electrical heated apparatus was resumed after installing a Byron-Jackson canned motor pump. However, after one day of satisfactory operation, a leak developed between the process fluid and the cooling water. After it was determined that a stress crack had developed in the steel head separating the two liquids, the manufacturer's representative advised repairing the crack by welding.

Organic Heat Transfer Studies. A new flow control system composed of various sized needle valves was fabricated and installed in the organic heat transfer apparatus. In addition, a new disc type filter, designed to remove all particles 40 microns or larger, was installed immediately upstream of the flow meters. Trouble was experienced with one of the Potter turbine type flow meters in that the bearings had become "gummed up" during previous operation. It was found that normal operation could be restored by cleaning with benzene.

Mechanical Equipment Development

Organic Cooling Systems Components. The organic test facility (MOTS-1) operated for a period of 200 hours during the month at temperatures up to 175 C. The Dura Seal Type PT Mechanical Seal operated for a period of 45 hours with a leakage rate up to one pint per hour. Increasing the rotating speed of the seal from 2000 to 2400 rpm increased the leakage rate to an intolerable value. Examination of the seal revealed that the graphite sealing surface has started to wear. A seal housing is now being adapted to test a John Crane seal (Type 9).

The extra heater for the organic facility was fabricated and will be installed shortly. The heater consists of two sections of two-inch pipe in series and contains six 2-1/2 KW calrods.

The fabrication of the organic fire test apparatus was completed. The fire tests will be conducted during the month of January.

Irradiation Test Engineering

Shielding Studies. Foil data for the magnetite concrete heated to 200 C were analyzed and curves plotted for attenuation traverses and side to side traverses. The fast neutron relaxation length increased by about five percent compared with the 100 C case. Intermediate energy neutron leakage increased, as indicated by measurements made with the lucite integrator, but the increase was not significant in terms of dose rate. Transverse streaming seemed about the same as in previous tests. The magnetite slabs were heated to 300 C, and the irradiation for the first test was completed. A second foil loading was installed, but most of these foils will not be counted unless the data from the first test are inadequate or erroneous.

Two ordinary concrete experiments were run last month. The foils from the first experiment have been counted and the data sent to IBM for processing. The foils from the second experiment are currently being counted.

A design test proposal for attenuation measurements on ferrophosphorous concrete was issued (HW-54166). The test slab design was revised so that all test slabs were made eight inches thick with slots through the middle and on top to receive foil holders. The new design requires only a total of six slabs to fill the test well as compared to 11 slabs required in the previous design; thereby, facilitating slab loading and unloading. The test slabs were poured and are currently being cured.

The literature survey on irradiation damage to concrete was completed. A report on the survey results is being prepared.

The construction of the thermal shield tanks was completed. Fabrication of crates to contain the aggregate under test was started and is 70 percent completed. A method of loading foils into the shield tank was developed and tested. Installation of the tank is scheduled during the month of January. A detailed test description is being prepared.

At the request of the Reactor Modification Design Development Operation, attempts were made to obtain the neutron leakage associated with a VSR assembly of a new design to be installed in the 105-KE Reactor. The neutron flux was too high for the equipment on the first attempt. A new, less sensitive tube was found to be defective during the second attempt. A measurement will be made of the neutron leakage after the installation of the VSR assembly.

The 7/8" gold foils used in attenuation tests have weight differences as large as 10 percent. To compensate for the weight differences among the foils, weight correction factors were applied to the measured activity of the foils. To establish the validity of applying a weight correction factor, twenty 7/8" gold foils whose weight varied as much as 10 percent have been irradiated in the same neutron flux in the 305 Pile. The measured activity from these foils varied only 1.8 percent, thus showing that no weight correction need be applied to the measured activity.

To obtain the desired attenuation data from test slabs, a minimum of two foil loadings was required. The first loading consists of bare and cadmium covered gold foils. The second loading consists of bare gold and cadmium covered sulfur foils. A test was performed in the 305 Pile to determine if a gold foil and a sulfur foil can be enclosed in the same cadmium cover without distorting the resonance flux. The test showed that there was no distortion of the resonance flux within ± 1 percent; hence, it is possible to combine the two foils into one loading. Combining loadings in this manner effectively reduces the time for attenuation measurements by a factor of two.

Nonmetallic Materials Development

Thermocouple Development. Insulation resistance of a duplex silicone-impregnated, asbestos-insulated, chromel-alumel thermocouple and a similarly insulated iron-constantan thermocouple were measured before and after laboratory exposure in an inert atmosphere at 627 C. Corroborating previous results at Hanford and elsewhere, the insulation resistance of the chromel-alumel thermocouple pair dropped from 200,000 to 120 ohms in eight hours; the iron-constantan dropped from 130,000 to 42 ohms after the same exposure. However, after passing oxygen through the furnace at 600 C, the insulation resistance increased again to greater than 1000 Meg-ohms. The initial drop in resistance is believed due to the thermal cracking of resin impregnants in the insulation, leaving a conducting residue of carbonaceous and/or other degradation products. This would explain many of the thermocouple failures which have occurred in the Hanford production reactors. Restoration of the high resistance by the passage of oxygen at 600 C is explained by oxidation of the conducting residue.

Five IP-103A experimental thermocouples have been delivered to IPD for installation in D Reactor in mid-January. Four are chromel-alumel couples, three of which are insulated with vitreous alumina and one with porcelain, the other is a Geminol couple with vitreous alumina insulation.

Thermal Conductivity Measurements. Graphite samples are being machined for the cylindrical radial flow method and also the spherical envelope method of measuring thermal conductivity. Measurements are being attempted on virgin TS-GBF graphite in the comparative method apparatus. All of these methods are designed to measure thermal conductivity at high temperature.

High Temperature Graphite Irradiations. The GEH-9-6 assembly was charged into the MTR L-42 position December 9 for a three-cycle irradiation (Cycles 97, 98, and 99). This schedule was obtained for Hanford after it became apparent that KAPL-37-2 would not be ready in time to occupy the facility as previously planned.

Control temperatures of 1025, 975, 750, 750 C were realized after startup. With the exception of the 1025 C sample, all samples are at the predicted temperature of control; the fourth unit (1025) was intended to be twenty-five degrees higher, but insufficient gamma heating was available to maintain the higher temperature without risking burning out the resistance heater on this sample. The principal limitation at these temperatures is the melting point of the platinum heater which operates at several hundred degrees above the sample temperature when at maximum power. This necessitates conservative power ratings to prevent heater burnout. The 975 degree control point was selected so that a contraction rate comparison could be made with the previous 975 degree irradiation in GEH-9-5.

The control units for the Hanford graphite irradiations (IP-22A) are 70% complete and will be ready for testing next month. This equipment will control irradiation temperatures in the range 30 to 400 C.

Low Temperature Graphite Irradiation. Near saturation of the physical distortion of CSF graphite caused by irradiation at 30 C has been observed for the first time in samples recently discharged with an accumulated exposure of 5725 MD/T. This occurs in both parallel and transverse cut samples. The rate of expansion of transverse samples apparently decreases after 4500 MD/T and saturates at about 3.2 percent expansion near 5500 MD/T. Contraction of parallel samples exposed at 30 C saturates at about -0.9 percent length change. Further confirmation of these data will be made in the near future when samples with an exposure in excess of 7000 MD/T will be discharged.

Chemical Studies of Irradiated Plastics. Results of radiation catalyzed oxidation of Irrathene 101, 201, U-101 and U-201 have been obtained. The 201's contain an antioxidant; the U-101 and U-201 are polyethylene materials similar to those used in making the Irrathene but have not received the electron irradiation.

Carbonyl Absorbance in Polyethylene

Sample	Thickness (mils)	Radiation Dose, Roentgens (None)	5×10^6	10×10^6	50×10^6	100×10^6
U-101	5	0.029*	0.047	0.136	0.788	1.13
U-201	5	0.039	0.066	0.106	0.750	1.01
Ir-101	10	0.052	0.135	0.215	0.755	1.17
Ir-201	10	0.058	0.090	0.171	0.635	0.863

*Note: Absorbance numbers are approximately proportional to carbonyl present.

In general (correcting for thickness differences) it is observed that the 101's oxidize more than the 201's as expected. Furthermore, the U-101 and U-201 oxidize more than the Irrathenes, indicating that the initial crosslinking done in making the Irrathenes has increased their oxidation resistance. The magnitude of the two effects in preventing oxidation, i.e., presence of antioxidant and initial crosslinking, seems approximately equal.

A sample of Macrofol (a polycarbonate) irradiated in air and in vacua to a total dose of 1×10^8 shows identical hydroxyl increase. Hence, it is concluded that a chain clevage reaction occurred in both cases rather than an air oxidation.

The mass spectrometer results on polyvinylchloride show a large evolution of CO_2 which would come from the plasticizers present in the material. It is significant that no chlorine gas or compounds were evolved indicating no appreciable attack of the main polymer chains. This is substantiated by physical property data.

The mass spectral clevage pattern of three types of polyethylene indicates the effect that crystallinity has on radiation stability. This is shown in the following table:

Evolution of Hydrocarbons from Polyethylene

Material	Mass	H_2	CH_4	C_2H_x	C_3H_x	C_4H_x	C_5H_x	C_6H_x
Marlex 50+	%	97.8	0.1	1.1	0.4	0.1	-	-
Alathon 3, NC-10	%	97.5	0.09	1.1	0.6	0.4	0.1	0.1
Irrathene 101	%	96.88	0.28	2.32	0.22	0.26	0.03	-

+Due to incomplete vacuum, 0.5% (O_2 + N_2) found.

The highly crystalline (~95%) Marlex 50 shows little evolution of gases in the C_4 - C_6 range. Evolution of these hydrocarbons is attributed to side chain branches which would be lacking in the crystalline material. The low evolution of these gases in Irrathene is attributed to the crosslinking of these side-chain branches with the initial radiation that the material received. The effect of crystallinity on other chemical changes, i.e., oxidation, is being investigated as well as application to mechanical properties.

Radiation Vulcanizing. Preliminary results indicate that gamma vulcanizing of silicone elastomers significantly improves their resistance to immersion in high-temperature sealed water systems. This method eliminates the chance for residual catalyst reacting with the polymer as is the case when the materials are vulcanized with heat and conventional peroxide catalysts. Radiation curing also eliminates the necessity of a 24-hour post heat cure at 480 F.

Structural Materials Development

Zircaloy-3 B-D-F Process Tubes. Inspection of the eight tubes received during November from the Superior Tube Company is continuing. Although eddy-current tests revealed possible flaws in all tubes, single and double wall radiographs indicated that there were no cracks or discontinuities in the tubes. Testing with a Vidigage (ultrasonic resonance) instrument disclosed thinning of the wall in selected areas by as much as 10 to 15 percent of the nominal wall thickness. These periodic thin spots are now believed to be the explanation of the eddy-current "flaws", and are not considered serious enough to prevent installation of the tubes in the Hanford reactors. Based on an analysis of all test results, it is concluded that these tubes should be suitable for in-reactor experimental use.

Thirteen additional extrusions, equivalent to a maximum of 26 finished BDF tubes, were tube reduced, inspected, and annealed during the month. The final tube reducing operation is in progress, and if successful, contract DDR-5 should be completed by early February 1958.

The Allegheny Ludlum Steel Corporation has processed 15 extrusions through the first of four tube reducing steps. These tube blanks are being inspected, conditioned, and vacuum annealed prior to the second tube reducing step.

NPR Type Process Tubing. Zircaloy-2 ingots were shipped to the three companies who will endeavor to fabricate process tubing of the type to be used in the new high temperature reactor. Design and fabrication of tooling is progressing at Reactive Metals and Allegheny Ludlum Steel Corporation. Chase Brass has produced short extrusions suitable for initial welding experiments. These welding experiments demonstrated the need for improved dry box design and construction of larger capacity welding equipment.

KER Type Process Tubes. Ten "ribless" extrusions have been tube reduced to size. Surface condition of all tubes is satisfactory although the smaller cold reductions produce the best surface finishes.

Advance Studies

Fluidized-Bed Reactor. The H_2O fluidized pellet-bed reactor concept proposed by C. Anderson and further studied by E. R. Astley and L. Johannesen is currently under investigation. Study to date indicates a need for a better determination of fluidizing velocities required for various possible water entrance jets. Reactivity change during the exposure of the initial fuel loading is to be investigated with a machine program, and the results will be compared with the values reported by Astley.

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 Radiation Laboratory (Project Whitney). Details of these activities are reported separately via distribution lists appropriate to weapons development work.

C. CUSTOMER WORK

Corrosion and Coatings

H Reactor Rear Face Pigtails. The corrosion of several stainless steel pigtails from the rear face of H Reactor is being evaluated. These pigtails were cleaned on the reactor with Turco 4306 B (a sulfamic acid-sodium chloride-ammonium fluoride cleaner) on September 23, 1957. The pigtails were removed from the reactor November 18. The purpose of the investigation is to determine whether any serious damage was done to the rear face piping by the cleaner. The fatigue life of one of the pigtails as determined on a fatigue test machine was comparable to a new pigtail under the same conditions. The examination of the pigtails by an eddy-current testing device which is being developed showed two pigtails with possible corrosion areas. These areas are being evaluated by metallographic techniques.

Radiometallurgical Examinations

Hot Spot Failures (RM 196). The examination, requested by IPD Process Analysis Operation, of four hot spot failures from KE Reactor was continued. All of the slugs are 1/2" cored natural uranium, canned in 1245 aluminum alloy jackets.

Failure No. 831 was one of two slugs selected for detailed examination. It was irradiated in tube 1480-KE to an exposure of 532 MWD/T, at an average tube power of 1092 KW. A transverse wafer was sectioned from the hot spot zone for metallographic examination. The jacket was found to be severely undercut for about two-thirds of the circumference. The uranium within the undercut portion reached temperatures well above the beta transformation temperature, while that in the bonded zone did not exceed this temperature. A large group of macro-voids was observed between the edge of the core and hot spot. Numerous micro-voids were also found distributed throughout the heat-affected zone. These voids apparently resulted from the nucleation and growth of fission gases at temperatures estimated to be in excess of 900 C. No evidence of melting was observed. The unusually high temperatures reached by this slug and the consequent formation of fission gas bubbles in the uranium appear to be responsible for the release of radioactive gases in the reactor storage area which was observed following the discharge of this piece.

Additional iron analyses of 1245 aluminum jacket samples from hot spot failures were completed by Analytical Chemistry. The results are tabulated below:

Failure No.	Tube No.	Exposure, MWD/T	Can Mfg.	Wt. % Fe
831	1480-KE	532	Alcoa	0.21
863	3572-DR	208	Hunter-Douglas	0.17

Examination of Ruptured Slug from 1178 KE (RM 202). With examination of the ruptured slug from 1178 KE completed, IPD requested examination of a second non-ruptured slug with similar in-reactor experience to determine whether beta phase transformation temperatures were reached in the core. The non-ruptured slug was irradiated to 515 MWD/T in 2374 KW and was discharged August 27, 1957. The slug was badly warped for a distance of 3-3/4 inches from the cap end. Maximum warp was 60 mils ± 10 mils at two and one-fourth inches from the cap end. Metallographic examination of a wafer removed from the center of the slug revealed an area 0.425 inch in diameter at the core of the slug which had operated at or near uranium beta phase temperatures. The recrystallized area was cross hatched with both macro and micro cracks.

Metallography Service

Laboratory tests have been completed on the Buehler automatic polishing attachments which are mounted in a glove box to facilitate polishing of metallographic specimens of low to moderate levels of radioactivity. Most metals can be polished to a specular finish successfully with the machines; however, aluminum and other soft metals require that an additional manual polishing step of five to ten minutes duration be used. This should not pose any problems of radiation over-exposure to the operators' hands, however, since generally adequate shielding is afforded by the bakelite mounting material used to contain the specimens.

Samples Processed During the Month

Total samples processed: 148

Photographs:

Micrographs	146
Macrographs	58
Total	204

The following Trips and Visits Reports apply to activities on 2000, 3000, and 4000 programs. Technical activities on the 4000 Program are reported separately in HW-54284 A2.

F. W. Albaugh

Manager, Reactor and Fuels Research
and Development Operation

FW Albaugh:kb

VISITS TO OTHER INSTALLATIONS

Name	Dates of Visit	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
HJ Pessl	12/2-4	General Cable Co., Bayonne & Perth Amboy, N.J.	Participate in cable cladding experiments	--	No
	12/5-7	Verson Allsteel Press Co., Chicago, Ill.	Discuss aluminum jacketing production methods	F Zapf	No
		Clearing Machinery Co., Chicago, Ill.	" "	Mr. Bannon	No
		Danley Mach. Specialties, Chicago, Ill.	" "	--	No
GT Geering	12/2-6	Nuclear Metals, Inc., Cambridge, Mass.	Engineering consulting on present development contract	HR Sawyer	Yes
KR Merckx	12/3	Combustion Engineering, New York, N.Y.	Discuss methods of analyzing stresses & high temp. & pressure eqp't.	F Acker	No
	12/4	Foster Wheeler Co., New York, N.Y.	" "	W Goodman	No
		Babcock & Wilcox, New York, N.Y.	" "	DR Wilson	No
	12/5	M. W. Kellogg Co., New York, N.Y.	" "	--	No
	12/6	ASME, New York, N.Y.	Present paper	--	No
	12/9	ANL, Lemont, Ill.	Discuss mechanical testing of fuel elements	P Lattes	Yes
WV Cummings	12/11-12	duPont, Savannah River Plant Aiken, S.C.	Mtg. of Working Committee of Fuel Element Comm.	VI Montenyohl	Yes
DC Kaulitz	12/11-12	Raymond A. Wolf Assoc., Bloomingdale, N.J.	Discuss ETR high pressure loop discharge facilities & vacuum welding eqp't.	RA Wolf	No
	12/13	Vitro Corp., New York, N.Y.	" "	--	No
JE Minor	12/12-13	BMI, Columgus, O.	High temperature fuels conference	F Rough	Yes

it	Personnel Contacted	Access to Restricted Data
experi-rtup	Mr. Phillipson	Yes
	AS Richardson	Yes
conium	DK Crampton	No
	--	No
of nerator	FD Acker	No
	WG Slack	No
	RA Beck	No
	EB Schrengauer	No
	WR Weaver	No
	--	No
re eqp't.	PA Lottes	Yes
luminum	R Scott	No
minum	RFS Robertson	Yes
	F Krenz	
mic	EL Brady	Yes
leeting	BJ Schonland	
rs	GB Greenough	
	JC Bell	
	JHW Simmons	
	J Wright	
	H Loner	

VISITS TO OTHER INSTALLATIONS (CONT)

Name	Dates of Visit	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
R Harrington	12/3-4	Utah State University, Logan, Utah	Delivered talk to chemistry students	MC Cannon	No
RC Aungst JW Riches	12/16	Tube Reducing Co., Wallington, N.J.	Consultation on zirconium fabrication	S Randall	No
		New Rochelle Tool Co., New Rochelle, N.Y.	" "	WC Rudd	No
	12/17	Nuclear Metals, Inc., Cambridge, Mass.	" "	P Loewenstein	No
	12/18	Allegheny-Ludlum Steel, Watervliet, N.Y.	" "	RE Rohrabaugh	No
	12/19	Chase Brass & Copper Co., Waterbury, Conn.	" "	DK Crampton	No
HP Oakes	12/17	Carpenter Steel Co., Newark, N.J.	" "	N Chernik	No
	12/18	Damascus Tube Co., Greenville, Pa.	" "	B Burd	No

VISITS TO HANFORD WORKS

Name	Dates of Visit	Company & Address	Reason for Visit	HW Personnel Contacted	Access to Restricted Data	Bldgs. & Areas Visited
MD Fiske	12/2	GE Research Laboratory, Schenectady	Discuss technical programs	FW Albaugh JJ Cadwell RE Nightingale	Yes	328, 326, 300
MJ Sinnott	12/4	U. of Michigan Ann Arbor, Mich.	UO_2 fuel fabrication & assembly problems	JJ Cadwell WE Roake	Yes	325, 326, 300
P Berner J Harris	12/12	Star Machinery Co., Seattle, Wn. EW Bliss Co., San Jose, Calif.	Discuss press eqp't for cold closure Al jacketing of fuel elements	HJ Pessl	No	326, 300
CD Vail	12/26	Minneapolis-Honeywell Regulator Corp.,	Inspect instruments in Nonmetallic Matls. Dev. Labs.	JM Davidson	No	326, 300

PLUTONIUM RECYCLE PROGRAM

MONTHLY REPORT - DECEMBER 1957

REACTOR & FUELS RESEARCH & DEVELOPMENT OPERATION

Plutonium Fuels Development

Al-Pu Alloy Capsules for MTR Irradiation (GEH-3-24). Two Zircaloy-clad capsules, one with an Al-12 w/o Si-1.65 w/o Pu alloy core and one with an Al-1.65 w/o Pu alloy core, are presently being irradiated in the MTR as part of the GEH-3-24 test. Irradiation and examination of two similar capsules have been completed. The two capsules are being irradiated in a flux of 2.9×10^{14} nv or greater. As of December 1, 1957, the total exposure on the capsules was estimated to be 6.01×10^{20} nvt and 6.07×10^{20} nvt or about 40 per cent burnout of the Pu atoms. The original goal was to obtain a total of about 7.5×10^{20} nvt or a Pu atom burn-out value of about 50 per cent.

Because of difficulties encountered in the radiometallurgical examination during the dejacketing operation on the initial pair of irradiated capsules, four dummy capsules (stainless steel cladding and Al cores) were fabricated to evaluate various dejacketing schemes prior to the next irradiated capsule examination. Two of the cores were a slip fit in their respective tubes and two were a shrink fit (0.0005 -- 0.0015 inch interference).

Al-Pu Alloy Clusters for KER Irradiation. The four-rod cluster with swaged Al cores, Zircaloy-III tubes, Zircaloy-II end caps, and stainless steel rod holders or spiders was examined after 19 days exposure to 240 C pressurized light water coolant (pH 4.5) in the ELMO-7 loop facility. Definite buff-colored bands were noted on the welded ends of all tubes. One tube which was welded at a different time than the other three showed the corrosion product to a lesser degree. The bands covered the OD of the tubes uniformly from the end downward to a distance of about 5/16 inch. This zone roughly approximates the weld bead plus the heat affected area on each side of the welded bead. No pitting was detected. It is presently believed that insufficient atmosphere purification during the welding step may have contributed to the formation of the buff-colored bands. The cluster was recharged into the loop to continue the test which is scheduled to run 50-60 days initially, and then to a total of 120 days.

Two, four-rod clusters with Al cores and stainless steel cladding and rod holders are being prepared for hydraulic tests. One cluster was completed and delivered for testing and the completed rods for the second cluster are ready for final assembly. Zircaloy jacketing components for the two clusters to be irradiated and the flux monitoring cluster for the 305 pile tests are under fabrication. The Al-8 w/o Pu and Al-12 w/o Si-8 w/o Pu alloy cores for the pile tests have been cast and machined, analyzed, and are being dimensionally inspected.

Casting of Al-Pu Alloys. Several Al-Pu alloys were cast at 700 C into 1/2 inch diameter rods from which tensile specimens will be machined for mechanical properties determinations. The composition of the cast alloys was Al and Al-2, -4, -6, -8, -10 and -13 w/o Pu. However, since centerline shrinkage voids occurred in most of the rods, the alloys will be recast at a lower temperature in order to eliminate this problem. Three extrusion billets, 2-3/8 inches in diameter by 8 inches long, were cast. Radiographs of two of the billets showed very few internal voids. The third billet was not radiographed. Chemical analysis results of samples taken from various sections of the billets have not been completed.

Pyrometallurgical Techniques. Pyrometallurgy offers several methods of reconstituting irradiated Pu bearing fuel elements through separation of a Pu bearing phase from the principal alloying elements. Two methods of obtaining segregation in the Al-Pu alloys are: (1) slow cooling of the molten alloy through the two-phase (liquid plus Al) region in which primary crystallization of Al occurs until the liquid reaches the eutectic composition (about 13 w/o Pu), and (2) adding an element to the molten Al-Pu alloy to form a high melting Pu phase which precipitates out of solution. The Pu phase may be separated by liquation, sedimentation or filtration. Two melts of Al-1.7 w/o Pu alloy were slowly cooled through the liquid plus Al region. Samples were taken from sections which were first and last to solidify to determine the degree of segregation. Chemical analyses have not been received on these samples. Silicon was added to a third melt of Al-1.7 w/o Pu alloy in order to reduce the melting point of the alloy and form a high melting Pu phase which should precipitate and settle in the solution. Chemical analyses of samples taken from this melt have not been received.

Vacuum Injection Casting. A method of fabricating Pu containing fuel elements by vacuum injection casting the core material directly into the jacket is being developed. One type of injection casting apparatus presently being evaluated employs air pressure to force molten Al into 1/2-inch diameter tubing. The air line to the pressure vessel on this equipment was a 1/4-inch pipe and the time required to pressurize the chamber to 30 psig was 10-15 seconds. It was found that the Al would sometimes freeze before filling the tube. An air receiver or accumulator is being installed which will increase the volume of air flow and, hence, decrease the time required to pressurize the chamber. Another type of injection casting apparatus which also uses air pressure to displace molten Al is nearly completed and will be evaluated when it is available.

Mechanical Pressure Injection Casting. The development of a method of mechanical pressure injection casting of Al-Pu fuel elements is progressing. The casting cylinder has been reworked and the clearance between the piston and the cylinder walls is now satisfactory. Effectively cooling the lower portion of the casting cylinder and the hydraulic cylinder head seems to present the greatest problem at this time. Initially, cooling coils were omitted; however, it is now obvious that cooling of the hydraulic cylinder connecting rod is essential. Cooling coils will relieve the heating problem. Radiographs of the three-foot section

of pressure cast rods showed porosity at the top of the casting. The bottom, however, was sound, indicating that the melt first froze in the casting tube and that molten metal was forced into the shrinkage cavities as solidification progressed downward.

Extrusion Program. Aluminum tubing has been satisfactorily extruded for use in fabrication of fuel elements for MTR irradiation. The tubing was extruded at 500 C through a shear die and over a French mandrel. The finish on the as-extruded external and internal surfaces was very good. An Al-1.65 w/o U rod 3/4-inch diameter was extruded, using the same billet temperature of 500 C. The Al-U alloy extruded the same as normal cast 2S aluminum. Installation of the pressure sensing and recording instrumentation equipment will not be attempted until the modifications for increasing the capacity of the extrusion press from 125 tons to 284 tons are completed.

Zircaloy-III Tubing for PRPR Fuel Element Development. The six sections of Zircaloy-III tubing received from Wolverine Tube Company for PRPR fuel elements have been under continuing examination. Spectrographic analysis of the material is being made. The tubing is also being analyzed for oxygen and hydrogen content. The Radiographic Testing Operation issued a report with the results of their radiographic examination and eddy current testing of the six tubes for side wall defects and irregularities. The summary is as follows:

Radiographic Examination

Rejects	- 2 tubes (excessive die and gall marks)
Questionable Rejects	- 3 tubes (die and gall marks)
Satisfactory	- 1 tube (moderately die marked)

Eddy Current Test

Satisfactory	- 6 tubes

The spot check radiographic examination covered 32 degrees of the total circumferential area of 360 degrees. A total of 240 lineal feet of tubing was examined.

Welding Development. The final closures and assembly of the NPD type 19-rod cluster fuel element containing Al core material and stainless steel jackets have been completed. This fuel element will be used for hydraulic testing studies. A tungsten inert gas spot welder has been installed and put into operation for joining the split length end fuel rod holders on the four-rod cluster type fuel element assembly.

Experiments have been initiated to determine the feasibility of cold welding Al for cladding flux monitoring samples.

Fabrication of a portable dual purpose inert gas and vacuum welding chamber is now underway. This device serves the same purpose as the vacuum welding box; however, it is much smaller and cheaper to construct.

Facilities. Cell 1 has been cleared of process equipment, the floors have been resurfaced and ventilation and filters are being provided. The swage, extrusion press, and two rod straighteners will be located in this space. The oxide preparation hood in Cell 5 is being activated and the hydrogen sintering furnace will be attached to this hood. Necessary safety devices and controllers for the operation of this furnace will then be installed.

Long tube furnaces are required for annealing PRP-type fuel elements. A prototype furnace has been mocked-up to determine the feasibility of heating such a furnace by passing a high current through the tube. The equipment consisted of a 56 amp, 220 volt auto transformer to feed the primary side of a step-down transformer. The maximum current output of the second coil of the step-down transformer is 2000 amps at 6.5 volts. A 4-inch OD tube, 12-feet long with a 0.120-inch wall was connected to copper bus bars and three-inch thick MgO pipe installation was placed around the tube for 10 feet of its length. Ten feet of the tube was used to carry the current load and approximately 8 feet of this length was unifromly heated to 1200 F from room temperature in less than one hour. This seems to be a successful and simple method of heating a tube furnace. An insulating liner will be required for annealing high conducting materials such as aluminum.

Plutonium Fuels Pilot Plant. Design efforts on the Plutonium Fabrication Pilot Plant by Construction Engineering Operation were reduced to a base minimum about November 1st due to lack of funds. This situation has continued through December and all design efforts will be suspended January 1, 1958, if new funds are not made available. Schedules made in advance of November 1 are now unrealistic and new schedules will have to be drawn up when funds again become available. The engineering assistance provided by PMO has been continued during this period.

UO_2 Fuel Development

Swaging of Uranium Dioxide. Simultaneous compaction and cladding of ceramic materials by swaging offers promise as a method of fuel element fabrication at reduced costs. In previous studies with a No. 4 swage, UO_2 densities of approximately 90 percent of the theoretical were obtained by swaging pre-sintered and ground UO_2 powder contained in one-inch O.D. stainless steel tubing having a 0.060 inch wall thickness. Efforts to duplicate this result with one-inch O.D. Zircaloy-3 tubing having a 0.030 wall frequently have led to ruptures as the density of the UO_2 powder approaches 80-85 percent of the theoretical. This difficulty apparently was caused by the combined effects of work hardening, defective material, and the thinness of the tubing. Attempts to anneal the Zircaloy between swaging passes have not eliminated such ruptures. Difficulties in swaging the thin cladding material suggest the desirability of "inverted" swages, which may exert less stress on the swaged material. In a demonstration experiment by the Sutton Engineering Company, specimens of one-inch O.D. were successfully reduced to 0.563-inch O.D. in a single pass through a Farmer-Norton 4-die, stationary-spindle (inverted) swaging machine

The fabrication of relatively large sintered and ground UO_2 contained in stainless steel also was swaged in the No. 8 Fenn swaging machine in Building 314. The final pass was made through a 1.440-inch die and resulted in an element having an outside diameter of 1.456-1.487 inches. The density of the UO_2 after swaging was 85 percent of the theoretical. Further studies with this swage will be discontinued until a feeding mechanism and improved dies are obtained. The smaller swage can be used for the cladding studies now being emphasized.

Fabrication of Uranium Dioxide by Combined Pressing and Sintering. The sintering of uranium dioxide under pressure as a means of fabricating high density UO_2 has resolved itself to a problem of obtaining a die material able to withstand desired pressures and temperatures. Inconel dies gave indications of satisfactory performance if a suitable design is used. Graphite did not permit the use of sufficient pressures. Alumina and Graphitar are being investigated as possible die materials.

Isostatic Pressing of Extruded Rods. Uranium dioxide rods fabricated by extrusion frequently have voids and cracks at their centers after sintering, because of density gradients across the diameters. Photomicrographs of sintered, isostatically repressed, extruded rods, and of sintered extruded rods which were not isostatically repressed, reveal that the grain size in the isostatically pressed rods is larger than in the extruded rods, and that the extruded rods have many small cavities which are not found in the isostatically repressed rods. Porous, sponge-like areas are sometimes found in both materials, but the density of the UO_2 in these areas is much less in the extruded rods than in the isostatically repressed rods. A much higher quality UO_2 element is obtainable by isostatic pressing.

Uranium Dioxide Powder Preparation. Fabrication of sintered uranium dioxide fuel elements to specified densities requires accurate control of oxide particle size, cold-pressing pressure, and sintering temperature. Particle size control of the uranium dioxide powder to be used in preparing fuel elements for the PRPR will be obtained initially by using a continuous ball mill and air classifier unit. Equipment for this purpose was installed and operated successfully during the past month. Preliminary experiments with the equipment produced 7 pounds per hour of oxide that was cold-pressed at 20 TSI and sintered at 1600 C to 93 percent of the theoretical density. Optimization of the equipment is expected to increase the rate of production of a suitable oxide powder.

Sintering Studies. Activation of UO_2 powders by ball milling and oxidation-reduction treatments has been used to lower the sintering temperatures required to produce high density UO_2 shapes. During the past month TiO_2 additions were used to increase UO_2 sintered densities. The most significant result was an increase of 16 percent in the theoretical density of untreated "PWR grade" UO_2 powder with a 0.75 U/O addition of TiO_2. Studies are planned to evaluate smaller additions of TiO_2 to UO_2 powders.

Vacuum Cast Zircaloy-2 End Fittings. A substantial part of the cost of massive nested tubular fuel elements is found in the end fittings. An economical production method for fabricating Zircaloy-2 end fittings may be vacuum casting. Two sets of vacuum cast parts recently ordered from Oregon Metallurgical Products have been received and appear to be of excellent quality. The structural properties and density of these units are being determined and compared to those of parts fabricated from bar stock by machining methods. This method of production appears very encouraging for small quantities of test element fittings, as well as for production quantities. Results of the testing program will be reported as tests are completed.

Welding Development. The tubular fuel element being developed for the Plutonium Recycle Program requires a support system to accurately fix the location of the several components within the fuel element. The support system consists of three rib-type supports attached 120 degrees apart around the jacket. Overlapping resistance spot welding is being evaluated for this application. A special jig and welding head has been constructed and several test specimens have been fabricated. The test specimens are now being corrosion tested in 680 F water and other specimens are being checked for atmospheric gas content in the weld region. From the results obtained to date by this method it appears that this application may be developed into a suitable method of attaching supports.

External Pressure Resistance of Large Diameter, Thin Walled, Zr-2 Tubing. A test was conducted to determine the maximum permissible void space gap in a 3.058 inch diameter by 0.030 inch wall Zircaloy-2 tube subjected to PRPR operating temperature and pressure. A section of the tubing, 6-3/4 inch long, was loaded with a tight fitting (0.003-inch diametral clearance) mandrel which contained a series of evenly spaced, deep, circumferential grooves, 0.650, 0.500, 0.375, 0.250, 0.125, 0.065, and 0.032 inch wide. Caps were welded to each end of the tubing and the entire assembly was autoclaved at 1075 psi and 553 F for 20 hours. The cladding extruded into gaps wider than 0.250 inch. Intrusion into the 0.250 gap was barely perceptible and showed a reduction in diameter of approximately 0.008 inch. There was no intrusion of cladding into gaps smaller in width than 0.250 inch. This indicates that (1) small edge chips are permissible on the uranium dioxide core pieces, and (2) void space, which is necessary in the fuel element to permit expansion of the UO_2 under irradiation, may not permit collapse of the cladding if the space is uniformly distributed along the length of the fuel material. Further ex-reactor studies are being completed, and irradiation tests are being planned.

Fission Gas Release from UO_2 Powders. One of the efforts to radically decrease fuel costs is concerned with evaluating the in- and ex-reactor behavior of unsintered powders, either loosely compacted or compacted by swaging. In either case, fission gas release is a possible limitation. The extent of fission gas release as a function of burnup is one of the most important of a number of variables. Sixteen capsules containing loosely packed UO_2 were irradiated in the MTR for one and two cycles. Statistical analysis of the results reveals that, within the limits of experimental error, there is no evidence of any increase in

the quantity of fission products released, as a function of exposure. In fact, neither of two groups of samples having degrees of enrichment varying by a factor of 2, indicated any increase of released fission gas as a result of doubling the exposure in the MTR. The effects of other variables such as surface area, packing densities, and degree of enrichment are being analyzed, but the analysis will not be completed until accurate burnup analyses are available. Other radiation experiments probably will be necessary to separate a surface area effect from other factors, and to determine whether exposure becomes a significant variable at extremely high burnups.

High Temperature Characteristics of UO_2. Determination of the volume change in UO_2 upon melting is desirable for safe design of fuel elements. A glass enclosed, induction heating furnace has been assembled and vacuum leak tested. Tungsten pycnometers, radiation shields, and UO_2 specimens have been fabricated for UO_2 melting studies. Solar furnaces and the recently developed plasma jet furnace also have been considered as heat sources for high temperature UO_2 studies. A fourth possibility is a carbon-arc image furnace, a model of which has been constructed and is now being evaluated. The unit consists of two six-inch diameter paraboloidal mirrors, 24.0 inches apart and enclosed by a transite box. The mirrors are so arranged that when a carbon arc is placed at the focal point of one of the mirrors, energy is focused onto the substance to be heated at the other mirror. Preliminary experiments, using arc carbons 0.250 inch in diameter, drawing 100 amperes and operating at 50 volts, produced furnace temperatures of approximately 1500 C. Extrapolation of this data indicates that 15 KW will be necessary to produce a furnace temperature of 3000 C. Equipment is being designed to operate under these conditions.

Thermal Conductivity of UO_2. The effect of irradiation on the thermal conductivity of UO_2 is one of the most debated subjects in the UO_2 field. Arrangements have been made with the Irradiation Testing Operation to have a number of test elements irradiated at Hanford. Assembly of the test elements is nearing completion and the writing of a production test was completed. Arrangements were made with the Battelle Memorial Institute to determine the thermal conductivity of the irradiated and unirradiated UO_2 specimens.

Oxide Fuel Elements. If the rib supports on the tubular oxide fuel rods for the PRPR could be removed, fabrication problems of the cans would be reduced. When the rods are supported from the top they are mechanically stable; but should they deflect due to fabrication inaccuracy or operational changes, a thermal-mechanical instability may arise. A fuel element has a thermal-mechanical instability if its deflection due to a peripheral temperature gradient in the clad is greater than the fuel element deflection needed to cause this temperature gradient. In order to test for instability, one assumes a virtual temperature gradient and calculates the corresponding deflection. If the deflection due to the virtual temperature gradient causes a temperature gradient in the clad greater than the virtual gradient, the fuel element is unstable. Assuming channeled flow in a tubular fuel element with a rod diameter equal to the original diameter plus twice the eccentricity at burnout flow condition, the center rod of the PRPR tubular fuel element would be unstable if at least one central spacer were not added.

Further complications arise in a fuel element which is eccentric due to manufacturing inaccuracies or deflections caused by irradiation behavior. In these cases, an initial deflection causes temperature gradients which create further deflection. No stability calculations have been made for the thermal-mechanical stability of initially deflected fuel elements. In horizontal fuel rods, the effects of bending should also be included as an initial deflection as well as the above possible defects. Further work on the combined effects of mechanical, thermal, and hydraulic stability should be performed. The results of these investigations will be included in Chapter 800 of the proposed Fuel Element Design Handbook.

Thermal-Hydraulic Studies

Progress continued in installing the piping for the PRPR calandria and moderator mockup in 185-D. This piping work, which is being performed by Minor Construction, is approximately 10 percent complete.

A small velocity measuring instrument was developed to measure the moderator flow distribution within the calandria mockup. The instrument consists of a small propeller arranged such that each revolution will be counted by breaking continuity between a light source and a photocell. Preliminary calibration indicates that the meter will measure velocities as low as 0.1 foot per second.

A search of the literature concerning subcooled boiling burnout was conducted in an effort to determine the boiling burnout conditions for the PRPR fuel elements. Limited calculations indicated subcooled burnout is highly improbable for the Mark II and III tubular fuel elements. Upon loss of flow or increase in heat flux, it is likely that bulk boiling conditions would be established before the element experienced subcooled burnout. This means that the subcooled boiling burnout limitations do not apply to the tubular fuel elements and attention should be focused on burnout under bulk boiling conditions. Data which apply to these latter conditions are quite scarce.

Design Test Proposal PR-10. Work was continued on building an electrical heated mockup of the Mark II fuel element for experimental use in the high pressure heat transfer apparatus. Bids on purchase requisitions for materials were received and orders were placed although it appears that construction of this three-piece element will be quite difficult. Tolerances on dimensions must be close and it is difficult to get manufacturers to bid on the materials necessary to match the electrical resistance of the test section to a value necessary for use in the experimental apparatus.

Coolant Systems Development

Report HW-53672, issued during the month, contains recommendations for the optimum pH for PRPR coolant and moderator if aluminum process tubes are used. The calculations were based on the data obtained from H Loop. In view of the recent studies concerning the effect of extended aluminum surface, these recommendations may be unduly conservative. This was pointed out in the report. A review was made of the literature relating to chloride stress corrosion of materials considered for PRPR. A review of crevice corrosion and galvanic corrosion is continuing.

A test is being started to determine corrosive effects of decontaminating solutions on PRPR component materials under static conditions and sub-boiling temperatures.

Examination of the Zircaloy-3 clad mockup of the Pu-Al four-rod cluster proposed for irradiation testing in KER has shown evidence of corrosion on all but one end cap weld. Corrosion was indicated on the tubing cladding in all weld affected areas. Also, approximately 180 degrees full length of all cladding tubes but one showed evidence of corrosion. Test conditions were 240 C, 775 psi, 4.5 pH. Examinations after 280, 450 and 565 hours of testing indicated a steady build-up of corrosion products.

Mechanical Equipment Development

Design Test PR-20 - Calandria Characteristics. The connecting piping between the calandria and the moderator storage tank is being fabricated and installed. The evaluation of the necessary instruments to perform the moderator dump tests and the moderator level control tests continued during the month. The completion date of this design test is being re-evaluated.

Design Test PR-24 - Calandria Shroud Tube Bellows. The bellows flexure test was re-run using the required flexure. One bellows failed in the convolute section after 7500 cycles. Tests on the feasibility of re-welding the bellows have been delayed until the receipt of shroud tubes. Proposals are being prepared for bellows corrosion tests.

Design Test PR-25 - Shroud Tube Collapsing Pressures and Installation. The design of a suitable experimental facility to determine collapsing pressures was completed and fabrication begun. A purchase requisition was prepared for the aluminum plate for the installation tests. Preparation of a proposal outlining the design test was started. The test completion date is March 1958.

Design Test PR-50 - Reactor Piping Seal Testing. The revised completion date of this design test is April 1958.

Seal No. 1 - Inlet jumper to inlet piping connection, Seal No. 7 - Outlet jumper to outlet nozzle connection, and Seal No. 8 - Outlet jumper to outlet header connection. All three of these seals are 1-3/4 inch flared tubing fittings. Difficulty was experienced in obtaining acceptable flares for these seals. An appropriation request was prepared and is being processed to purchase a power flaring machine.

Seal No. 2 - Inlet jumper to process tube connection. Twelve flares were fabricated for the test assembly before four successful flares were secured. The flares were hydrostatically tested to 3000 psig and required 700 ft-lbs of torque to seal. These flares were fabricated by hammering the tubing into a 37-1/2° die, polishing with a valve seat reaming tool, and then annealing.

Seal No. 3 - Inlet gas seal. The work on this seal has been completed.

Seal No. 4 - Process tube to outlet nozzle. Test Assembly A was hydrostatically tested to 3000 psig. End 1A employing a flexitallic gasket with 700 ft-lbs of torque had no leakage. End 2A employing a delta gasket with 800 ft-lbs of torque had a very slight leakage above 2500 psig. There was no progress during the month on Test Assembly B which will use nickel gaskets.

Seal No. 5 - Nozzle cap seal. Cap Assembly A was tested on ELMO-7 for a period of 280 hours. This test was an isothermal run at 460 F and 775 psig. End 1A employing a flexitallic gasket with 100 ft-lbs of torque per bolt had no leakage. End 2A employing a self-energized "O" ring has an initial torque of 100 ft-lbs per bolt. After 160 hours of testing leakage was evident. After re-tightening to 125 ft-lbs torque, gross leakage stopped.

Seal No. 6 - Outlet gas seal. Recommendations were received from various packing manufacturers on the type of packing to be used in this seal. Dura Metallic Type D and Johns Mansville Style 873 were ordered.

Design Test PR-51 - Reactor Piping Structural Integrity. The revised completion date of this design test is July 1958. Progress on most portions of the test has been delayed due to the lack of a firm design on the jumper arrangement. During the past month, the design of the jumper flexing machine proceeded. The design is now 95 percent complete. Fabrication of the machine will start early in January.

Design Test PR-63 - Process Channel Leak Detection Facility. The design of an electrically heated test facility was started. The completion date of this design test is July 1958.

Other Activities

Single Tube Prototype Facility (Phase I). Construction work was temporarily halted on December 12 until the long term delivery components of the facility are received. It is anticipated that construction will resume by February 1, 1958. The facility is now approximately 32 percent complete.

Single Tube Prototype Facility (Phase II). The design is scheduled for completion during the first week of January. Procurement of materials and equipment is proceeding through Construction Operation channels.

Components. Process Pump - The vendor is delaying construction of the pump at our request until a final decision is reached on the horsepower rating of the motor. 14 Inch Gate Valve - The order was placed with the William Powell Company on December 19. Delivery of the valve is scheduled for July 1958.

Eight Inch Check Valve - The requisition for this valve with an option clause for two additional valves was re-written. A specification was added that the valve must open with 0.16 psi pressure drop for a flow of 370 gpm. Comments are now being obtained from Construction Engineering Operation and Advance Engineering Operation.

Injection Pump - Revised quotations were received and are being evaluated. Although the injection method of cooling the process pump seals is not being planned now, the injection pump is needed to maintain the water volume in the Single Tube Prototype Facility (Phase II) during the 45 minute cool-down period. The order for this pump should be placed during January 1958.

PRPR Inlet Piping Valves - Two 1-1/2-inch Powell angle valves and one 2-inch Hammel-Dahl angle valve with 1-1/2-inch weld ends and with a 1/4-inch drain valve incorporated were ordered. These valves will be tested on a high pressure, high temperature facility.

Process Tube Development

PRP Process Tubes and Jacket Tubing. Orders have been placed for ten prototype process tubes. Experimental fabrication of tube flanges and tapered sections has been completed and sample pieces are being evaluated.

The last lot of seamless fuel-jacket tubing (sizes 0.505 inch, 0.598 inch, and 0.938 inch I.D.) has been shipped by the vendor. Nuclear Metals, Inc. has produced a few external ribbed tubes (0.750 inch I.D.). Although dimensions and surface conditions appeared to be acceptable, the production of a good rib-to-tube bond requires additional development effort. Satisfactory progress has been made on fabrication of welded jacket tubing. Ten tubes have been received out of an order for 50 tubes in the 3-inch-diameter size range.

M-388 Extruded Fuel Jacket Tubing. Ten experimental compartmented tubes have been extruded from M-388 aluminum alloy by Harvey Aluminum Company and delivered on-site. The cross-section of the ten-foot-long tubes is made up of a nominal 1.5-inch-diameter outer tube and a concentric nominal 0.6-inch-diameter inner tube with the two tubes being integrally connected by six equally spaced radial "spokes", as in a wheel; hence, the "wheel element" name for this tubing. The six radial compartments will be filled with UO_2 by the Ceramic Fuels Development Operation.

Corrosion of Aluminum-Nickel-Titanium Alloys

It has recently been determined that some aluminum-nickel alloys with titanium additions corrode by a logarithmic rate process rather than a parabolic rate process. A series of aluminum alloys of varying nickel-titanium concentrations has been cast at Hanford, and additional samples have been received from the Kaiser Aluminum Corporation. These experimental alloys will be subjected to laboratory corrosion tests as part of a program of evaluating the optimum nickel-titanium concentrations for reactor operating conditions.

Plutonium Fuel Cycle Analysis

Cycle Analysis. Work has progressed on the formulation of a fuel economics program which will be carried out in the IBM 650. A rough draft on the methods for determining the economics of fuel elements is nearly completed. This draft treats in detail the fundamental bases for the study together with required refinements as well as the methods to be used in placing the study in a form suitable for IBM 650 calculation. The program allows the use of both positive and negative dollar values for each of the plutonium isotopes. Processing charges are, however, made only against plutonium-239 and 241.

A study was started on the value of plutonium as compared with uranium-235 based on maximum attainable exposures in several thermal reactors. Successful completion of the study should allow the formation of accurate value ratios for various qualities of plutonium, both with itself and with various qualities (% burnout) of uranium-235. Use is being made of existing machine codes for the IBM 650 to determine the amount and quality of plutonium as a function of irradiation time.

Generalized Plutonium Recycle Analysis. The G.P.R. Code was used to examine the effect of process losses on reactor operation. The following cases have been run for the PRPR using Mk IIb fuel elements. Using Westcott's notation for spectral index, r = 0.05, 0.07, 0.08, 0.10 percentage process losses of 0, 2, 4, 6, 8 and 10 were examined at 80 C. At a constant r = 0.08, temperatures of 20 C, 80 C, 200 C and 400 C were examined for process losses of 0, 2, 4, 6, 8 and 10 percent.

The closest case to PRPR operating conditions is r = 0.08, T = 80 C. For this case one finds that at 5 percent process loss, there is approximately 500 MWD/T gain over the zero process loss case. At greater than 5 percent loss, the exposure begins to drop. For a uniform loading with D_2O reflector, the maximum exposure is 6000 MWD/T. For a spike loading, the maximum, which also occurs near 5 percent loss, is about 3700 MWD/T.

Investigation of the effective cross section for Pu-240 is underway with emphasis on the self-shielding factor.

Fuel Element Investigation. A two group calculation of heat generation in a PRPR Mk IIa fuel element irradiated in an E-20 test loop in the NRU reactor has been completed. Calculation of the U-235 concentration to give an initial heat generation of 1200 KW indicated an enrichment only slightly less than natural uranium. This study was carried out at the request of the Fuels Development Operation.

Safeguards Analysis. The PRPR preliminary safeguards analysis was reviewed by the G.E. Reactor Safeguards Committee on December 9. As a result of questions and comments by the Committee further study will be made of the effect of metal-water reaction following an incident.

A revised study of the kinetic behavior of PRPR has been completed. Since the first study was completed (HW-51398), a measured value for the metal temperature coefficient has become available. In addition, the analog computer program was rescaled such that overloads would not occur on strong transients, hence giving more reliable data for the worst incidents. A metal temperature coefficient of 1.51 x 10^{-5} δ k/C was used, based on a measured value of 2.4 x 10^{-5} for an all UO_2 loading. Analysis of the data indicated a reassessment of pressure transients to be in order since they are expected to be slightly higher. However, it is believed that they will still be well within building design allowances.

PRPR Shim Rod Control Worth. The Murray Method of evaluating one ring of off-axis control rods is being applied to determine PRPR shim rod control worth. This is a two-group analysis programmed for the IBM 650.

Experimental Reactor Design

General. The design of Phases II (the service area) and III (the reactor and auxiliaries) is about 15 percent completed. Additional design funds were released during the month by the Atomic Energy Commission.

Scope changes incorporated in the PRPR design during the month include: 1) removal of the 1500 KW turbo-generator, together with the structural and mechanical features provided to accommodate it, in response to an AEC directive; and 2) modification of the wall between the lower face access room and the process cell, to accommodate pressure equalization and to facilitate the installation of piping.

Core Components. Flexural tests of a prototype shroud tube bellows of stainless steel with aluminum end rings manufactured by the U.S. Flexible Metallic Tubing Company were successfully completed. Additional corrosion tests of the bellows are contemplated.

Helium Gas System. A preliminary proposal from Autoclave Engineers for Hofer diaphragm-type compressors for the high pressure helium compressors in the PRPR looks very encouraging. The compressors appear to be of adequate size and within estimated cost. It is believed that diaphragm-type compressors would be superior to American made piston compressors from a wear and leakage standpoint.

Instrumentation and Control. Proposals received for design of the PRPR shim control assembly were opened on December 23. Seven firms expressed interest in this job; five of these submitted estimates of design costs, varying from $17,000 to $95,000. One vendor proposes to design the assemblies on a fixed-price basis. A review of the proposals did not give sufficient basis for selection of a single firm. Further contacts with the interested vendors are planned during the month of January, before a selection is made.

A revised list of electrical motors and control locations has been prepared and will be circulated for comment.

A number of discussions was held during the month on selection of a primary coolant activity monitoring (rupture detection) system. The two systems being seriously considered are the scintillation-type monitor scoped in the instrumentation criteria (HW-48101) and a total-gamma monitor utilizing GM tubes as sensitive elements. Consideration was also given to combining the activity monitor sampling system with the primary coolant bleed-off to the purification train.

Reactor Analog Studies. The investigation of the gas balance and moderator system dynamics is now underway with completion expected early in January. Some work has been done on the combining of the gas and moderator system with the physics kinetics system already available.

Process Piping and Equipment. Scope revisions 101-1, 103-1, 113-1, and 114-2 were issued during the month. In order, these requested removal of total steam flow instrumentation, installation of extra stator windings to permit operation of two primary pumps at one-third speed for shutdown cooling, reduction of the reflector heat exchanger tube surface by 50 percent, and removal of the process cooling water by-pass around the small heat exchangers and the zeolite bed.

Five manufacturers of boiler equipment were visited during the month for the purpose of developing information on fabrication techniques and commercial heat exchanger specification practice. This information will be used in writing a recommended specification for the PRPR steam generator which will result in reduced fabrication costs.

Manufacturers visited were Combustion Engineering, Foster-Wheeler, Yuba, Babcock & Wilcox, and Griscom-Russell.

Reactor Fueling Equipment. Bids were opened December 23 on proposals for design of the reactor fueling equipment. Eight firms submitted proposals or expressed interest; three declined. Proposals have been reviewed, but it is not possible to select one of the firms on the basis of the information received. Further contacts with the bidders are planned before a selection is made. Four bidders submitted design cost estimates, varying from $14,000 - $74,000. One bidder proposes to do the job on a firm price basis.

Pressure Equalization in Containment Vessel. Calculations were made on pressure buildup in A and B cells following rupture of the main primary coolant line to assist in estimating the consequences of a major reactor incident. Greater venting area is being incorporated between cells to facilitate pressure equalization and reduce loads on the structure.

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

DECEMBER 1958

FISSIONABLE MATERIALS - 2000 PROGRAM

REACTOR

STUDIES RELATED TO PRESENT PRODUCTION PILES

Dry 7-1/2" Lattice Temperature Coefficient

Work on the analysis of the data was continued. A study of the errors involved in the PCTR measurements of $\frac{1}{k_{oo}} \frac{dk_{oo}}{dT}$ relative to those incurred in making activation measurements of the individual parameters involved was begun.

Thermal Neutron Flux in a Medium with a Temperature Discontinuity

Work on an alternative scheme for solving the partial differential equation of this problem has been started. Suggested by Professor J. L. Powell, it involves the use of partial difference equations based on a network of discrete points in two dimensional energy-position space. It has the advantages of furnishing numerical results directly and of being applicable to systems with arbitary temperature patterns in the medium.

K-Pile I and E Versus Solid Fuel

The large square driver array of the PCTR was used for the first time in making graphite lattice measurements. In addition, a buffer array of symmetrically positioned 1/2" diameter uranium rods were used around the central core of nine cells. The spectrum of neutrons in the test cell was varied by simply changing the numbers of 1/2" rods in each buffer hole.

Very preliminary estimates on the errors indicate that the following values of k_∞ are accurate to ± 0.002 and the differences to ± 0.001.

	Solid	Solid - I and E	I and E
Dry	1.0579	0.0071	1.0508
Wet	1.0358	0.0062	1.0296
Dry-Wet	0.0221		0.0212

The measured thermal utilizations are as follows:

	Solid	Solid - I and E	I and E
Dry	0.909	-0.001	0.910
Wet	0.868	0.000	0.868
Dry-Wet	0.041		0.042

The specifications on the lattices are (in inches):

Reactor	Type	OD_U	ID_U	OD_{can}	ID_{can}
k	Solid	1.336		1.44	
(7-1/2" Spacing)	I and E	1.384	0.481	1.474	0.375

K-pile Process Tube OD 1.806

K-pile Process Tube Thickness 0.066

Tube block coring in test lattice was 10 mils on radius.

Analog Computing

A series of runs was completed on the boil-out problem using constants appropriate to the K reactors.

STUDIES RELATED TO FUTURE PRODUCTION PILES

Lattice Measurements for Cluster Type Fuel Elements

In order to provide experimental information concerning the reactor parameters of cluster fuel assemblies, the program to measure material bucklings for bundles of 0.926" diameter uranium rods has been resumed. Previous measurements using bundles of 5, 6, or 7 rods in a 14" lattice were reported in HW-43441 (Physics Research Quarterly Report, January, February, March 1956). Additional measurements which have been completed since that time are for the same 5-rod cluster with water coolant in a 10-3/8" lattice, and for the same 7-rod cluster in both a 7 and a 10-3/8" lattice, with and without water coolant for each case. The bucklings have not yet been derived for the cases using a 7" lattice.

Bucklings in a 10-3/8" Lattice Spacing

Rod Assembly	C/U Atom or Molecule Ratios	H_2O/U Atom or Molecule Ratios	Al/U Atom or Molecule Ratios	Buckling ($10^{-6}cm^{-2}$)
Cluster of 5	52.0	0.704	0.52	- 12*
Cluster of 7	37.2	0	0.45	13*
Cluster of 7	37.2	0.258	0.45	25

* Completed in second quarter of 1956, but not reported in Quarterly Reports.

The uranium rods have now been assembled in seven-rod clusters with a 70 mil gap between rods. Measurements are about to begin with this fuel assembly in 7, 10-3/8, and 14" lattice spacings.

Graphite Cross-Section Measurement

The graphite samples that will be used in an experimental determination of the absorption cross section for reactor grade graphite are being machined.

The experiment will be carried out in the PCTR with the heavy water tank in the core to reduce slowing down of fast neutrons in the sample. The "dih" of the graphite samples was determined in the Hanford Test Pile and found to be 1.24 ± 0.006.

Correlation of Exponential Pile Bucklings

The correlation study has resulted in some success in calculating externally cooled fuel element lattices. Calculations will continue with increased water volumes; and internally cooled element lattices to see if any serious discrepancies appear.

Development of Methods of Calculating Reactor Parameters

A. Buckling Program for Machine Calculations

Fairly extensive changes have been made in the routine buckling program (BKL001) to accommodate new two-region harmonic and end corrections. An adaptation of the floating decimal utility program, for use with BKL001, is in for assembly.

B. P-3 Program, Solution of Simultaneous Differential Equations

A utility-type program (SOLNXN) for solution of simultaneous linear equations of order $3 \leq n \leq 49$ is now being debugged. This program will be needed specifically for the revision of P-3 program, but has been written in general terms so that it may be used as a subroutine in a larger program, or as a program complete in itself. The scheme was devised and flowcharted by Data Processing Operation.

The revised P-3 program is approximately 80% written.

C. Program for Bessel Function Calculations

A subroutine which extends the allowable arguments for the modified Bessel functions K_0, K_1, I_0, and I_1 beyond X = 10 has been written and is being debugged. This is a reprograming of a subroutine which was written in early 1956 but which has inadvertently been lost in the interim.

D. Conversion to Floating Decimal

A utility program has been written which changes to floating decimal form numeric input data of any type. The flow chart for this program was drawn by Data Processing Operation. Debugging is complete and a symbolic deck is in order for use as a subroutine with any program.

E. Fast Effect Study

The investigation of fast effect has been completed. A new and more accurate method of determining the value of cadmium ratio from experimental data has been developed, but even though it lowers the stated probable error considerably, the values obtained by this method are in close agreement with those obtained by the present method. It is therefore concluded

that the added time and effort involved in the more accurate method are not justified.

The final figures on the ratio of fast fission to thermal fission, δ, have been obtained and a report is being compiled.

Plutonium Isotopic Concentrations at High Neutron Temperatures

Values have been calculated for the plutonium isotopic concentration versus exposure for neutron temperatures up to about 1200° C and exposure of 500 MWD/T and 1000 MWD/T. As described in the November report, linearized equations and Tripartite cross sections were used. The empirical value r = 0.046 which was used in these calculations, while duplicating low temperature results rather well, is inconsistent with the value of 0.13 obtained from cadmium ratio measurements. The reason for this discrepancy is being sought.

A possible improvement in the formulation of the Tripartite cross section formulations to extend their range of validity to higher r is also being investigated. This amounts to replacing the step function transition to 1/E flux by a linear transition. The effect of this modification, which should be of most importance for the 0.3 ev resonance of Pu-239 and Pu-241, is still to be determined.

A cosine weighting correction is also being applied. The analytical evaluation of an integral encountered in this correction is being investigated. An asymptotic series expression for this integral has been obtained.

Instrumentation

The investigation continued on the experimental cross-correlation detector. Tests with a 0.3 microcurie Pu^{239} source indicated a substantial improvement in the 17-kev x-ray photopeak definition over that obtained with a count-rate meter.

An experimental system was assembled to determine the feasibility of the utilization of active components for generating a wide-range, accurate logarithmic device. Some limitations were observed and development effort is presently directed to improve the system.

STUDIES RELATED TO SEPARATIONS PLANTS

Measurement of k_∞ for UO_3 - H_2O and Uranyl Nitrate - H_2O Mixtures

The purpose of the "criticality" experiment is to determine the maximum safe U-235 enrichment for homogeneous systems of uranyl oxide and water and of uranyl nitrate and water. Recent measurements were taken with UO_3 - H_2O mixtures for three different enrichments at an H/U atomic ratio of about 4. The results of the data analysis are given below:

Enrichment	% H_2O by Weight	H/U (Atom Ratio)	k_{∞}
1.006% ± 0.002%	10.77	3.85 ± 0.05	0.986 ± 0.005
1.071% ± 0.003%	10.64	3.78 ± 0.05	1.005 ± 0.006
1.157% ± 0.003%	10.52	3.73 ± 0.05	1.031 ± 0.006

The maximum safe enrichment for a homogeneous mixture of UO_2 and H_2O is now given as: 1.02 ± 0.02%; for this enrichment value the highest k_{∞} which can be obtained is unity; the safe enrichment value was previously given as 1.03%. These additional measurements with the UO_3-H_2O mixtures were conducted in order to define more precisely the limiting enrichment value and the uncertainty.

The first measurements were taken in the PCTR for determining k_{∞} of enriched uranyl nitrate water mixtures. These measurements were taken with "miniature" tanks in order to determine the approximate enrichment values for use in preparation of large tanks for the full-scale part of the experiment. Only approximate values of k_{∞} can be obtained in the "miniature" phase since for this case the buffer thickness is not sufficient to provide the correct neutron energy spectra incident on the test cell. The enrichment values of the test cells were: 1.2%, 1.5%, and 1.8% with a buffer enrichment of 1.5% and 1.8%, 2.1% and 2.4% for a buffer enrichment of 2.1%. The mixture was: $UO_2 (NO_3)_2 \cdot 6 H_2O$. The data is being analyzed.

Buckling Measurements for Fuel Elements in a Random Array Versus a Uniform Array

With reference to the E-metal dissolver problem, the buckling has now been measured with four different random distributions of 1.66" O.D., 0.94" I.D. fuel elements with 1% enrichment; the fuel elements were 4" in length. The bucklings are listed as follows:

Exp. No.	H_2O/U (by volume)	Buckling for Random Distribution
38	1.48 ± 0.03	2139 μB
39		2149 μB
40		2428 μB
41		1480 μB

The average value is 2050 μB. The buckling for this type of fuel element, aluminum clad, positioned in a uniform array at the same H_2O/U volume ratio is estimated from previous measurements to be 2750 μB. The effect of the aluminum process tubes on the buckling was calculated to be 325 μB. The value which is to be compared with the random cases (bare fuel elements) is then 3075 μB. Thus, these results indicate the buckling to be reduced roughly 30% for the fuel elements in the random array.

These data, together with previous data on 0.925" solid fuel elements in a random array, are being studied by personnel of the Research and Synthesis Operation to determine the confidence limits of the errors to be associated

with the measured values; the results will be reported when the analysis is complete.

Additional measurements are being taken with 1.37" O.D., 0.48" I.D. fuel elements with 1.44% enrichment for four different random distributions; two of these measurements were completed this month.

Plutonium Critical Mass Laboratory

The Preliminary Project Proposal Revision No. 1 of the Critical Mass Laboratory (Project No. CG-731) was approved by the local AEC Project Review Board. This proposal requests authorization of $175,000 for the design of a Plutonium Critical Mass Laboratory to be located at Hanford. Before these funds can be made available, it is necessary to have approval from the Washington AEC office; the final word on this request is expected to be forthcoming about February 1.

Nuclear Safety, Critical Mass Consultations

1. 234-5 Building Nuclear Safety

   a. The design of a new recirculating pump system for solution in the THT tank of Hood No. 7 was discussed with personnel of Facilities Engineering and a final pump design and location approved.

   b. Tracings for the Hood 42 plutonium metal dissolvers were approved.

   c. A tracing on the design and location of a filter for THT solution in Hood No. 7 was approved.

   d. A new continuous filter for plutonium oxalate slurries was studied and approved.

2. Advanced Process Technology

   At the request of the Advanced Process Development Operation of CPD, a study was initiated to determine the nuclear safety requirements for processing fuels of 1.0-1.8% U-235 enrichment. Preliminary critical mass data was given to CPD for planning purposes in connection with processing possible E-N loads. Maximum safe critical slab thicknesses and cylinder diameters were determined for heterogeneous systems (dissolver problem) with enrichments in the region of 1% to 1.8%; safe cylinder diameters were estimated for homogeneous systems (calciner problem) consisting of UO_3-H_2O mixtures with enrichments up to 1.8%. This preliminary study is nearing completion.

   Discussions of the criticality problems involved have also been held with personnel of Facilities Engineering of CPD.

3. AEC Technical Assistance

   Two meetings were held with personnel of the Hanford AEC Operations regarding the nuclear safety in the production quantity shipment of Model Pit 65.

4. Miscellaneous Studies

a. A study has been made of the criticality parameters for homogeneous mixtures of UO_3 and water. With the availability of new information on the densities of UO_3-water mixtures, density corrections have been made to the neutron ages and diffusion lengths used in HW-51364, "Nuclear Safety in Processing Uranium Solutions of All Enrichments," for systems containing less than 5% U-235. This will allow a relaxation of some of the restrictions on critical mass and vessel geometry as reported in the above document; the results will be presented in a separate document.

b. A study is being made to determine the critical mass of E-metal when surrounded by a heterogeneous system of natural uranium and water. This problem is of interest since the probability exists of mixing natural uranium and E metal, either intentionally in dissolvers for processing, or otherwise in storage and handling. Two and one group calculations are being carried out; the two group, two region calculations have not been completed.

Neutron Age Measurements

One run was made on this measurement using the small diameter neutron source in water. Difficulties were again encountered in source handling by Irradiation Testing personnel when the source support rod was bent while loading the source into the shipping cask. It appears probable that adequate corrections for source position error can be applied both for this small diameter source run and for the preceding large diameter source run. A scheduled run using a dummy Na-Al source to investigate the effects of local gamma produced neutrons had to be postponed because of a reactor outage.

Mass Spectrometer for Plutonium Analyses

The construction of this spectrometer is proceeding according to schedule in Technical Shops.

REACTOR DEVELOPMENT - 4000 PROGRAM

STUDIES RELATED TO THE PLUTONIUM RECYCLE PROGRAM

Theoretical PCTR Study, The Effect of a Cavity on Neutron Flux

Numerical evaluation of the thermal flux expression in the vicinity of the cavity has disclosed errors in some of the expansion coefficients. It is believed that these errors have been located by a recheck of the derivation of the expression. Numerical reevaluation has not been completed.

Resonance Escape Probability

The calculations of the resonance integrals for each of the 18 resolved resonances of U-238 have been received from Data Processing. With these data now available, the resonance escape probability determination can be completed.

PRPR Annular Fuel Measurements

Experiments on the PRPR MK II A annular fuel elements were concluded. The results of the experiments are now being calculated. The following constants were measured for these three-piece annular fuel elements in the 8" triangular lattice with the coolants noted:

Coolant	f	k_{∞}
Air	.9246	1.0549
D_2O	.9208	1.0493
H_2O	.7941	1.0022

The errors in k_{∞} due to spectral mismatches and incorrect poisoning are being evaluated.

Plutonium Spike Measurements

Preparations have been completed for taking measurements on the reactivity value of a fuel element containing enriched fuel (Pu-Al) in a matrix of fuel columns containing unenriched fuel (natural uranium). The preliminary considerations which have been made on the interpretations of the PCTR data show that there will be errors incurred which are somewhat larger than those for uniform lattice systems. However, this is still thought to be an acceptable approach to a problem which is otherwise very difficult.

Analog Computing

The second phase of a study on the PRPR neutron kinetic equations was completed at the request of Advance Engineering Operation.

The programming has been completed for the PRPR gas and water control dynamics study and the computer circuits are being checked out.

Instrumentation

A design study was completed on a system for slug rupture detection by measuring the amount of fission product activity in the primary coolant. It was concluded that a system employing separate G-M detectors for each sample tube would be more reliable and less costly than the previously proposed Iodine Monitor.

CROSS SECTION MEASUREMENTS PROGRAM

Pu-239 and Pu-241 Low Energy Fission Cross Sections

Approximately half of the data have been collected on the variation of the Pu-239 and Pu-241 fission cross sections from 0.0027 to 0.0052 ev. These data show the expected 1/v variation over this interval to precisions of 6 to 1.5 percent for Pu-239 and 15 to 3.5 percent for Pu-241. Total cross section measurements were made on a platinum sample simultaneously with the fission

measurements. A considerable amount of spectrometer time was lost on reactor outage.

Absolute Fission Cross Sections

Attempts were made to re-evaluate the weight of the HLO standard U-235 fission foil from alpha count analysis by the Analytical Chemistry Operation. Results to date have not been of the required precision on the determination of the U-234 to U-235 alpha count ratio.

The precision with which the area of the U-235 deposit can be obtained was estimated for the HLO and Harwell standard U-235 fission foils. Estimates were 1.0 percent for the HLO foil and 2.0 percent for the Harwell foil obtained from repeated traveling microscope determinations of the diameter of the deposited uranium.

Time-of-Flight Measurements

The Van de Graaff alignment was improved by centering the accelerated beam in the midplane of the analyzing chamber and parallel to the pole faces. The adjustment increased the target current to the rated maximum of the machine or about one-half of this for best energy resolution. In addition, the beam position on target is very nearly the same for protons and deuterons.

Several runs were made on "thin target" Be(d,n) neutron spectra. An over-all resolution of 2 millimicroseconds was achieved at 1.5 meters flight path. The resolution of the neutron peaks observed compares favorably with data taken at ORNL at a 5-meter flight path. Peaks were observed at neutron energies of 6.08, 5.39, 3.99, 2.55, and 1.33 mev, unresolved peaks at 0.95 and 0.89 mev and a possible peak at 4.39 mev. Resolution at present is still limited by deuteron burst width. Considerable improvement must be made in the background for future measurements.

Subthreshold Fission Measurements

Analytical Laboratories have encountered considerable difficulty in electrodepositing Np-237 fission foils. Efforts are still in progress to obtain the foils by electrodeposition.

Three Crystal Spectrometer

Consultation was given to Construction Engineering on the spectrometer installation and specification testing. Installation is proceeding according to CEO schedule.

TEST REACTOR OPERATION

Operation of the PCTR continued routinely during the month. There were seven unscheduled shutdowns, six of which were due to electronic failure and one to operation error. Noise in the channel 2 period circuit caused four shutdowns, and the remaining two were due to a faulty "out" limit switch in the "C" safety disk circuit.

The testing of the annular fuel in the 8" D_2O lattice was completed during the

month. The K reactor I and E wet versus dry reactivity measurements were completed. k_{∞} measurements were started on UO_2 . NO_3 - moisture mixtures.

Two-shift operation continued all month.

The installation of the thermocouples in the TTR thermal column has been completed. The final check of the wiring is in progress.

The wiring of the heaters in the oven has been completed, and testing is scheduled.

One graphite sample for Materials Development was compared to their standard in continuing the experiment to determine the amount of boron that will be deposited in graphite exposed to BF_3 gas at elevated temperatures.

There were no unscheduled scrams during the month.

BIOLOGY AND MEDICINE - 6000 PROGRAM

BIOPHYSICS RESEARCH

Atmospheric Physics

A second experimental determination of the dilution and distribution of airborne material which emanates from the 100-Areas and moves across the Wahluke Slope was completed. During this experiment, the generator was placed just west of the 100-B Area and air samplers were located approximately cross-wind at distances of two and eight miles from the source. The wind direction was predominantly SSW and the wind speed varied around 20 mph. Analyses of these concentration measurements and those taken during November have been completed; interpretation of these data must be confined to the "slow leak" situation (the source was continuous and was located approximately six feet above ground level). Also, in both cases, the temperature stratification was slightly unstable and the wind speeds were moderately steady around 20 mph. The airborne concentrations observed under light wind speeds and stable temperature stratifications may be considerably higher; only future experience can provide a reliable answer as to how much greater they may be. On the other hand, the average concentrations observed at a fixed point may be reduced below those observed when the wind is light and highly variable in direction and the temperature stratification is highly unstable (a typical summer afternoon situation).

The cross-wind distribution of airborne concentrations at two miles NNE of the 100-B Generator site exhibited a clear maximum. However, at a distance of eight miles, this distribution was extremely broad (at least six miles) and the maximum, while present, was not clearly defined. At distances of three to five miles from the 100-H site, no maximum was evident. This lack of a classical cross-wind distribution pattern is not surprising when one considers the distances and roughness or irregularity of terrain involved in these experiments.

The data do give reliable estimates of typical concentrations which may be expected under the conditions of the experiments. These are summarized in the following table:

Generator Site	Wind Direction and Speed (mph)	Distance from Source (mi)	Average Concentration* (units/m^3)	Time of Averaging (hrs)
100-H	NW 22	3	5×10^{-8}	3-1/2
100-B	SSW 20	2	1×10^{-7}	2-3/4
100-B	SSW 20	8	2×10^{-8}	2-3/4

* Adjusted for an emission rate of one unit of material per second.

It is interesting to note that the ratio of the concentrations at two and eight miles is approximately equal to the inverse of the ratio of these distances. Extrapolation on the basis of this fragmentary result shows that no significant further reduction in concentration below that observed at eight miles will be achieved within the confines of the Wahluke Slope under the conditions of the experiment.

A wind erosion experiment was completed at the new site for this work.

DOSIMETRY

A shipment was received of rocks that tests this summer showed to be low in radioactivity. The rock was finely-crushed talc and was packed in 100-pound sacks. These were made to form an enclosure approximately four feet in inner dimension and with walls, floor, and ceiling at least two feet thick. A rolling door of the same material is not yet complete. This shield will be used for Body Monitor studies and other low background work.

During tests of this rock shield, it was found that the case of the large NaI crystal for the Body Monitor had developed a leak. This time the crystal was slightly damaged. Arrangements are being made to send it back to the manufacturer for remounting; this will be the second remounting.

Two people with hand wounds involving possible plutonium contamination were examined with thin NaI counters. One gave no result but the other had about 0.0014 microcurie in a finger wound.

A plutonium coincidence counter in which there was no light pipe was tried. The purpose was to avoid Cerenkov radiation background. The counter worked, but the efficiency was so low that it is not practical. A light pipe was made of plastic scintillator; the hope is that rays that would produce Cerenkov radiation will produce instead scintillations that can be biased out.

The 0.5 mr insertion reading of the pulse reader for pencils was found to be due to contact potential between the materials of the pencil and the reading jig. Use of aluminum for both did not eliminate the trouble; apparently oxidation made the surfaces different. Painting both with silver paint reduced the insertion reading to less than 0.1 mr. A few checks with pencils over periods of two to four days indicated that they could be used for measurements of background levels. In one test, a pair of Landsverk

pencils were worn for three days in a shirt pocket and another pair was worn taped in the man's crotch to compare general body dose with dose to the gonads. In this test, the two were equal at 13 μr/hr. Radiation Protection Operation has begun extensive field testing of the pencils for use in regional monitoring.

Regional Monitoring Operation has taken over use of the large plastic scintillator for their regular program.

The calorimeter at the electron Van de Graaff was found to now be in agreement with electrical measurements of power input to within a few percent. The chief source of error now appears to be measurement of the Van de Graaff voltage. A method of reducing the error is being developed.

A recent paper was found in the literature that predicts an average energy for the plutonium fluoride neutron spectrum in agreement with our experimental results reported last month. It thus appears that the early work on this source was probably in error.

The Van de Graaff accelerator operated satisfactorily during the month. Nuclear Physics Operation is developing the use of the time-of-flight system and the vernier chronotron. In the course of this work they have improved the alignment of the accelerator and raised the output current to its rated maximum value. The calibration constant of the magnetic resonance system of energy control was changed 2% by this realignment; this is a significant change but has no consequences other than the necessity for recalibration.

A system was developed to permit use of the 256-channel analyzer in the proton w measurements.

INSTRUMENTATION

The scintillation-transistorized alpha Hand Counter has now operated successfully for about two months with no maintenance or recalibration of any kind necessary. The instrument is in general use by 329 Bldg. personnel. It will detect fifty d/m of Pu contamination easily and consistently and can be used as new instrumentation for the PRPR project and as replacement for any four-fold. Estimated production cost is $2000 per unit with a provision for an external cable-connected scintillation probe and loudspeaker for general clothing or shoe checking.

The modified combined alpha, beta, gamma Hand and Shoe Counter is nearly ready for use with new zinc sulfide alpha detecting screens installed and tested. The alpha section (scintillation type) will consistently give a detection register ratio of source to background of five to one for a 500 d/m alpha source; thereby giving an ultimate alpha detection limit of about 100 to 200 d/m. A 50-millimicrocurie uranium nitrate source consistently gives at least three times background. With the addition of a blower and some cables, the combined Hand and Shoe Counter will be in building operation.

Development work for the portable scintillation-beta-gamma dose-rate meters is about completed. Remaining work is of a design nature to insure adaptability of different phototubes, etc. The instrument has five linear ranges

from 0-0.5 mr/hr up to 5.0 R/hr.

Evaluation testing will start in January on two newly completed Fast Neutron Scintillation Dose-Rate Meters with the detectors modified to enhance sensitivity between 0.1 and 1.0 Mev.

Development work was completed on the portable transistorized gamma energy analyzer, and several printed circuits for it were designed and fabricated. Two experimental prototypes will be fabricated for field testing and evaluation. Minimum window width available is 40-Kev giving adequate resolving characteristics. The instrument, as now set up will determine isotope photopeaks between 100 Kev and 1.5 Mev. This can be varied, as necessary, for lower or higher energies.

The newly developed transistorized pulse amplifier has been fabricated on a plug-in printed circuit form to be used in portable pulse-type instruments of the scintillation type.

A new Scintillation Remote Area Monitoring System was devised, principally from available commercial instruments. The system uses one high-voltage supply, one chopper-stabilized DC amplifier, alarm, recorder, and a stepper switch at the central station. The remote stations would be scintillation detectors (phototubes and NaI or anthracene crystals) cabled to the central station up to 1500 ft. away. Sensitivities as low as 0.01 mr/hr are possible with stability and reliability.

Several types of source holders (Americium and Plutonium) were tested for the zinc sulfide particle detector for the Atmospheric Physics Operation in order to reduce background counting and to improve the counting efficiency.

The dust particle counter was used in conjunction with an oscilloscope and camera to ascertain how the pulse spectrum appeared. By carefully weighing and measuring particle samples from 50 micron to 500 micron sizes, the phototube counting efficiency was determined to be about 1%.

The electronic portions of the Dog Counter for Biology have been assembled, cabled and tested for operation and instrument cabinet heat rise with good results. The mechanical portions of the system are about half fabricated with expected completion in February, 1958.

Evaluation and modification of the Scintillation Beta-Gamma Dose-Rate Meters is continuing and evaluation work on the Victoreen Remote Area Monitor was continued. Evaluation of a personnel dose alarm ("pocket screamer") was started. Acceptance tests and reports were completed on 30 battery scintillation poppies, 97 HAPO G-M's, 22 HAPO CP-TP ion chamber dose-rate meters, and 5000 Victoreen pocket pencils.

WASHINGTON DESIGNATED PROGRAMS

The construction of the mass spectrometer for this program is proceeding according to schedule in Technical Shops. Special vacuum valves were designed and successfully fabricated for this machine.

CUSTOMER WORK

Analog Computing

Computer running time has greatly improved over previous months. The computer has now been in continuous operating condition for approximately six weeks. Minor troubles still exist but they do not affect the over-all operation.

A computer program and schedule for calendar 1958 is being prepared.

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	81.0
24-Hour General	62	77.5
Special	168	84.5

December was warmer and dryer than normal. The period from the 17th to the 28th was very windy, although there was fog on fourteen of the first seventeen days, no more occurred during the remainder of the month.

Demand for the 24-hour general forecast as evidenced by the number of calls answered by the recorder was 30% over demand in previous months. Peak demand of over 1600 calls occurred the week ending December 22.

Gumbel's asymptotic theory of largest values was applied to the annual flood (or high water) of the Columbia River as measured at Trinidad for the period 1913 through 1957. From this analysis, it was determined that the recurrence period for a flood of the magnitude observed in 1948 is about sixty years with a two-third probability that the true recurrence period lies between twenty-six and 180 years. Future experience will, of course, depend upon controls exercised by new dams.

Assistance to the Industrial Hygiene Operation in the experimental determination of airborne oxides of nitrogen in the vicinity of 300 Area process plants and laboratories was continued.

Optical Service

An optical system was designed and fabricated previous to this month for the purpose of permitting the Reactor Charging Machine to be remotely aligned with a process tube nozzle. During the past month, this system was tested in the Optical Shop. Performance was good. The system was then installed on the Charging Machine where it proved satisfactory for visual use. Some modifications are being made to make possible a better TV picture.

An arc furnace employing two mirrors to focus the heat flux of a carbon arc was tested. This unit was built for Ceramic Fuels Development. A temperature sufficient to melt copper (1100°C) was reached at the focus of the secondary mirror. New and larger (12-inch dia.) mirrors have been ordered and pyrex mirrors are being fabricated from round bottom flasks. The unit is intended for experimental work with UO_2 at high temperatures.

An optical profilometer designed here and fabricated offsite has been received by 105-C Metal Examination Facilities. The components were tested at the Optical Shop. The mounts for the objective lenses were modified to accommodate both large and small diameter fuel elements. At the time the instrument was designed, measurement of large-diameter fuel elements was not contemplated.

The routine Optical Shop work included the fabrication of 13 glass bearings, a target assembly for the Reactor Charging Machine Periscope, a modified lens mount for the 105 Fuel Inspection Facility profilometer, a borescope head, and low-power lens mounts for a Purex Remote Crane Periscope. An Arc Furnace was assembled, a Zeiss Winkle camera was modified, and two lead glass windows and four lead glass bricks were polished. An elbow eyepiece for the 105-C Fuel Inspection Facility was installed and two lenses were resurfaced. Repair work was completed on a crane periscope head, a borescope head, a small Lenox borescope, two microscopes, and an Underwater Periscope.

Paul F. Gast

Manager
Physics and Instrument Research
and Development
HANFORD LABORATORIES OPERATION

PF Gast:mcs

VISITS TO HANFORD WORKS

Name	Dates of Visits	Company or Organization Represented and Address	Reason for Visit	HW Personnel Contacted	Access to Restricted Data	Areas and Buildings Visited
M. D. Fiske	12/2	G-E Research Lab. Schenectady, N. Y.	Discuss electron damage work at the Research Lab.	JE Faulkner TI Moran JL Carter BR Leonard DA Kottwitz	No	300: 326

VISITS TO OTHER INSTALLATIONS

Name	Dates of Visits	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
G. R. Taylor	12/8-13	Goodyear Aircraft Corp., GEDA Products, Akron, Ohio	Discuss maintenance and observe production testing of analog computer.	Karl Starks	No
A. E. Tucker	12/9-12	Eastern Joint Computers Conf. & Exhibit Washington, D.C.	Attend National Simulation Council Meeting.	--	No
J. De Pangher	12/15-16	Los Alamos Labs. Los Alamos, N. M.	Discuss Neutron Dosimetry & Particle Accelerator Techniques.	J. A. Sayeg L. Cranberg J. E. Perry, Jr.	Yes
	12/19-21	Stanford University Palo Alto, Calif.	Give paper on "Double Moderator Neutron Detectors."	--	No
	12/23	USNRDL San Francisco, Cal.	Discuss Neutron Dosimetry.	E. Tochilin B. Shumway W. M. Mallett	No
	12/24	Lockheed Missiles Div., Palo Alto, Cal.	Discuss Particle Accelerator Techniques.	J. Elliot C. D. Moffatt	No

VISITS TO OTHER INSTALLATIONS

Name	Dates of Visits	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
J. De Pangher	12/26	Univ. of Calif. Radiation Lab. Livermore, Calif.	Discuss Particle Accelerator Techniques.	C. Wong J. Anderson	No
	12/27	Univ. of Calif. Berkeley, Calif.	Health Physic, Particle Accelerator Techniques.	W. Stubbens B. Moyer	No

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
2000 Account				
1. Present Production Piles Carry on research and development program in physics and instrumentation aimed at providing sound and adequate bases for improving operability and safety of present reactors.	4	PCTR TTR	Loss of reactivity in K reactors on going to I & E slugs determined to be 240 ± 40 inhours. Initial measurements of temperature coefficient of 7½" lattice in PCTR attempted but serious difficulties encountered interpreting measurements. Theoretical study of neutron behavior at hot-cold boundary in reactor made substantial progress.	Improved experiment in PCTR will be attempted during third quarter FY-1958. Experiments in TTR hot terminal column will be carried out during second half FY-1958.
2. Future Production Piles Carry on research and development program in physics and instrumentation aimed at providing sound and adequate bases for design of improved production reactors.	5	Exponential Piles	Lattice measurements with 1.66" solid natural uranium slugs completed by measurements in 5-3/16" lattice in addition to those reported in the previous quarter. Exponential experiments begun for cluster elements. Experiments continue at Quarter's end. Correlation of results of experiments with theoretical recipes was continued during the Quarter	Program will continue as outlined in HW-52922 and "FY-57 Program for Irradiation Processing Department" 11-7-57, J. E. Faulkner.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
2. Future Production Piles (Cont'd)			with special attention to fast effect and resonance capture. Calculation begun on plutonium isotopic concentrations for neutron temperatures up to 1200° C.	
3. Separations Plants Provide critical mass information for safe operation and design of separations plants.	4	Exponential Tank PCTR	Exponential experiments conducted with randomly stacked slugs to assist in determination of critical mass specifications for dissolver to handle slightly enriched slugs. Experiments to determine limiting safe homogeneous uranium enrichment fixed this value at 1.02 ± .02% for oxide in water. Project for Critical Mass Lab design submitted to AEC. Measurement of neutron age in hydrogenous liquids continued. Fabrication of plutonium mass spectrometer in progress.	Experiments on dissolver problem will continue with enrichments up to 1.4%. Progress for support of studies on processing power reactor fuels up to 3% enrichment will begin. Homogeneous experiments with uranyl nitrate will begin to supplement experiments concluded with oxide.
4. Cross Section Program (Jointly supported by 2000-4000 funds)	4	Neutron Spectrometers	Measurements on low energy fission cross-section of Pu^{239} and Pu^{241} were begun and were continuing at Quarter's end. Work on standardization with other laboratories continued. Time-of-flight equipment has been installed at the Van de Graaff.	This program will continue. New spectrometer available toward end of FY 1958.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
5. 4000 Program - Plutonium Recycle	7	PCTR	Measurements of k and f and Mark II A annular fuel elements were carried out and theoretical studies conducted on the performance of the PCTR and on the resonance escape problem.	Preparations being made for taking measurements on properties of spike enrichment Pu-Al. Physics parameters of plutonium graphite elements will be determined during the next half year.
6. CAD Program	1	--	Fabrication of mass spectrometer in progress.	Mass spectrometer to be completed in calendar 1958.

7. 6000 Account

Separately reported in Quarterly Biology and Medicine Report.

Chemical Research and Development

ORGANIZATION AND PERSONNEL

J. R. Morrey, Chemist I - L, was hired and assigned to Chemical Research Operation.

RELATIONS

The Hanford Operations Office has advised that the Summer Institute of Nuclear Energy - Chemical Processing will be repeated at HAPO in 1958. Similar to last year, Dr. C. A. Rohrmann is planning and organizing the training course with the help of many HAPO people. Plans this year call for twenty participants, twice as many as last year.

RESEARCH AND DEVELOPMENT

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Analytical Service

Co^{58} and Co^{60} in reactor effluent cooling water are being separated by potassium cobalt nitrite precipitation and electrodeposition. Separation is needed for Co^{58} because other radioisotopes have interfering gamma energies.

Perhaps the 1706-KE coolant radioanalysis laboratory can be transferred to facilities of the Purex (202-A) Analytical Control Laboratory. If so, CG-757--Coolant Radioanalysis Laboratory Expansion (HLO portion of Project CG-781--Service Building Additions to 1706-KE), $77,500 estimate, would not be needed. Main obstacle: The Purex laboratory has stainless steel hoods and duct work which would not stand the required heavy use of hydrochloric acid in coolant concentration steps. The obstacle is not unsurmountable. Feasibility should be known early next month.

Automatic Analyzing Monitor

Semi-routine operation of the analyzing monitor was achieved during the month. Operation of the instrument unattended for periods of 16-24 hours pointed out the need for improvements for sustained use. A feature added as a result of this experience is a circuit to prevent sample delivery in the event of heater failure or if the motor circuit indicates trouble. Improvement was also incorporated in the cup reject port to insure positive removal of the used cups. Other modifications in the cup-handling mechanism improved the reliability of operation. There appears to be some difference in the action of cups recently received from those used to make the earlier tests which has required some adjustment. Effort will continue to insure cup handling with no malfunction.

The Np^{239} channel background proved to be excessive under the conditions imposed by the present location of the instrument and effort continued to reduce this background to a workable value. Shielding experiments demonstrated that the problem arises to a large degree from radiation from the 107 Basin water discharge sump in the adjacent room. Most effective corrective measure proved to be lowering

the upper shield one inch directly over the sample, thus closing any pathway for scattered radiation to the lower crystal. This measure will be avoided if at all possible since it will involve added mechanism to raise and lower this shield, between samples. Wall shielding for the entire instrument may prove to be the most effective solution. Beta counter background was reduced to acceptable levels through shielding the counter from the bottom.

Uranium Oxidation-Melting Experiments

Calibration of flowmeters continued in preparation for the uranium oxidation experiments. The experimental work was not started, however, because of a delay in the shipment of the resistance furnace. It is now expected the first experiment will be carried out in January.

Two hundred uranium samples measuring one-eighth inch in diameter and one-inch long were received and are being stored under silicone oil to prevent oxidation. A cursory examination of these samples revealed the following facts.

a. Weight, unpolished, is 3.99 ± 0.04 g per specimen.

b. Weight loss after a light polishing with 2/0 polishing paper was about 10 mg.

c. Microscopic examination (30 X magnification) showed that the samples contained many pits and longitudinal cracks. Polishing with heavy emery cloth followed by 3/0 paper eliminated some of the surface defects, but it will not be possible to obtain a perfectly polished surface.

Fission Product From Ruptured Fuel Elements

Analytical results of a suspect rupture in Header 32 at 105-KE showed Ba^{140} to be only twice that in the control tube. The Sr^{89-90} value was about ten times that in the control. The results are so much lower than anticipated it seems possible that the sampling may have been from the wrong tube. If the rupture monitor was actually signaling this concentration of fission product, it would have a sensitivity of 0.02 per cent of the working standard release rate (0.3 curie per minute), which is not compatible with other measured sensitivities ranging from 0.6 per cent to 60 per cent.

SEPARATIONS PROCESSES

Purex

Mini Runs

A mini run was made testing the modified Purex first cycle flowsheet described last month, in which irradiated uranium is processed in turn through the HA, 1B, HS, and 1C columns. The shielded 21-stage mini unit was used as a dual-purpose HA unit. Unshielded 16, 19, and 16-stage units were used for the 1BX-1BS, HS, and 1C units, respectively. The HA and 1C units were operated at ambient temperature, the other two units at 50 C (about the maximum temperature deemed feasible in the plant).

The flowsheet used in this run was as follows:

Stream	Composition	Relative Flow	Entry Point (No. of mini stages below organic effluent in each unit)
HAF	1.65 M U, 0.92 M HNO_3	75	10
HAX	30% TBP in Purified Soltrol	365	21
HSS	3.0 M HNO_3	67	1
1BX	0.5 M HNO_3, 0.03 M Fe^{++}, 0.06 M NH_2SO_3	33	8
1BS	30% TBP in Purified Soltrol	33	16
3WB*	8.0 M HNO_3, 0.05 M $Fe_2(SO_4)_3$	25	12
1CX	0.01 M HNO_3	455	1
HSR	(as found)	-	2

* Synthetic stream.

Decontamination results obtained were as follows:

	Ru-Rh	Zr-Nb
HAF/HAP	1.9×10^3	9.4×10^3
HAF/1BU	3.1×10^4	3.9×10^4
HAF/HSU	6.5×10^4	6.5×10^4
HAF/1CU	6.7×10^5	1.4×10^5

It is of interest to note that in the case of ruthenium extensive scrubbing in the HS unit produced an additional decontamination factor of only about two in that unit but resulted in a 1C unit decontamination of ten. The fact that the decontamination factor for zirconium-niobium in the 1C unit was only about two suggests that more extensive scrubbing in the HS unit might have resulted in more substantial zirconium-niobium decontamination in the 1C unit. A second run was attempted in which the HSS flow rate was doubled; however, the HAF was exhausted before steady state conditions were attained.

Niobium Pentoxide Scavenging

Niobium pentoxide, precipitated from a potassium hexaniobate solution and dried at 110 C, proved highly effective as a scavenger for zirconium-niobium in dilute dissolver solution. The decontamination factor for a four-inch deep bed of Nb_2O_5 averaged 400 for 22 volume throughputs of dissolver solution at a superficial rate of 30 gal/(hr)(ft^2).

Citric acid, tartaric acid, versene, sodium oxalate, oxalic acid in 3 M nitric acid, and five per cent oxalic acid were tested as elutriants for the fission products. Only the last two showed any significant promise as elutriants, and both of these resulted in partial dissolution of the bed.

Calcination of Nb_2O_5 at 800 C converted the oxide to a form insoluble (visually) in oxalic acid. This was tested as a scavenger by passing synthetic 2UC (2 M U, 0.3 M HNO_3, 0.002 per cent aged dissolver solution) through a six-inch deep bed at a superficial rate of 60 gal/(hr)(ft^2). The zirconium-niobium decontamination factor decreased from an initial value of 34 to 10 after 20 throughputs and 7 after 60 throughputs. This decrease in effectiveness can probably be ascribed to the loss of surface in calcination. Further work is planned to determine optimum precipitation and drying or calcination conditions for producing an insoluble, yet effective, Nb_2O_5 scavenger.

Another synthetic 2UC was scavenged by precipitating about 2.5×10^{-3} M Nb_2O_5 in the solution, digesting 15 minutes at 60 C, and filtering through a silica gel bed which had previously been used to scavenge a similar solution. The zirconium-niobium decontamination factor was 16, of which perhaps half can be ascribed to the SiO_2 bed, based on the previous experience. The rather gelatinous Nb_2O_5 precipitate essentially plugged the bed; however, on drying overnight, the bed was found to regain its flow capacity.

Degradation Studies

Chemical degradation of Shell E-2342 (and many other hydrocarbon diluents) produces compounds which strongly complex zirconium-niobium. The zirconium-niobium thus tied up, however, is not completely fixed in the solvent phase but exhibits abnormally high E_a^g's. To investigate quantitatively the possible effect of degraded diluent in limiting the overall decontamination factor through one solvent extraction cycle, Shell E-2342, degraded by shaking with 6 M HNO_3, 0.05 M $NaNO_2$ at 50 C for seven days, was put through the following procedure:

Step	Solvent Gamma Activity, c/m/ml	E_a^o
1. Diluent washed at 50 C successively with 0.01 M $KMnO_4$ in five per cent Na_2CO_3, five per cent Na_2CO_3, and 0.5 M HNO_3.	-	-
2. Contacted with dilute dissolver solution.	3.2×10^4	-
3. Scrubbed with 2.4 M HNO_3.	2.2×10^4	1.1
4. Scrubbed again with 2.4 M HNO_3.	2.0×10^4	2.1
5. Stripped with 0.01 M HNO_3.	2.0×10^4	15
6. Diluent from above steps composited and made up to 30 per cent TBP.	1.6×10^4	-
7. Thirty per cent TBP contacted with cold "HAF" to give HAP U concentration.	1.3×10^4	1.2
8. "HAP" scrubbed with 2.4 M HNO_3.	1.2×10^4	4.4
9. Stripped with 0.19 M U to give ICU U concentration.	1.1×10^4	16

Although the gamma E_a^o was very high in the "C" contacts, enough activity transferred to the aqueous phase -- from the degraded diluent alone -- to limit the decontamination factor of the product to a gamma ratio of 12. E_a^o's under scrub conditions were so high that no more than one scrub stage would be effective in decontaminating the diluent. Gamma material balances were excellent, indicating no surface favoring compounds were present as are generally found in plant solvent.

HS and IC Gross Gamma Equilibria

Further studies to characterize the behavior of fission products under HS and IC column conditions were made. The primary objective of the work was to determine the potential IC column decontamination factor as a function of the HS column decontamination factor. IBU from mini run 10-29 was used as feed, 3 M HNO_3 (0.044 M U) as HSS, and 0.19 M U as ICX. Basically the procedure involved successive equilibrations of the IBU with HSS, while a portion of the IBU after each scrub was reserved for equilibration with the ICX. Thus IC "feed stage" equilibrations were made after 0, 1, 2, 3, 4, and 5 HS scrub stages. The results were corrected for UX_1. The following table summarizes the results:

	GSC c/min/ml					
	HS Contacts (50 C)			IC Contacts (25 C)		
Stage No.	Org.	Aqueous	E_a^o	Org.	Aqueous	E_a^o
IBU (feed)	36,600	-	-	36,600	-	-
1	5,660	62,000	0.091	21,700	14,700	1.5
2	2,720	3,570	0.76	4,110	1,320	3.1
3	2,490	778	3.2	2,330	403	5.8
4	1,730	361	4.8	1,880	159	12
5	1,590	214	7.4	1,690	73	23
6	-	-	-	1,570	43	37

These results confirm that the more activity scrubbed from the solvent prior to the IC column, the higher will be the E_a^o and, in theory, the higher will be the decontamination factor in the IC column. By plotting these data as equilibrium lines on an X-Y operating diagram, the following correlations were derived, relating HS decontamination factor to the number of theoretical stages and the L/V (aqueous-to-organic flow ratio) and the IC decontamination factor to the HS decontamination factor. In all cases, the IC column was assumed to have four stages and an L/V of 1.5:

HS and IC Decontamination Factors as a Function of the L/V and Number of Stages in the HS Column

	HS DF		HS - IC DF	
No. of Stages	HS L/V = 0.1	HS L/V = 0.5	HS L/V = 0.1	HS L/V = 0.5
1	3.9	6.4	6.4	13
2	7.2	12	15	37
4	11	18	30	140
6	13	20	40	180

SECRET

IC Decontamination Factor as a Function of HS Decontamination Factor

HS Decontamination Factor	IC Decontamination Factor
1	1.3
5	1.8
10	2.5
15	4.2
20	9.5

As a matter of some interest, the HS equilibrations were similar to some made 40 days earlier with the same IBU feed and reported last month. After correcting for decay, the two equilibrium curves were surprisingly congruent, indicating little or no effect of aging (at least not after an initial aging of one or two days -- the period between preparation of the IBU and the first equilibrations).

Solvent Extraction

Purex IC Column Studies. Studies directed toward the development of a cartridge for the Purex IC Column to provide increased capacity under Phase II Flowsheet (HW-47889) conditions were continued.

Efficiency tests in a 3-inch-diameter by 9-foot-high glass column were made with a cartridge consisting of groups of four stainless steel sieve plates (0.125-inch-diameter holes, 23 per cent free area) alternated with single polyethylene sieve plates (0.1875-inch-diameter holes, 33 per cent free area). All plates were on a 2-inch spacing, and a 0.5-inch pulse amplitude was used. Variation of temperature and aqueous to organic flow ratio (A/O) gave the following results:

Volume Velocity Gal./Hr.Sq.Ft.	Temp., C. ICX	ICF	A/O	Pulse Frequency, Cycles/Min.	% U Loss
1173	50	35	1.0	70	1.3
670	25	25	1.0	90	11.3
1173	50	35	1.0	80	1.3
1173	50	35	1.0	60	5.0
1173	50	35	1.0	70	2.5
1290	50	35	1.2	63	1.9
1290	50	35	1.2	49	4.8

Complete evaluation of the above results cannot be made until H.T.U. values have been calculated. However, they appear sufficiently encouraging to schedule additional runs.

Spiral Cartridges. Capacity tests in a 3-inch-diameter by 3-foot-high column containing a spiral baffle were continued. General observations were as follows:

1. Results of A-type extraction runs indicated that when either a standard cartridge or a spiral cartridge with a 3-inch pitch were operated under "mixer-settler" conditions (same amplitude and frequency in both columns), the waste losses were approximately the same. This was true even though channeling occurred in the spiral cartridge.

2. An attempt to measure "stagnant column backmixing" (with pulsing but with no stream flows) was made by filling the column with 0.01 molar sodium hydroxide solution and a trace of phenolphthalein indicator. Approximately 125 ml. of 60 per cent nitric acid was added to the top of the column and the time required for the color line to move through the column was recorded. Spiral cartridges with a pitch of 2, 3, and 6 inches as well as standard type cartridges were tested. This type of backmixing seemed to be independent of pitch and primarily a function of pulsed volume unless severe turbulence was caused by the use of sieve plates with smaller than normal free area. Thus, an increase in the amplitude or frequency decreased the backmixing time. Generally, values ranged from 2 minutes at frequencies of 100 to 14 minutes at frequencies of 50. A 5 per cent free area plate gave a value of 3 minutes at a frequency of 50.

3. Tests of a spiral cartridge with a 2-inch pitch were performed in an HAX-water system. Even this small pitch allowed fairly good performance as long as the frequency was kept high and the amplitude small. At a 1-inch amplitude, the column was inoperable above a total volume velocity of 400 gal./hr.-sq.ft. When the amplitude was 0.25 inches flooding frequencies for 200, 400, 600, and 800 gal./hr.-sq.ft. were 105 ± 5, 95 ± 5, 85 ± 5, and 85 ± 5, respectively.

Plastic Plate Geometry. Studies to evaluate the wetting characteristics of plastic plates were continued. A 3-inch-diameter by 3-foot-high glass pulse column containing alternately two linear polyethylene and four stainless steel sieve plates (0.08 inch diameter holes, 21 per cent free area) with 1-inch plate spacing was used as in previous tests. The pulse amplitude was maintained at 0.6 inch. Variables studied were as follows:

Volume velocity: 420 and 840 gal./hr.-sq.ft.
Plastic plate free area: 10 to 40 per cent.
Plastic plate hole diameter: 1/16 to 1/4 inch.
Aqueous to organic flow ratio (A/O): 0.14 to 1.3.
Solution composition:

I. Purex A-type scrub section conditions (aqueous = 7 g. U/L. and 126 g. HNO_3/L). Results have been reported previously.

II. Low acid system (aqueous = 0.01 g. U/L and 0.7 g. HNO_3/L).

III. High acid system (aqueous = 0.004 g. U/L and 95 g. HNO_3/L).

General observations were as follows:

1. Coalescence improved significantly with increasing free area and was relatively independent of hole size.

2. Coalescence was generally good with system I in which uranium was present and poor-to-fair with the other two systems.

3. A "zebra" effect (alternate layers of organic- and aqueous-continuous emulsions) was not obtained with the low acid system because the stainless steel plates could not be maintained aqueous-wet.

4. A "zebra" effect was obtained with the high acid system only when the nitric acid was in equilibrium in the aqueous and organic phases.

5. The flooding frequency at 420 gal./hr.-sq.ft. was in the range 90-100 cycles/min. for the high acid and low acid systems and was independent of hole size and free area. This is about 10 cycles/min. higher than for the Purex scrub section conditions.

6. Increasing the volume velocity to 840 gal./hr.-sq.ft. decreased the flooding frequency about 10 cycles/min. with uranium absent as compared to a decrease of 20 cycles/min. with scrub section conditions.

UO_3 Studies

Work this month was concerned with the characterization of UO_3 powders produced in the miniature calciner and with a study of the fluidizing characteristics of plant product UO_3.

Characterization of the UO_3 product of the miniature calciner runs reported in HW-53961-C, p. C-6, disclosed very low surface areas and slow reduction rates in the absence of sulfate.

PROPERTIES OF UO_3 PRODUCED BY CONTINUOUS CALCINATION OF 100 PERCENT UNH

NH_4/U	S ppmU	Surface Area M^2/g	Time for 97% Reduction - Sec
--	--	0.34	3260
0.02	200	0.30	3040
0.017*		0.20	2690

* Added as ammonium nitrate.

With 2000 ppm sulfur present, surface areas ranged from 0.82 to 0.95 and reduction times from 730 to 1030 seconds. On the basis of the above measurements, there

appears to be little difference between the use of ammoniated feeds in the continuous calcination process as compared to pure UNH. The ammoniated feeds (in the absence of sulfate) also resulted in production of much greater quantities of dust and fines (cf. HW-43961-C).

Since HAPO UO_3 product is subsequently put through a two-stage fluidized bed reduction process, it is desirable to know how the fluidizing characteristics of the powder are related to its physical properties. A sample of product UO_3 known to operate satisfactorily was examined with respect to particle size distribution, fluidizing characteristics, minimum mass velocity for fluidization, particle shape factor and angle of fracture. Similar examination of samples prepared by mixing known particle sizes was also made and comparisons were drawn. The detailed findings will be reported in a forthcoming document; the following represents a high-spot summary of the work to date.

1. In the case of HAPO UO_3, more than 80 per cent passed through a No. 200 screen (0.0029 inches diameter) and over 35 per cent passed through a No. 325 screen (0.0017 inches diameter). The geometric mean particle diameter was 0.0019 inches.

2. An "ideal" particle sign distribution was determined from theoretical considerations, and a sample having this distribution was synthesized. Upon screening, 8.5 and 1.5 per cent passed through 200 and 325 mesh sieves, respectively. The "ideal" mixture was substantially better than the production powder in all respects related to fluidization.

   A "poor" powder was also synthesized of which 50 per cent passed through the No. 325 screen and 100 per cent passed through the No. 200 screen. This material was substantially poorer than production powder.

3. The angle of fracture of the "ideal" material was 45°, for the production powder 65° and for the "poor" powder 80°. Measurement of the angle of fracture provides a simple and effective means of predicting the behavior of the powder towards fluidization. If the angle of fracture is less than 60° the material will probably be satisfactory. If greater than 60° channeling and generally poor operation are likely to occur.

4. The presence of a high percentage of 325 mesh fines in UO_3 powder is detrimental to its fluidizing properties. Although the present material is apparently satisfactory, a reduction in the fines would represent a significant improvement.

Continuous Calcination

Addition of Ammonia. As reported last month an attempt was made to operate the pilot plant scale continuous calciner with 100 per cent UNH feed containing 2.4 per cent ammonia and from 0 to 300 parts per million sulfur on a uranium basis. The operation was plagued with caking, poor heat transfer, and bed throw-out, and the calciner was judged to be inoperable. In addition the performance of the concentrator used to prepare the 100 per cent UNH had been impaired insofar as its capacity was concerned.

Observation of the concentrator internals after last month's run revealed extensive scale build-up on the steam coils which resulted in relatively poor heat transfer and accounts for the limited capacity of the unit. In addition a heavy, yellow precipitate, presumably ammonium diuranate, was found at the bottom of both the concentrator and the 100 per cent UNH storage tank.

Two runs, differing only by feed point temperature, were made this month. Operating conditions were as follows:

Feed Point Temperature: 290 and 260 C.

Feed Composition: 100 per cent UNH containing 1.8 per cent ammonia, 600 ppm sulfur and -0.5 M nitric acid.

Agitator Speed: 66 rpm

Findings include:

1. No precipitation was found in either the concentrator or 100 per cent UNH storage tank.

2. The concentrator performed satisfactorily at through-put rates in excess of 300 lb. water evaporated per hour.

3. No cake build-up was observed during the 290 C calcination run. On the other hand, during the 260 C calcination run, a soft, chalk-like build-up was formed at each feedpoint zone. However, the build-up did not cause uneven shell temperatures nor impair the operation in any manner.

4. The operating bed level remained constant during both runs.

5. Spheriodal-shaped particles, with very little dust, were produced in both runs.

6. Average UO_3 production rates were 180 lb./hr. at 290 C feedpoint temperature and 220 lb./hr. at 260 C feedpoint temperature with equivalent heat in-put.

Laboratory examination of the product is incomplete at this time.

On the basis of the successful operation, a recommendation has been made to Finished Products Operation that a plant test would be feasible.

The UO_3 produced during these runs will be shipped to K-25 plant for evaluation.

Continuous Calciner Agitators - 224 UA Building. Hinged-arm agitator blade and shear pin failures in H- and K-cell calciners demonstrated that:

1. The hinged-arm agitator assembly (SK-2-43238) will sustain severe shocks and loading (due to foreign objects in the bed, lumps of uranium oxide, etc.) without gross damage to the shell or agitator.

2. The two-piece welded blade and shear pin with 3/8-inch notch diameter are inadequate for long period service.

On the basis of these failures, a one-piece blade and increased notch diameters (7/16 and 1/2-inch) will be recommended. This will give a better balanced design.

Ion Exchange

The pressure drop and flow characteristics of the anion-exchange resin Amberlite IRA-401, 20-50 mesh particle size, were investigated in the moving bed ion-exchange contactor. In a water system with a combined feed and scrub flow of 3.0 l./min. a 4-inch resin push (6-inch water push) was obtained with an air pressure of 10 psig. In an acid system (ca. 6.5 M HNO_3 XAF and XAIS) with the same flow, however, an air pressure of 30 psig was necessary to obtain a 1-inch resin push with a 6-inch water push. After 12 hours of successful continuous operation under these conditions, the resin was removed from the unit and sent to the Purex plant.

WASTE TREATMENT, FISSION PRODUCT RECOVERY

Special Geological Studies

The contract for the fixed-price portion of the CA-700 well drilling project was extended to February 1, 1958 to allow completion of the additional wells and footage authorized to be drilled by the Hatch Drilling Company. Their portion of the project is now about 90 per cent complete, with two wells in process of completion and one yet to be begun.

Observation Wells

Radiostrontium persisted in the ground water beneath the 216-S-1 and 2 cribs in 200 West Area as indicated by samples from adjacent wells. No radiostrontium or radiocesium was found in ground water samples from any other site. Radiostrontium detected in one sample from a well near the 216-A-8 crib was shown to be the result of sample contamination in the laboratory and subsequent samples from this well contained no radiostrontium.

Detectable ground water contamination appears to have spread eastward from 200 West Area and westward from the 200 East Area has joined in the relatively permeable aquifer between the two areas. This very low concentration of radioactive material is moving to the northwest and to the south in the ground water. Special samples were taken from wells in the BC Crib and trench area. These facilities have received large volumes of scavenged waste disposed by cribbing and specific retention. A measurable ground water mound exists beneath the site but no radioactive material has previously been found in the ground water that could be attributed to these disposal facilities. The special samples taken from BC monitoring wells were simultaneously collected from various depths. A few of these samples indicated the presence of radioactive contamination at depth in the ground water while none was found at the ground water surface. The concentrations observed were very low and the results of repeated sampling not completely consistent. It is believed possible that these results may indicate sinking of high-density scavenged waste in the

ground water. The approximately one-million curies of radioactive material discharged to the BC site is expected to ultimately produce low-level contamination in the water table beneath this facility.

During the first week of operation of the new Gable Mountain swamp all of the cooling water from the Purex plant was discharged to it. This flow, ranging from seven to nine millions of gallons per day resulted in a 0.2 foot rise in the water level in a well 4000 feet from the discharge line outfall. During the second week of operation the flow to the new swamp was reduced to about one-third of the total discharge, about 3 million gallons per day. It is estimated that after discharge at this rate for one year the mound beneath this swamp will be about 1.6 foot above the normal ground water level.

Disposal to Ground

Samples from three batches of in-farm scavenged waste were evaluated by means of soil column tests. All three of the samples resulted in a rapid Cs^{137} breakthrough and one also displayed a breakthrough of Sr^{90} in less than one column volume. As a result of these soil reaction tests it was recommended that the wastes not be discharged to cribs.

Preliminary data from two additional soil column tests with Purex boiling-tank condensate waste indicate ultimate crib capacities of 8.5 and 19 column volumes. Previous tests resulted in calculated crib capacities ranging from 9 to 27 column volumes. The poor reproducibility of these data is ascribed to variations in waste composition and to excessive sensitivity to unavoidable differences in the test columns and analytical results. No method is apparent for properly integrating these results to obtain a true crib life. It is therefore necessary to accept a conservative estimate based on the lowest calculated life, with a recognition of the probability that the crib will be useful for some longer period.

Experiments are in progress to evaluate the soil reactions of samples of Purex process condensate (216-A-5 crib) by means of soil column tests. Very preliminary results indicate a possible crib life of about 17 column volumes. The crib has actually received 23.6 column volumes to date and no evidence of long-lived isotopes in the ground water was observed. Further tests of this waste are planned and special monitoring samples from adjacent wells were scheduled.

Research conducted to evaluate soil column variables in waste-soil reaction tests included experiments using soil saturated with magnesium rather than with calcium. This change was originally made to facilitate analysis of the effluent since magnesium salts on the counting plates proved to be less hygroscopic than those of calcium. It was found that solutions passed through the magnesium saturated soil did not attain full equilibrium breakthrough as expected. Part of the radiostrontium tracer used in the tests was permanently retained in the soil by some mechanism having a much longer equilibrium time than the normal ion exchange reaction. A hypothesis that this mechanism involved a strontium-calcite reaction was supported by experiments with soils previously flushed with acid for the latter calcite-free soils did not show non-equilibrium retention of strontium. It has now been found that strontium solutions containing up to 1000 ppm calcium do not display

evidence of this calcite reaction with strontium although the same soils continue to retain part of the strontium from solutions containing up to 1000 ppm magnesium. It is felt that the data indicate a calcite-strontium reaction in which calcium is capable of competing with strontium, but in which magnesium does not compete. If further work bears out this theory it might be possible to use the mechanism to extend the life of certain Hanford cribs by neutralizing the wastes with magnesium carbonate or hydroxide in place of limestone.

The two batches of in-farm supernatant liquid (26 and 27) scavenged this month by CPD contained Co^{60} below the recommended test disposal limit of 4×10^{-4} uc/cc. However, since batch 26 demonstrated poor cesium adsorption and batch 27 poor cesium and strontium adsorption in soil column tests, they were discharged to the 216-BC specific retention trenches. Two batches (approximately 1,000,000 gallons) remain to be scavenged prior to termination of the in-farm scavenging program in the 200 East Area.

Recuplex aqueous waste which is sent to the 216-Z-10 cavern has plugged the soil to the extent that a pool exists which is about 4-1/2 feet deep. Thus the cavern is functioning as originally planned. However, the plutonium bearing waste is sent to the ground at pH 2.5 which is not conducive to optimum soil removal of plutonium.

It was recommended that wells to ground water be provided in the vicinity of the 234-5 Waste Cribs. This resulted from the fact that plutonium was found in mud samples from two dry wells at depths of only fifty feet above the regional ground water table. The wells are necessary in order to monitor the ground water and to evaluate the status of the present waste cribs.

Gelling of Wastes - Field Work

Observation of the aluminosilicate gel in the test disposal pit east of the 300 Area revealed that the moisture content of the gel near the surface has increased from 80 per cent to 85 per cent (wet basis). The moisture content in the gel near the bottom of the pit remained at about 75 per cent. The increase in moisture content near the surface was at first thought to be due to condensation of water vapors from the air; however, the uniform 46 F temperature of the gel, which is greater than the average air temperature, rules out this possibility. Although no evidence of gel shrinkage has been observed during the past month, the material does have a decidedly firmer texture than was previously noted. This may be due to the low temperature of the gel bed.

A proposed procedure for a laboratory-scale test to demonstrate and obtain data on the self-sintering of gelled Purex high salt and coating wastes was prepared. Utilization of heat generated by radioactive decay of fission products to achieve self-sintering temperatures in wastes contained in a gel matrix may have potential as an ultimate disposal method. Preliminary investigations will be conducted to determine proportions of the various solutions which when combined will produce a satisfactory gel.

Preliminary laboratory investigations concerned with the drying of synthetic coating removal waste by mechanical methods indicated that drum-drying of liquid or gelled coating waste may have practical application as a disposal method. The objectionable feature of gel disposal per se is the subsequent loss of contaminated liquid from the gel to the soil. Partial or complete dehydration of the gel prior to disposal should eliminate this undesirable characteristic. A small drum-dryer was

constructed and will be operated to evaluate drying characteristics and economics of this dehydrating method. Solubility, and later leachability, tests of the final dried product are planned.

Ultimate High-Level Waste Disposal

In cooperation with CPD personnel, a study was begun on the processing, economics, and justification for alternate methods of ultimate high-level waste storage (Purex). Work was done on calculations of heat generation rates and maximum waste temperatures anticipated in pipes cooled by air. The ultimate storage method assumes retention of calcined wastes as dry solids.

FISSION PRODUCT RECOVERY

Cesium Recovery

Additional data were obtained during the month on the effect of temperature and several other variables on the precipitation of cesium with zinc ferricyanide. The findings are summarized in the following paragraphs.

The effect of temperature is shown in the following table. The temperature coefficient is much greater than expected and leads to a ΔH of adsorption of about - 13,000 calories. Because of this large temperature effect, it may be necessary (in a plant scale application) to provide some cooling to overcome the temperature rise caused by the heat generated in 1WW by fission product decay.

EFFECT OF TEMPERATURE ON CESIUM RECOVERY WITH ZINC FERRICYANIDE

Conditions: 2 M $NaNO_3$, 0.1 M Fe, 0.1 M HNO_3, 0.001 M Cs, 0.01 M Zn, 0.005 M $K_3Fe(CN)_6$

Temperature, °C	Cesium Recovery*, %
0	99.2
10	98.3
20	96.5
25	94
45	78
65	56
85	32

* Each number is a mean of four experiments.

A factoral experiment was set up to investigate the effect on cesium recovery of the various constituents expected in a plant 1WW solution. The data were subjected to statistical analysis, and a number of significant dependencies were established. The data are presented in the following table. It will be noted that substitution of potassium nitrate, ammonium nitrate, uranyl nitrate, or chromium(III) nitrate

for sodium nitrate has no effect. Similarly, aluminum nitrate at concentrations up to 0.2 molar has no effect. High concentrations of sodium nitrate or ferric nitrate are detrimental, and even very small concentrations of nickel have a very adverse effect. It is also seen that the extent of cesium precipitation is highly dependent on the concentration of cesium and of zinc ferricyanide. The most unusual effect, however, is that of sulfate, which improves cesium recovery when present at concentrations of 0.1 to 1 molar.

EFFECTS OF CERTAIN VARIABLES ON CESIUM RECOVERY

Conditions: 2 M $NaNO_3$, 0.2 M $Fe(NO_3)_3$, 0.1 M HNO_3, 0.001 M $CsNO_3$, 0.01 M $Zn(NO_3)_2$, and 0.005 M $K_3Fe(CN)_6$ unless otherwise specified.

Reagent	Concentration, M	Cesium Recovery, %
$NaNO_3$	2	89
$NaNO_3$	3	86
$NaNO_3$	4	79
$NaNO_3$	5	66
$Fe(NO_3)_3$	0.3	82
$Fe(NO_3)_3$	0.4	84
$Fe(NO_3)_3$	0.5	63
$Al(NO_3)_3$	0.1	88
$Al(NO_3)_3$	0.2	89
$Ni(NO_3)_2$	0.01	66
$Ni(NO_3)_2$	0.02	55
$Ni(NO_3)_2$	0.05	48
KNO_3	1*	86
NH_4NO_3	1*	87
$UO_2(NO_3)_2$	0.1*	87
$Cr(NO_3)_3$	0.1*	87
Na_2SO_4	0.1	94
Na_2SO_4	0.2	98
Na_2SO_4	0.5	98
Na_2SO_4	1	99
$CsNO_3$	0.0002	99.5
$CsNO_3$	0.0005	99.4
$CsNO_3$	0.001	92
$CsNO_3$	0.002	88
$Zn(NO_3)_2$	0.002**	10
$Zn(NO_3)_2$	0.005**	16
$Zn(NO_3)_2$	0.01**	88
$Zn(NO_3)_2$	0.02**	99.2

* $NaNO_3$ concentration reduced to keep total nitrate concentration constant.
** Ferricyanide concentration half of zinc concentration.

Cesium Isolation and Packaging

Scope drawings for the Cesium Isolation and Packaging Facility are nearly complete. These drawings show the equipment arrangement, basic component designs, piping, electrical, and instrumentation requirements, and the architectural modifications to the processing cell.

Studies were continued to determine process parameters for the hydrolysis of cesium zinc ferrocyanide and the conversion of a cesium chloride brine into a dry crystalline product. Sodium chloride has been used as a stand-in material to establish crystallization technique.

Waste Treatment

A program has been initiated (see HW-52824) aimed at improving the long term safety and economy of storage of the high level Purex wastes. The objective of this work is to develop methods for converting the wastes to compact stable solids. Three areas of work are under active investigation:

1. Removal of nitric acid from 1WW.

2. Calcination of Purex and Fission Product Recovery wastes.

3. Effect of higher temperatures on release or fixation of fission products, thermal conductivity, etc.

Some preliminary experiments have been run on the drying and calcination of a "cold" synthetic 1WW solution. Evaporation in an air stream was found to be very slow. However, it was noted that neutralized 1WW evaporated more rapidly than unneutralized 1WW. The salt which had precipitated from the neutralized 1WW when the volume was reduced by a factor of two was shown by X-ray diffraction to be sodium nitrate.

Samples of both neutralized and unneutralized 1WW were also calcined. This was done both in a tube furnace and on a thermal balance. The latter showed that the dried neutralized waste decomposed in two steps, one commencing at about 275 C and the other at 350 C. The unneutralized 1WW salts decomposed at a somewhat lower temperature. The sodium nitrate in the neutralized salt melted during calcination and spattered badly. The unneutralized waste decomposed to a porus cinder with no apparent melting or spattering. Weight loss measurements indicated that considerable nitrate decomposition took place during drying at 110 C prior to calcination.

Iodine Chemistry

Further experiments were performed to determine the effectiveness of mercuric salts in enhancing the absorption of radio-iodine in nitric acid solutions (or in retaining iodine in such solutions). The following table shows the results when air was passed through 1 M nitric acid containing the indicated concentrations of iodine and mercuric nitrate.

EFFECT OF MERCURY ON EVOLUTION OF IODINE FROM NITRIC ACID SOLUTION

Iodine Concentration M	Percent Retention in Aqueous	
	No Mercury	0.01 M Mercury
10^{-4}	19.5	99.80
10^{-5}	65.6	99.73
10^{-6}	99.95	99.97
10^{-7}	99.52	100
10^{-8}	99.94	99.89

It will be noted that 0.01 M mercury effectively inhibits the evolution of iodine from the 10^{-4} and 10^{-5} molar solutions. However, iodine loss is negligible at lower iodine concentrations even in the absence of mercury. The reason for this is not clear. Future experiments will involve removal of iodine from the gas stream, rather than from solution, to see whether the kinetics of this transfer are limiting and to more closely simulate the proposed plant application.

Neptunium Recovery

It was reported last month that the corrosion rate of stainless steel by boiling nitric acid is much enhanced by the presence of sodium vanadate (a promising reagent for oxidizing neptunium to the extractable plus six oxidation state). Further experiments have shown that reducing the vanadate to V(IV) with ferrous sulfamate prior to simulated acid recovery does not significantly decrease the rate of corrosion of stainless steel (0.51 cm/year). Vanadium thus appears to be eliminated from consideration for use in controlling neptunium routing.

The results of analyses of Purex plant streams for neptunium-237 are shown in the accompanying table.

PATH OF NEPTUNIUM-237 IN THE HANFORD PUREX PLANT

Sampling Date	Neptunium-237 (c/m/ml)*					
	1AF	1AW	1BP	2DF	2DW	U Product**
9-22-57	1550	288	204	2520	940	(768)
9-28-57		848	74	942	28	(1070)
10-13-57				450	558	813 (401)
10-18-57	1052	40				(1190)
10-20-57	1320			310	60	(538)
10-29-57	1560	16	128	638	660	(1020)
11-5-57	1470		420	585	146	(768)
11-12-57				980	76	
11-17-57				775	70	

* Normalized to HAF flow.

** Numbers in parenthesis are from Purex Analytical Laboratories, all others from Analytical Laboratories Operation.

These data continue to show that most of the neptunium gets through the HA column, most of that reaching the 2D column is partitioned into the uranium product, and part of the neptunium is found in the 1BP. It also appears that there may be an analytical discrepancy between the results of the two laboratories.

Following Purex start-up after the December shut-down, the neptunium content of the uranium product dropped off sharply, apparently due to decreased nitric acid concentration in 2D column operation. The acidity has now been increased, and the product neptunium figure has started to rise. A plant test is to be made wherein the acidity will be raised further in an effort to force neptunium quantitatively with the uranium. Following this test, 1B conditions will be varied in an effort to achieve a clean neptunium routing with either product stream, as desired.

ANALYTICAL & INSTRUMENTAL CHEMISTRY

Analytical Services

Plutonium isotope analysis by thermal ionization mass spectrometry is now being provided. Then samples were analyzed during the month. Additional use will permit cost and accuracy comparisons against fission counting which provides only Pu^{240} values.

Iron measurements were made to support a study of $Cs_2ZnFe(CN)_6$ hydrolysis. The standard o-phenanthroline method worked. Preliminary digestion in high boiling acid expelled cyanide interference.

X-ray absorption was useful for measuring uranium in arc furnace melted uranium dioxide. The first step was metal removal by leaching with cold, half-strength hydrochloric acid.

Sixteen samples for uranium burnup were received from 327 Building dissolutions. They are being processed at the one/day rate. Twelve are complete. Final testing of the 325 Building dissolver is on schedule aimed at a rate of two dissolutions/week by February.

The Five Peak Analyzer operated routinely. Two-hundred and thirty samples were completed. To do the same work with a scanning spectrometer plus some chemical separations would have required an additional 1.25 employees. The Analyzer often permits cost savings even when chemical separations are still necessary. The reason is that separations need not be so precise. For example, a single perchlorate separation was found adequate for cesium. And again, twenty-one hours time was saved through shortened forms of niobium and zirconium separation procedures.

Controlled Potential Coulometry

The precise determination of plutonium by controlled potential coulometry at a macro level (two to ten milligrams plutonium) has been previously discussed. A mercury pool cathode in a citrate buffered medium was used. The method did not permit the separate titration of plutonium and iron, but a correction for iron

impurity was required. Recent work with a platinized platinum gauze electrode in acidic media has led to a method which has no iron interference and retains the high precision of about plus or minus 0.05 per cent standard deviation in the optimum range. The titration is carried out in a one molar nitric acid solution containing a small amount of sulfamate ion to eliminate nitrite interference. For the Pu(III) to Pu(IV) conversion, potentials of 0.50 volts for reduction and 0.90 volts for oxidation against a saturated calomel electrode are applied. Chromium and nickel do not interfere, and iron does not interfere unless its concentration exceeds the plutonium concentration.

Studies of low level plutonium titrations at 100 to 200 micrograms are being made by plotting oxidation-reduction titration curves of plutonium and of various possible interferences in several media using the controlled potential coulometer. In addition, a unique instrumental adaptation of the coulometer permits the direct recording of the derivative of the titration curve, yielding a peak at the E^{o} which closely resembles the results of derivative polarography.

Fission Counter

The gas scintillation fission counter has been modified to use an ultra-violet sensitive multiplier phototube with the elimination of the wave length shifter previously required (nitrogen in argon). A subject report has been issued as HW-46412.

EQUIPMENT AND MATERIALS

Pumps

Deepwell Turbine Pump Conical Slinger - Deflector Liquid Seal. A modified conical slinger-deflector seal for deepwell turbine pumps has been placed on life test. The cone consists of two pieces and is mounted with the base facing the liquid throttle bushing. The top of the cone is attached to the pump shaft, the base of the cone is free to move axially and is pinned to the top of the cone so that it rotates with the shaft. With the cone set 20 mils below the liquid throttle bushing and 10 mils diametral clearance between the liquid throttle bushing and the shaft the maximum leakage at shut off (217 feet head) was 710 ml/min. At 8 feet of head the leakage was zero. The leakage averaged about 350 ml/min at discharge heads typical of plant operation.

These preliminary test results indicate that a two piece, hydraulically loaded, conical slinger-deflector will be superior to the one-piece cone unit recommended for plant application and reported in HW-53530.

Canned Motor Pump. An order has been placed for a 5 HP canned motor suitable for in-line or submersible pump application. The motor will be in accordance with the design developed by the General Engineering Laboratory in 1950 (HW-51826). Titanium will be used instead of stainless steel and the bearing retainers have been modified to permit easier replacement.

Valves

Elkem Solenoid. A plastic solenoid valve supplied by the Elkem Corporation failed after 44,000 cycles. The solenoid coil burned out. Operation was smooth until failure occurred.

Hills McCanna Saunders Type Valve. Super Dylan and Marlex 50 (high density polyethylenes) diaphragms molded in the normally closed position are being tested. Most materials used for diaphragms in these valves are susceptible to radiation damage at relatively low total exposures (Teflon at 10^5 - 10^6 r). These polyethylenes have some physical properties desirable in diaphragms after exposures to 10^9 r gamma and retain them at exposures of 2 x 10^9 r gamma. One diaphragm exposed to 10^9 r has endured 400 off-on cycles.

Corrosion Studies

Hard-Surfaced Titanium. Hard-surfacing of titanium is under study as a means of preventing scoring and deformation of mating faces of nozzles on remote jumpers. Three samples of A-55 titanium ranging from as received to "fully hard-surfaced" (cyanide bath) were submitted to Huey corrosion tests in this laboratory. Microscopic examinations were made after each 48-hour test period. There was no significant difference in observed corrosion rate among the three samples. However, all three corroded at a rate about five times greater than normally observed for A-55 titanium under these conditions. In addition, localized cracking was observed around numbers placed on the samples. Preliminary metallurgical examination indicates the cracks do not penetrate much beyond the hardened layer and they may have been present prior to the Huey test.

Pressurized Heat Transfer Units. Exploratory experiments are being conducted in the pressurized heat transfer units to determine how data obtained with them correlate with those obtained with atmospheric pressure units. In an exposure of 347 stainless steel to 60 per cent HNO_3, corrosion was considerably more severe under conditions where heat was transferred from the sample to the solution than when the sample received heat from the solution even though the sample surface temperature was about the same (ca. 115 C) in both cases. Also, crevice corrosion at the sample-gasket interface was evident in the former and absent in the latter case. The observed differences in corrosion rate may be due to differences in boiling nucleation on the two surfaces.

NEW PROCESSES

Flurex Development

304-L Stainless Steel Anode. Long term (200 hours) tests indicate the equilibrium anodic corrosion rate of sensitized 304-L stainless steel in 0.1 M NH_4NO_3 (pH~9.4) to be about 4.8 mg/sq.in./amp.hr. when operating at 1 amp/sq.in. Based on cost of materials and previously determined corrosion rates for Pt under the same conditions, the cost per unit weight of uranium processed would be about twice as much for Pt anodes as for 304-L anodes. In this run, fluoride concentration was 0.0003 M and temperature was 30 C. The effect of these and other variables such as stainless steel type and pre-treatment will be studied in future runs.

Catholyte Composition. A series of runs was made to determine the effect of certain variables in catholyte composition on efficiency for uranium reduction at the cathode. Data obtained are shown in the following tabulation.

Reduction Efficiency, Per cent, vs. Cathode Composition

	0.01 M U		0.1 M U	
	0.1 M F	1.0 M F	0.1 M F	1.0 M F
0.0 M H_2SO_4	62	57	86	93
0.1 M H_2SO_4	64	72	70	92

These were preliminary, batch type experiments performed primarily to determine significant variable ranges to use in planning a more comprehensive series of runs which will permit a statistical evaluation of the interaction of six factors considered significant in catholyte composition and operating conditions. Although subject to considerable error, these experiments do show uranium concentration to have a significant effect on reduction efficiency.

Feed Compartment Composition. Further studies of current efficiency for uranium transport (across the cation membrane) as a function of feed compartment composition and operating conditions indicate (a) current efficiency for uranium transport is independent of equilibrium uranium concentrations in the range 0.1 to 1.5 M, (b) gross water transport increases with decreasing uranium concentration and increasing cell temperature.

Other studies in progress (cathode compartment fission and corrosion product decontamination and correlation of static and operating membrane stability tests) can not be reported this month due to lack of analytical data.

Anion Exchange Process

Anion Exchange Kinetics

Studies of plutonium absorption and desorption kinetics on anion exchange resins have been continued. For all resins studied to date, the concentration of plutonium absorbed on the resin increases approximately linearly with the logarithm of the time with the exception of one per cent crosslinked Dowex 1. The Dowex 1, X-1 loads much more rapidly than the other resins, and the plutonium concentration varies in a more complicated fashion with time. The greater shrinkage which this resin undergoes on loading may account in part for its more complicated rate behavior as compared with higher crosslinked resins. The elution of the anion resins with 1 M HNO_3 at 60 C results in data which approximates very closely a first order rate mechanism. Elution at 25 C with 0.35 M HNO_3 deviates from this type of rate expression, apparently because of plutonium polymerization in the resin phase. Increasing elution temperature with 0.35 M HNO_3 results in increasing initial rates followed by a sharp break and very slow elution. Apparently this behavior is due to increased tendency to polymerize at increased temperature. This indicates that a shallow bed cannot be eluted completely by 0.35 M HNO_3 at elevated temperature and high flow rate. The reason for complete elution in a deep bed using 0.35 M HNO_3 at elevated temperature appears to be that the elution is occurring mainly into $Pu(NO_3)_4$ - 0.35 M HNO_3, and the resin contacts the low nitrate elutriant only

after most of the plutonium is already removed. Much more variation between resins is seen in the elution kinetics than in loading kinetics. Times required for 90 per cent elution by 1 M HNO_3 at 60 C are: Dowex 1, X-1 (50 - 100 mesh), 2 minutes; Dowex 1, X-4 (50 - 100 mesh), 25 minutes; Dowex 1, X-8 (50 - 100 mesh), 290 minutes; Amberlite IRA-401 (20 - 50 mesh), 95 minutes; Permutit - SK (20 - 50 mesh), 10 minutes.

It was previously reported that Dowex 21K (50 - 100 mesh) was incompletely eluted by 0.35 M HNO_3. This appears to be due to non-uniformity of the resin beads, and this difference is probably exaggerated by the fact that the plutonium on the beads which lag behind the sharp elution band undergoes polymerization in the dilute nitric acid. Elution of this resin with 0.45 M HNO_3 at 60 C results in complete elution with a maximum product concentration of 52 grams per liter. The non-uniformity of the resin is still apparent from the lagging of some of the beads behind the sharp band, but this tailing is not serious at this acidity.

Recovery of Plutonium from Purex 1WW

A series of runs is in progress to determine the plutonium adsorption characteristics of Dowex 21K and Amberlite IRA-401 resins for feeds of the plutonium level expected in Purex 1WW.

With synthetic Purex 1WW spiked to 50 mg Pu/l, Amberlite IRA-401 (20 - 50 mesh) exhibited a plutonium capacity (to 50 per cent breakthrough) of 10, 10 and 15 grams plutonium per liter of resin at temperatures of 60, 40, and 25 C, respectively. Analytical data for a run with a feed concentration of 2 mg Pu/l (approximately that expected in plant 1WW under steady state two-cycle operation) are incomplete, but indications are that the capacity of Amberlite IRA-401 to 50 per cent breakthrough is at least 2 grams plutonium per liter of resin and at 10 to 20 per cent breakthrough, is probably of the order of 0.5 to 0.75 grams plutonium per liter of resin.

Although low, these capacities are sufficient to enable economic recovery of significant amounts of plutonium from Purex 1WW even with the low solvent extraction losses expected from the two cycle flowsheet.

However, it is emphasized that several uncertainties exist in extrapolating these data to the in-plant processing of 1WW. The oxidation state of plutonium in 1WW is not known, and an additional step may be necessary to convert the plutonium to the required tetravalent state. Plugging of the resin bed by suspended solids, if present, in plant 1WW is an additional potential complication.

Pyrochemical Processing Studies

Further work has been done to determine how aluminum reacts with the species formed when UO_2 and UO_3 dissolve in $KAlCl_4$. Preliminary experiments were also performed to learn how oxides of cerium, thorium, and plutonium behave in the $KAlCl_4$ system.

When UO_3 reacts with excess $KAlCl_4$, the uranium reaction product is UO_2Cl_2. Upon addition of aluminum to this melt, its color changes from red to purple, and part of the uranium is reduced to metal. The reaction is believed to be

$$3\ UO_2Cl_2 + 4\ Al \longrightarrow U + 2\ UCl_3 + 2\ Al_2O_3 \qquad (1)$$

which at 1000 K has a free energy change of -109 kcal/mole UO_2Cl_2. Further reduction of the UCl_3 to metal is unlikely since the free energy change for this reaction is +27.5 kcal/mole. On the basis of equation (1), the theoretical yield of uranium metal is one-third of the total uranium present as UO_2Cl_2. Experiments in air, however, have resulted in metal (alloy) yields up to 79 per cent (see the following Table). This result is perhaps due to a reaction such as reaction (2).

$$3\ UO_2Cl_2 + 14\ Al + 6\ O_2 \longrightarrow 3\ U + 6\ Al_2O_3 + 2\ AlCl_3 \qquad (2)$$

The data of the accompanying table and experimental observations tend to support this hypothesis. When aluminum is added to the UO_2Cl_2 - $KAlCl_4$ solution, there is an immediate reaction and the color of the system changes to purple indicative of uranium (III). It is believed that initial reaction according to equation (1) is very rapid. The subsequent reaction involving atmospheric oxygen proceeds more slowly and is perhaps limited by the diffusion of oxygen to or through the salt-air interface. The data in the table, although fragmentary, support this mechanism: The extent of metal production by the secondary process apparently increases linearly with time; it decreases with an increase in volume of the salt phase (which dilutes the UO_2Cl_2 and increases the distance between the air-salt and salt-aluminum interface); and, it decreases with increasing UO_2Cl_2 concentration.

Reduction of UO_2Cl_2 by Aluminum in the System UO_2Cl_2-$KAlCl_4$-Al[(a)]

Run No.	Time Min.	UO_3 Moles	$KAlCl_4$ Moles	Al Moles	% U Reduced to Metal	% U Reduced Less 33%
10	10	0.0035	0.048	0.148	46	13
11	20	0.0035	0.048	0.148	60[(b)]	27
11	20	0.0035	0.048	0.148	60[(b)]	27
14	20	0.0035	0.072	0.148	36	3
15	20	0.0035	0.096	0.148	38	5
13	20	0.0018	0.048	0.148	79	46
11'	20	0.0035	0.048	0.148	60[(b)]	27
12	20	0.0070	0.048	0.148	39	6

(a) Reactions took place in unstirred quartz test tubes at 770 C in air. The reaction mixtures were quenched by pouring into porcelain evaporating dishes.
(b) Same run.

It is not believed that volatilization of $AlCl_3$ provides the driving force for the reaction of aluminum with uranium trichloride since a relatively large quantity of aluminum chloride is present in the solvent at all times.

A run similar to run 10 but conducted at 700 C was made with 20 mg of Ce_2O_3 containing Ce^{144} added to the system. The salt phase contained 10^6 times the activity of the uranium-aluminum alloy button. This large decontamination factor is important not only for the size of the single stage effect but because it demonstrates the fact that clean phase separations are not difficult to attain.

Similar runs were also made with ThO_2 and PuO_2, the extent of reduction being 11 per cent and 1 per cent, respectively. These results reflect the greater thermodynamic stability of $PuCl_3$ as compared to UCl_3 in reaction with aluminum and offers possibility of a simple partition technique. The potential for partition is even greater because of the alternate oxidation mechanism available to uranium which is not available to plutonium.

PROCESS CONTROL DEVELOPMENT

Assistance to the Purex Plutonium Resin Column Controls

Instrumentation for the Purex Plutonium Resin Column has been activated preparatory to operating the column with plutonium feed.

The resin level indicator operates satisfactorily at flowsheet acid concentrations and detects the resin level in the reservoir to plus or minus one-half inch.

The XCP gamma absorptiometer ion chamber was replaced because a Kovar insulator cracked and caused excessive current leakage. The new chamber was carefully cleaned, internally dried, sealed with an epoxy cement and painted to minimize current leakage and corrosion. The absorptiometer now appears to function properly although some difficulty is being experienced with microphonic pick-up from the signal cable.

The Ohmart absorptiometer is installed on the XA column, one foot above the feed point. An initial calibration in the range zero to 120 grams plutonium per liter on the resin was completed using lead absorbers.

The 2BP contact alpha counter is installed and will be tested and calibrated when plutonium solution is introduced into the system.

The measured conductivity of nitric acid in direct contact with the anion resin varies as much as 30 per cent depending on the packing of the resin around the measuring probe. Because of this the probe requires shielding even though the response time with the shield is longer than desired. However, some improvement in response time has been achieved by using a Dutch-twill type screen having a greater free area.

Assistance to Project CG-686

Electronic operability tests were completed on the six installed gamma monitors at Redox. The monitors were calibrated in the plant using a 2 millicurie per gallon cesium 137 solution. On December 19, the 1BP and 2BP monitors were put on stream and placed in the "Beneficial use category." Fluorothene gamma monitor sample cells for use on these streams have shown little or no background activity to date.

Assistance to Recuplex

A new thulium source was installed in the Recuplex CCP absorptiometer. This source is constructed differently from the previously used source and necessitates a recalibration of the instrument. The recalibration will be accomplished by comparing absorptiometer results with laboratory analysis of CCP stream samples.

Densitometer for Purex HA Column

A prototype densitometer for possible use in the Purex HA column has been in operation in the 321 Building for ten days. With the Foxboro dynalog recorder and Fisher Porter rotameter coil in use one-eighth inch of float travel is equivalent to 0.01 specific gravity units or 10 per cent of chart travel. Hysteresis and dead band are virtually non-existent. A drift from the set point of about 2 per cent per day is observed and as yet cannot be explained. Effort at present is being directed towards locating and removing the source of this drift.

Instrumentation for Measuring Quantity of Cesium-137 in Shipping Containers

A survey of instrumentation to measure the quantity of cesium in a shipping container has been made. It appears that an air filled ionization chamber feeding a Beckman amplifier will be a satisfactory system for this application. It is anticipated that most of the development effort will be concerned with ion chamber geometry, shielding, and method of standardization.

Magnetic Flowmeter Test

The Foxboro magnetic flowmeter, modified to operate in the 0 - 2 GPM range, has been under test metering 60 per cent UNH at a solution and ambient temperature of 90 C. During the test period of 140 hours the specific gravity of the solution varied from 1.6 to 1.8, yet the meter exhibited no change in calibration. The flow meter will now be tested with a 100 per cent UNH solution.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

Circular sawing has been recommended by several equipment manufacturers as the best method for cutting ceramic power reactor fuel elements to permit core leaching. Successful demonstration of a saw for this purpose will permit a greatly simplified design for a mechanical processing cell since sawing was already included for hardware removal. Consequently, the initial development step in connection with mechanical processing of non-production fuels will be to evaluate sawing techniques.

Separation of Chloride from Darex Dissolver Solutions

Solvent Extraction Removal of U and Pu. Separation of U and Pu from chloride (and other unwanted constituents) in Darex dissolver solutions by solvent extraction is under study as an alternative to azeotropic nitric acid vapor stripping of chloride. After equilibration of a simulated Darex dissolver solution (0.95 M UNH, 1.48 M HNO_3, 1.90 M HCl, SS dissolution products) with a two-volume portion of 30 per cent TBP-Shell E2342, the organic phase contained 5 g/l chloride and 97 g/l uranium. Six 1/5-volume scrubs with 3 M HNO_3 containing 16 g/l UNH reduced the organic chloride content to about 500 ppmp uranium. Two additional scrubs with water did not reduce the Cl/U ratio. A combination of the six HNO_3-UNH scrubs and three additional scrubs with 1/5-volume portions of 0.05 M $Cr(NO_3)_3$ produced an organic phase having a chloride concentration of about 15 ppmp uranium. With 0.05 M $Al(NO_3)_3$ vice $Cr(NO_3)_3$, residual chloride in the organic was about 150 ppmp uranium. Scrubbing with 0.05 M $Fe(NO_3)_3$ and $Hg(NO_3)_2$ following the HNO_3-UNH scrubs removed some chloride but neither was as effective as $Al(NO_3)_3$. Scrubbing the extraction organic phase (5 g/l Cl-97 g/l U) six times with 1/5-volume portions of 3 M HNO_3-0.05 M $Al(NO_3)_3$ - 16 g/l UNH produced an organic containing 320 p Cl/mp U. Further studies to determine optimum scrubbing with $Cr(NO_3)_3$ are in progress.

Spectroscopic analysis of the extraction organic phase showed only a trace of Fe and non-detectable amounts of Cr and Ni showing that the extracted chloride is not associated with stainless steel dissolution products.

Direct Boil-Off of HCl and/or Cl_2. Another alternative to azeotropic distillation for removal of Cl from Darex dissolver solutions is direct boil-off of HCl and/or Cl_2 (total condensation without reflux). Further runs made in this study confirm previously reported data and show Cl removal rates depend on HNO_3 concentration and boil up rate. No advantage in chlorine removal was obtained by air sparging or the addition of oxidants (O_3, H_2O_2, $KMnO_4$) during boil-off.

Investigation of Methods for Determining Chloride Ion Concentration in Darex Process Solutions.

Laboratory studies directed toward a suitable potentiometric method for determining chloride ion concentration in Darex process solutions are continuing. The two systems (1) calomel reference electrode, calomel detecting electrode and (2) silver-silver chloride reference, silver-silver chloride detecting electrode, yield non-reproducible results. The calomel detecting electrode is unsatisfactory in that the mercurous chloride adsorbs solution and has a "memory" and thus fails to detect changes in chloride ion concentration. The system of two silver-silver chloride electrodes gives very poor results under the conditions of the experiment. A calomel reference electrode with a silver-silver chloride detecting electrode exhibits excellent stability and reproducibility. Voltage readings have held constant for five days, and the system responds immediately to changes in chloride ion concentration. The logarithm of the chloride ion concentration is a linear function of the measured voltage from 1 M to 10^{-5} M chloride ion. The measured voltage changes 50 millivolts for a ten-fold change in chloride ion concentration.

Work is now directed towards determining the life of the electrode in various concentrations of nitric acid.

Corrosion of Materials in Feed Preparation

Darex Studies. A welded Haynes 25 coupon (no subsequent heat treatment) showed no visible preferential attack after exposure to 5 M HNO_3 - 2 M HCl for 200 hours. Weight loss measurements indicated a corrosion rate of about two mils/month. However, after 300 hours exposure, severe preferential attack occurred in areas adjacent to the weld. In a similar test with a welded Multimet alloy (cobalt-containing alloy stabilized with 1 per cent Nb) preferential attack near the weld was even more severe.

Zirflex Studies. The corrosion rate (weight loss) of 304 L stainless steel exposed for 312 hours to 6 M NH_4HF under heat transfer conditions - bulk metal temperature 135C - was 1.6 mils/month. Numerous shallow pits were formed and penetrations as deep as 3 mils were observed. In a similar test with 4 M NH_4F - 0.5 M HF an apparent corrosion rate of 5.7 mils/month was observed. However, most of the corrosion occurred under a deposit of calcined salt along the edges of the test specimen. Pitting was not observed. Additional heat transfer tests including the NH_4F-$(NH_4)_2ZrF_6$-NH_4NO_3 system are in progress.

A corrosion rate of 0.1 mil/month was observed for a 304-L coupon half submerged in boiling 4 M NH_4F. Shallow pits were observed beneath a heavy scale which formed at the interface.

Data from Huey-type tests of the corrosion of 304-L, by solutions simulating dissolution of Zirflex declad fuel elements by HNO_3-$Al(NO_3)_3$ solutions and without a metathesis step, have been reported previously. They indicated satisfactorily low corrosion rates. Results of similar tests under heat transfer conditions (metal temperature 140 C) are tabulated below:

Solution	Corrosion Rate, Mils/Mo.
12 M HNO_3 - 0.5 M $Al(NO_3)_3$ - 0.02 M UNH - 0.08 M HF	4.4
12 M HNO_3 - 0.5 M $Al(NO_3)_3$ - 0.02 M UNH - 0.16 M HF	7.1
6 M HNO_3 - 0.06 M $Al(NO_3)_3$ - 1.0 M UNH - 0.08 M HF	1.2

These rates are not considered excessive since the high acid conditions will exist for short times only. The corrosion was largely intergranular.

HNO_3-HF Dissolution of Clads and Cores. Consideration is being given to the use of HNO_3-HF or HNO_3-HF-$Al(NO_3)_3$ solutions for the total dissolution of stainless steel and Zircaloy clad fuel elements. Results of some dissolution rate and corrosion studies with these solutions are tabulated below. These are Huey-type tests and involve a one-hour exposure of the metal to the solution unless otherwise stated.

Dissolution Rates, Mils/Hr.

Solution	304-L	Haynes-25	Zr	Oxidized Zircaloy-2	Zircaloy-3
1) 5M HNO_3, 1M HF	1.03	0.055	--	--	~85
2) 2M HNO_3, 1M HF	2.15	0.040	--	--	~80
3) 1M HNO_3, 1M HF	4.00	0.050	--	--	~70
4) 5M HNO_3, 2M HF	2.07	0.105	--	--	>100
5) 2M HNO_3, 2M HF	4.75	0.120	--	--	>100
6) 1M HNO_3, 2M HF	6.93	--	--	--	>100
7) 5M HNO_3, 0.5M HF, 1M $Al(NO_3)_3$	--	--	3.94	0.012	--
8) 5M HNO_3, 0.5M HF, 0.5M $Al(NO_3)_3$	0.015	0.0051(24 hr)	10.2	0.085(1.1, 18hr)	--
9) 2M HNO_3, 1M HF, 2M $Al(NO_3)_3$	--	--	--	--	2.02
10) 2M HNO_3, 1M HF, 1M $Al(NO_3)_3$	--	0.0029(24 hr)	15.0	0.107	10.0
11) 2M HNO_3, 1M HF, 0.5 M $Al(NO_3)_3$	--	0.0048(24 hr)	--	--	27.7
12) 2M HNO_3, 0.5M HF, 1M $Al(NO_3)_3$	--	--	3.5	--	--
13) 4M NH_4F	--	--	--	0.121	--

These data indicate the possibility that Haynes 25 may be a satisfactory material of construction for a dissolver in which to perform total dissolution of both stainless steel and Zircaloy clad fuel elements with HNO_3-HF solutions. Either Haynes 25 or 304 L could be used as a material of construction when using HNO_3-HF-$Al(NO_3)_3$ solutions to dissolve Zircaloy clad elements. This assumes, of course, that mechanical abrasion or other technique will solve the problem of resistivity to attack by oxidized Zircaloy-2. The possibility of preferential attack by these solutions near welds in Haynes 25 must be examined.

Process Economics

The study of process and equipment requirements and economics of about 20 alternates for the processing of power and propulsion reactor fuels for fissionable and fertile material recovery was continued. The study also includes processing plutonium recycle test reactor fuels.

Equations were developed for use with a computor to determine the most economical design of heat transfer equipment such as a condenser to be fabricated of costly

titanium. This material of construction is needed for application in the Darex process for stainless steel fuel jacket dissolution in dilute aqua regia.

We have been advised that "The Summer Institute on Nuclear Energy - Chemical Processing" will be repeated at HAPO in 1958. Organization and planning for this program were begun on the basis of an attendance of up to 20 participants, twice as many as last year.

REACTOR DEVELOPMENT - 4000 PROGRAM

Reprocessing of PRP Fuels by Amine Extraction

Tri-laurylamine was tried as a plutonium extractant and found to hold much promise. Plutonium extraction was very similar to that obtained with tri-n-octylamine or tri-iso-octylamine; however, the laurylamine has the very important advantage over these that a third phase is not formed when the amine is diluted with a hydrocarbon diluent (Amsco) and contacted with a nitric acid solution. A second organic phase is formed in the presence of 1 M uranium; however, this may be prevented by the addition of as little as 1-1/2 volume per cent n-octyl alcohol. In addition, stripping the plutonium from the organic phase with ferrous sulfamate appears to be much easier and more complete than with the octylamines. Tri-laurylamine is available commercially at a price of only two dollars per pound.

Extraction-scrub studies were run with both tri-laurylamine and tri-iso-octylamine with Purex dissolver solution as feed. One extraction, three scrubs, and one strip were employed. Overall decontamination factors for Ce, Ru, and Zr-Nb were $>10^5$, $>10^5$, and 500, respectively, with ten per cent tri-laurylamine, five per cent n-octyl alcohol in Amsco, and 6×10^5, 1.5×10^4, and 10^5 for ten per cent tri-laurylamine in Amsco without n-octyl alcohol. In the latter case, a third phase formed on extraction; however, the two organic phases coalesced on scrubbing as the uranium was stripped out. This raises the interesting possibility that it may be feasible to operate in a conventional column without the octyl alcohol since only one organic and one aqueous phase will leave the column. Decontamination factors with tri-iso-octylamine (diluted with xylene) were comparable to those with tri-laurylamine, but plutonium stripping was much poorer. Thus, plutonium stripping coefficients (E_a^o) of 0.004 and 0.0023 were obtained in the laurylamine experiments versus values of 2.2 and 5.7 in two of the iso-octylamine runs. Raising the temperature to 60 C improved plutonium stripping from iso-octylamine ($E_a^o = 0.02$) and also improved Zr-Nb decontamination ten fold.

Processing of PRP Fuels

The recovery of plutonium from PRP feeds by anion exchange requires the use of about seven molar nitric acid and a uranium concentration less than 180 grams per liter. Feed preparation could best be made by dissolving to this acidity rather than dissolving to low acidity and diluting with acid.

An anion exchange run was made in the laboratory to determine what effect this dissolving procedure might have on fission product decontamination.

A piece of irradiated uranium was dissolved to a terminal acidity of eight molar nitric acid. This solution was diluted to ten per cent level with cold feed and filtered prior to being fed to the column.

The loading (out of 8.0 M HNO_3, 103 g/l U, 0.46 g/l Pu(IV), 2.7 x 10^9 γ/m, ml Zr-Nb, 1.4 x 10^8 γ/m, ml Ru-Rh), washing (with 7.5 M HNO_3), and elution (with 0.35 M HNO_3) were all conducted at 55 C. The loaded resin was washed with 60 column volumes of wash and the plutonium then eluted at a concentration of ca. 19 g/l Pu. Decontamination factors were 6.4 x 10^4 for gross gamma, 2.25 x 10^6 for zirconium, and 2.8 x 10^4 for niobium. The limiting fission product was niobium which accounted for about 99 per cent of the gamma activity in the product.

The gross gamma decontamination obtained in this run is about three-fold greater than was obtained in an earlier run which employed feed prepared from Purex dissolver solution. It is not known whether this improvement was due to the modified dissolving procedure or perhaps to a lower solids content in the laboratory prepared dissolver solution. In any event it appears that dissolving to a high terminal acidity will certainly not hamper fission product decontamination.

Radiation Expectations from High Exposure Plutonium

The plutonium to be recovered from power, propulsion, and plutonium recycle test reactor fuels will have a wide range of exposure with a trend toward far greater exposures than that of material now normally processed by essentially unshielded methods. A study was made to determine quantitatively the radiation intensities expected from plutonium derived from these new fuels. The study showed that the greater fraction of isotopes other than Pu-239 can be expected to present significant increases in radiation levels in the existing plutonium handling facilities. These radiation levels are of such magnitude that routine processing will require shielded facilities.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

The southeastern, subsurface extension toward Ringold of the Gable Mountain anticline was confirmed during the drilling of well 699-43-11. A bed of sand and gravel up to about 110 feet thick beneath 200 East Area and constituting the lowermost bed of the "blue clays" portion of the Ringold formation there was shown to pinch out completely west of well 699-43-11. A bed of clay overlying the sand and gravel beneath 200 East Area was traced to the clay bed in that well lying directly on basalt. The aquifer thus terminates eastward. Demonstration of similar situations in this bed in other directions will indicate slow moving if not stagnant ground waters in the bed, hence a horizon in which the presence of radioactive contaminants need cause little or no concern.

Considerable geologic data were procured from well records of the Bureau of Reclamation at Ephrata on wells in the Columbia Basin Irrigation Project immediately east of Hanford. Some data were also procured from the Standard Oil test well on Rattlesnake Hills, now about 8000 feet into the basalt series. Correlation of these data to previous records is under way.

The rate of growth of the mound beneath the new Gable Mountain swamp was used to calculate the transmissibility of the quifer in that region. A transmissibility of 2,600,000 gal/day/ft was calculated from the changes observed during the first week of operation. This agrees closely with the transmissibility determined earlier from pumping test data in a nearby well. The very high permeability of the gravels in this region will minimize the extent to which the swamp will affect the local ground water pattern.

Research continued in the study of the vertical flow distribution beneath a crib by means of a sand box model. The equipment was successfully revised to eliminate operational problems previously encountered. The model contains 187 flow collectors built into the bottom to demonstrate flow distribution. Initial tests were designed to study the wall effect of the model. Flow collectors adjacent to the model wall showed no evidence of distorted flow as a result of their location.

Soil Chemistry and Geochemistry

The reaction whereby strontium is removed from phosphate solutions by calcite crystals was shown to involve probably two mechanisms. The first is the growth of brushite, (Ca,Sr) $HPO_4 \cdot 2H_2O$, on calcite surfaces. This reaction occurs only with significant concentrations of strontium, above the solubility limit of brushite. The solubility product of brushite was measured and found to be between 10^{-8} and 5×10^{-8}. The mineral brushite gradually transforms to apatite over a period of a number of years. The apatite is somewhat less soluble than the brushite. The second mechanism involves the replacement of calcium ions in calcite crystals with strontium ions from solution. This reaction acts very much like a normal ion exchange reaction, with an equilibrium constant and typical breakthrough curve. It is unlike true ion exchange in that most foreign ions in solution do not compete with strontium in the reaction. This latter reaction does not depend on the presence of phosphate ion to proceed. Both reactions operate independently, but neither alone will account for the complete removal of strontium from solution on a calcite bed as demonstrated in the laboratory.

The calcite removal of strontium was found to proceed satisfactorily for all wastes with the exception of a synthetic TBP, scavenged waste. Further tests with this solution indicated that the strontium is occurring as a complex anion. Nearly complete removal of strontium from this waste was achieved by passing it through an anion exchange resin. It was found that the presence of $K_4Fe(CN)_6$ and $Fe(NH_4)_2(SO_4)_2$ in solution with the strontium was necessary to produce the strontium anion. Neither compound alone resulted in the complex formation.

Ground Waste Disposal

Further experiments were conducted to evaluate the influence of temperature on soil column breakthrough data. These at 18, 36, 58, and 83°C, indicated a continuous, but non-linear, temperature effect on the breakthrough of strontium from magnesium saturated soils. Quantitatively, if a breakthrough of Sr occurred at one column volume at 83 C, it would occur at 1.3 column volumes at 58, at 1.9 column volumes at 36 and at 2.7 column volumes at 18 C, from a Mg-Sr system.

It was hypothesized that the observed temperature effect is the result of dehydration of ions at the higher temperature, with a resulting increase in relative bonding energy of ions competing with strontium for ion exchange sites. It was predicted from this hypothesis that less temperature effect would be found in Ca-Sr systems than in Mg-Sr systems. Experimental data fulfilled this prediction, in fact the Ca-Sr system displayed a negligibly small temperature effect. Tests are planned to study further the reason for this temperature effect.

Origin of Radioisotopes in Reactor Effluent

A further study of the sulfuric acid used in reactor process water treatment is in progress. The study is intended to explore the possibility that this acid is the source of a significant part of the As^{76} found in reactor effluent. Eight representative samples of acid were collected and submitted for arsenic determination. The analyses are intended to supplement the analysis of a single acid sample previously obtained in which 5×10^{-2} ppm As was detected. This concentration is too low to contribute significantly to the As^{76} concentration in reactor effluent.

Field Apparatus Development

Two Becker peristaltic action pumps were tested to determine tube life. One unit was operated at 1750 rpm, at which speed it pumps 400 cc/min. After one week of continuous service perceptible wearing of the tube was evident. The second pump was checked for constancy of flow at a pump rate of about 1 cc/minute. After the pump had operated continuously for two weeks, the flow rate had decreased from 1.05 cc/min to 0.99 cc/min. The short interval flow rate has always been within ±2 per cent of the average.

The very low volume feed pump employing screw driven double-acting pistons and syringes has begun to give trouble after four month's of operation. Slippage in the speed changer resulted in non-steady flow rates. Check valves, too, were giving faulty operation resulting from rust particles in the system. Improvements will be incorporated as a result of these observations in the design of the multi-stream feed pump for soil column research.

Possible circuits employing thermistors for measuring very low water velocities were developed. A circuit design employed in a commercial application will be assembled and tested.

The deep well submersible pump was repaired by the Layne and Bowler Company and returned to service. A higher capacity pump was ordered for extending the present well pumping studies to deeper wells. The trailer-mounted 30 KW generator was tested using a 30 hp motor to simulate the load anticipated with the larger pump. The generator easily picked up the motor load and should be adequate for the new pump.

Further exploring the merits of magnetic and gravimetric surveys in the region to identify the surface of the basalt resulted in increased optimism for the success of these methods. Some of the observations bearing on the potential use and possible value of gravimetric and magnetometric instruments are the following:

1. The geology of the region is relatively simple (essentially one sedimentary member overlying an igneous member).

2. There are significant physical differences between sedimentary and igneous strata. Density will differ by about 50 per cent and magnetic susceptibility of the two strata will be different by a factor of about 20.

3. Cost of rent or outright purchase of the instruments is relatively low. A magnetometer can be purchased for about the cost of a 300 foot well ($2000). Gravity meters can be rented for around $400 per month, or purchased for about $8000.

4. Existing wells should permit point checks of the results obtainable with the instruments.

5. Operation of the instruments is simple though data reduction and interpretation are more complex.

The potential for amplifying our present knowledge of the depth to basalt merits further study of these methods since approval of the request for a major and refined geophysical study seems to be indefinitely delayed.

Recommendation was made and adopted that 12 inch screened wells be provided rather than the specified 8 inch screened wells for the Co^{60} test disposal monitoring wells. It was pointed out that, because of the greater depth and higher pumping rates required, a pump of the necessary capacity could not be placed in an 8 inch well.

The use of small humidity-sensitive resistors was suggested for application in experiments dealing with unsaturated flow through porous media. Further study is anticipated.

Analytical Services

The 256-channel energy analyzer is finally ready for routinely measuring vegetation fission products. Starting date will be January 2.

By means of gamma spectrometry, Co^{57} has been found in some marine biological material. The isotope was not noticed in samples processed (and reported) before using spectrometry. They are now being re-examined. Fortunately, separated fractions were retained.

A rapid method was devised for preparing thin films for use as source supports in 4π counting calibration. The film consists of VYNS resin having a thickness of 4 ug/cm^2 and made conducting by dipping into a commercial organic static preventative. The technically difficult and time-consuming evaporation of metal onto such films to make them conductive may no longer be necessary since preliminary results with the anti-static coated films appear to give the same results as metal coated films.

Instrumentation Development

Gamma ray spectrometric procedures were developed for La^{140} and the rare earth isotopes, Ce^{141}, Ce^{143}, Eu^{152}, and Sm^{153} in gallon samples of Columbia River water following a single chemical group separation step. Ce^{141} requires a two week decay period before measurement, but the other four radioisotopes may be determined immediately. Both the 100 channel and the Radiological Chemical Analysis 256 channel pulse height analyzers have been calibrated for these radioisotopes so that routine analyses may be made on Columbia River and sanitary water supplies. Reactor effluent water and area sanitary water supplies may also be analyzed by this method following a one day decay period.

The concentrations of several radioisotopes in a few samples of reactor effluent water were determined to provide data useful in assessing the relative hazards presented by these trace isotopes and are tabulated below.

	Concentration uc/ml x 10^9		
Sample	Sr^{85}	Sr^{89}	Ru^{103}
1	7.3	837	140.4
2	5.2	268	24.6
3	6.5	222	
4	9.2	332	
5			57.1

Sr^{89} can be formed both by n, gamma reaction and by fission, but Sr^{85} is not a fission product. When natural strontium is irradiated in a reactor Sr^{85} and Sr^{89} are formed in nearly equal amounts. Since the concentration of Sr^{89} in reactor effluent water is about 40 times (omitting sample 1) that of Sr^{85}, it appears that only a few per cent of the Sr^{89} in reactor effluent water comes from n, gamma reactions on strontium with the remaining 97 per cent probably arising due to fission.

Special radiochemical analyses were made on samples obtained in the joint studies with the Biology Operation on radioisotope uptake by living organisms. Sr^{85} and Sr^{90} concentrations in barley plant samples were measured by gamma ray spectrometry and bremsstrahlung counting. Measurements are continuing on the types and amounts of radioisotopes taken up by the various parts of bean plants raised in nutrient solution containing reactor effluent water or in a soil irrigated with reactor effluent water. Some algae collected immediately below 100-F Area were found to contain large amounts of Zr^{95}-Nb^{95}, Ru^{103}-^{106}, and Ce^{141} relative to the usual amounts of reactor effluent water isotopes. These high concentrations probably result from purging operations at F reactor.

The protective effect of anions in preventing the radiation-induced decomposition of erioglaucine in aqueous solutions was found to decrease in the order: thiocyanate > nitrate > thiosulfate > iodide > bromide > carbonate > nitrate > sulfite, sulfate, chloride, fluoride, phosphate, chromate, the latter group being indistinguishable except for chromate which increased the dye decomposition. In general the order follows the standard potential for oxidation of the anions, but since these indicate only the direction rather than the speed of reactions, exceptions were expected and found. Among other uses, a knowledge of the protection offered other molecules in aqueous solution by such anions allows their subtraction from the total protective effect of organic salts to obtain the protective effect of the organic cation alone. The protective effects of glucose, fructose, sodium acetate, benzene, and pyridine were also measured by the dye-competition method. Results from the latter two compounds suggest that good protectors are molecules which can form an activated complex of low energy with a free radical in which the latter is covalently bound to the protector. In some cases, the energy of such a complex can be calculated by a molecular orbital treatment and used to predict the protective abilities of various structures.

L P Bupp

Manager
Chemical Research & Development

LP Bupp:bp

VISITS TO HANFORD WORKS

Name	Dates of Visits	Company or Organization Represented and Address	Reason for Visit	HW Personnel Contacted	Access to Restricted Data
V. R. Thayer	12/2/57	duPont Wilmington, Delaware	Reprocessing of power reactor fuels.	MT Walling WH Reas	Yes
F. R. Bruce	12/6/57	Oak Ridge National Laboratory Oak Ridge, Tennessee	Reprocessing of power reactor fuels.	WH Reas LP Bupp	Yes
W. L. Carter A. M. Rom J. T. Long	12/5-6/57	Oak Ridge National Laboratory Oak Ridge, Tennessee	Consultation on problems relating to the preparation of a book on "Nuclear Fuel Processing"	CA Rohrmann HE Hanthorn ET Merrill	Yes

VISITS TO OTHER INSTALLATIONS

Name	Dates of Visits	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
D. M. Robertson	12/2-3/57	Argonne National Laboratory Lemont, Illinois	Bluenose Channel V Phase I meeting	FT Hagemann	Yes
O. F. Hill	12/2-5/57	UCLA Los Angeles, Calif.	PhD Recruiting Trip		No
		Cal. Institute of Technology Pasadena, Calif.	PhD Recruiting Trip		No
V. P. Kelly	12/4-5/57	Visited Chemical Industries Show in New York			No
	12/6/57	Loewy-Hydropress New York, New York	Consulation on equipment for processing power reactor fuel elements.	RG Berg	No
	12/9/57	Buffalo Forge Company Buffalo, New York	" " "	WC Tucker	No

VISITS TO OTHER INSTALLATIONS

Name	Dates of Visits	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
V. P. Kelly	12/10/57	United Engineering & Foundry Company Pittsburgh, Pa.	Consulation on equipment for processing power reactor fuel elements.	MD Stone	No
	12/11/57	Wallace Supplies Mfg. Chicago, Illinois	" " "	EJ DeWitt	No
D. W. Pearce	12/11/57	Attend Meeting of ACS-building campaign. Spokane, Washington			No

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
2000 ACCOUNT				
1. Separations - Process and Equipment - Solvent Extraction Development of contactors with improved efficiencies and high capacities, pumps, agitators, valves, materials of construction, etc. Evaluate effect of pulse column and flowsheet variables on kinetics of interphase transfer of fission products in pulse columns. Metal dissolution.	1. 11-17	1. Semiworks and prototype facilities. Laboratory-scale hot pulse column.	1. Feasibility of annular dissolvers (for criticality control) demonstrated for HAPO fuels. Sufficient data available to provide "C" Column cartridges operable at Purex capacity factor ± 4.0. No unique advantages observed for spiral cartridges. Support provided to Purex anion exchange prototype - selected Amberlite IRA-401 over Dowex-1 because of superior physical performance. Benefits of slinger-cone to protect liquid throttle bushing proven. Corrosion studies performed on surface-hardened titanium and Carpenter-20; coupons removed from Purex waste tanks for evaluation; inhibition of stainless steels by $Al(NO_3)_3$ in HNO_3-HF solutions further studied. Hot experimental facility for profile pulse column completed and cold testing begun.	1. Dissolution technology for dingot metal to be defined. Five-in.-diameter continuous tower ready to operate. "C" Column studies to continue to provide cartridges suitable for operation over the range of Purex capacity factors 2.0 to 4.0. To search for suitable "IB" Column cartridges at capacity factor = 4.0. Annular pulse column studies deferred for suitable weather. Continue support of start-up of Purex anion exchange prototype. New concepts of continuous ion exchange contactors for application to remote maintenance and operation to be explored. AgI reactor studies suspended in favor of other studies. Continue experimental work with hot pulse column on Purex uranium decontamination.
2. Purex Flowsheet Development Objective is closest practical approach to one-cycle process with Purex solvent system.	2. 2-4	2. Miniature mixer-settler.	2. Studies continued with major effort on improving uranium decontamination in two-cycle flowsheets; improving fission product scrubbing in the first cycle; use of complexing agents to reduce fission product extraction in the second cycle and improved tail-end steps to remove fission products from uranium product.	2. Continue at same level of effort.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
3a. Processing of Propulsion and Power Reactor Fuels Techniques for dissolving fuels clad in stainless steel and in Zircaloy-2 (Zirflex process).	3a. 2-4		3a. Removal of stainless steel clads by dissolving in dilute sulfuric acid investigated. Considered feasible for metal or alloy cores. Decision as to feasibility for uranium dioxide cores must await studies with uranium dioxide irradiated to appropriate high burn-out. Dissolution of stainless steel clad fuels by anodic electrolysis in nitric acid and by exposure to mixtures of nitric acid, bromine, and/or hydrobromic acid investigated briefly. Neither approach is considered attractive.	3a. Continue at same level of effort. Determine the feasibility of dissolving both stainless steel clad fuels and Zircaloy-2 clad fuels in mixtures of nitric acid and hydrofluoric acid and processing the resulting feeds in the Redox Plant.
			Dissolving Zircaloy-2 jackets in mixtures of ammonium nitrate and ammonium fluoride (vice ammonium fluoride alone) shown to have advantages in that tin is dissolved along with zirconium and hydrogen evolution is suppressed by a factor of 20 to 40. Preliminary studies with uranium irradiated to ca. 600 MWD/T show no greater rate of attack than with unirradiated uranium. Solubility data indicate no greater losses of uranium with ammonium nitrate-ammonium fluoride dejacketing media than with ammonium fluoride alone.	Continue at same level of effort. Examine effect of ammonium nitrate-ammonium fluoride dejacketing media on plutonium losses. Determine rate of attack of irradiated uranium dioxide by ammonium fluoride and ammonium nitrate-ammonium fluoride. Determine effect of ammonium fluoride and ammonium nitrate-ammonium fluoride mixtures on the intermetallic compound UZr_2 which has been shown to produce explosive reactions with nitric acid.
b. Non-Production Fuels Reprocessing Provide technology for feed preparation, solvent extraction at Redox, product specifications and processing, etc., for low-enriched power and propulsion reactor fuels.	b. 2-9	b. Cold Semiworks and prototype facilities.	b. Economic evaluation of various alternates for using U-Plant and Redox for feed preparation and solvent extraction is underway. Either direct boil-off or solvent extraction shown feasible as means to remove chloride from Darex dissolver solutions, as alternates to azeotropic distillation. Corrosion data	b. Dissolution and feed preparation studies to continue, including attaining definitive corrosion data and dissolution rates. Establish titanium fabrication techniques. Construct and install pilot plant equipment for Darex studies; initiate pilot

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
			being assembled on titanium and Haynes-25 for Darex service; 304-L and Haynes-25 for Zirflex service; Carpenter-20 for Sulfex service; and 309-SCb and Haynes-25 for HNO_3-HF service. Dissolution of fuel materials in HNO_3-HF initiated. First titanium received for construction of Darex prototype dissolver. Zirflex dissolution equipment being assembled in the pilot plant. Began studies on a titanium heat exchanger. Initiated instrumentation studies for in-line determination of chloride.	plant studies on Zirflex. Develop suitable valves, jets, pumps, instrumentation, etc., for corrosive service. Develop special instrumentation (e.g., Cl^- concentration) as required. Initiate development on remote mechanical disintegration of irradiated fuels.
4. Recovery and Packaging of Specific Fission Products and Transuranic Elements a. Cesium, strontium, cerium and rare gases for use as radiation sources.	4a. 4-6	4a. 222-S multicurie cell.	4a. The effect of variables on "acid side" flowsheets for cesium recovery from Purex 1WW has been studied more thoroughly and a report has been written. Modification of 222-S multicurie cell for liter scale flowsheet testing is nearly complete. A flowsheet was developed for recovery of megacurie amounts of cerium-144 from Purex 1WW and a terminal report on this work was being prepared. A process flowsheet for rare gas recovery from dissolver off-gases by low temperature methods was developed. Chose hydrolysis of $Cs_2ZnFe(CN)_6$ as the step to "free" Cs, permitting safer process and simpler equipment. New flowsheet issued. Scope data for prototype near completion. Design initiated.	4a. Liter scale flowsheet testing for recovery of solid fission products is expected to begin in January and a six-months program is currently envisaged. Some scouting work on other methods of cesium removal from process and waste solutions and a basic investigation of selected aspects of cesium-ferrocyanide chemistry is also planned. Equipment requirements and economics of rare gas recovery will be determined. Kinetics of hydrolysis step to be more fully evaluated. Design of components and prototype construction to be pushed forward. Manpower involved will decline by one with a personnel transfer in mid-January.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
b. Neptunium recovery.	b. 0-1		b. Work continued on the determination of the effects of Phase II Purex flowsheet changes on neptunium routing in the Purex Plant. Gassing difficulties in the anion exchange isolation process were successfully resolved; a report was being prepared on this work.	b. The effects of continuing Phase II changes will be followed; plant tests have been arranged aimed at forcing the neptunium quantitatively into either the uranium or plutonium product streams. Work to fill in important gaps in our knowledge of the basic chemistry of neptunium will be continued.
5. Analytical Chemistry and Instrument Development Emission and mass spectrometry; radiochemistry and instrumentation; coulometry; polarography; x-ray spectrography; in-line instrument and analytical development; equipment for effluent monitoring; gamma monitors; colorimeters; pH measurement; neutron monitors; contact alpha monitors for automatic continuous control.	5. 15-20	5. Prototype and commercial specialized instruments including mass spectrometer, spectrographs, x-ray diffraction-emission unit, radiation counters and spectrometers, multichannel analyzer, coulometers and ion exchange columns.	5. Completed preparation of an operating manual for mass spectrometer, a report of fission counter development, a feasibility study for direct reading spectrometer applications, and a study of coulometric analysis of plutonium metal. X-ray fluorescence methods developed for uranium in bismuth, uranium and plutonium in aluminum. Equipment modified to extend range and sensitivity. Provided follow-up and support to instruments installed on Project CG-686 and to instrumentation for Purex anion exchange prototype, including contact alpha monitor on 2BP stream. IAFS pH prototype monitor installed at Redox and evaluation begun. Began development on densitometer for Purex HA Column at feed point and on magnetic flow meters. An isotope analyzing monitor for application to reactor effluent was completed to the point of semi-routine operation. Improvement was realized in shut-down circuits in the event of malfunction. Operating data pointed up problems in background in Np-239 channel. Beta counter background brought to workable level.	5. Development of high resolution alpha energy analyzer will continue. Controlled potential coulometric and polarographic studies of plutonium at low levels will be accelerated. Applications of coulometry to final plutonium product assay, of direct reading spectrometry to AlSi analysis, and of x-ray fluorescence to fuel element analysis will be exploited, and reports issued on these subjects. Continue follow-up and support to new instruments and prototypes. Expand flow meter investigations. Explore problems related to in-jumper instrument installations. Some improvement required in reliability of cup handling mechanics in effluent monitor. Calibration will be made for isotopes of interest. Further tests to provide optimum operating parameters. Development of equipment to support research will continue. The use of thermistors for low flow rate

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
			Laboratory and field instruments and equipment were designed and specified for various phases of earth science research. Low rate feed pumps, fraction collectors, water velocity instruments, and gamma ray spectrometry were areas investigated.	measurements will be explored. Humidity sensitivity resistors will be investigated for moisture-in-soil measurements. Closed circuit TV for in-well measurements and observations to be exploited.
6. Conversion of Separated Uranium to UO_3, UO_2 and UF_4 UNH to reactive UO_3; definition of process requirements.	6. 1-6	6. Laboratory-scale continuous calciner, x-ray diffraction equipment, thermal balance, surface area equipment, differential thermal analyzer. Pilot-Plant prototype calciner.	6. Laboratory demonstration of high temperature feed system for continuous calciner continued. Evaluation of ammonia addition to concentrated feed made. Evaluated fluidization properties of Hanford UO_3. New paddle designs show improvement in production units. In the pilot plant calciner, four lots of UO_3 were prepared from UNH containing NH_3 and forwarded to K-25 for evaluation.	6. Provide support, as required, to plant operation with NH_3. Initiate studies on fluidized-bed calcination.
7. New Processes for U and Pu - Separation, Exploration, Evaluation and Development a. Anion exchange for Pu recovery from process and waste streams.	7a. 2-3		7a. Detailed studies of anion exchange kinetics show at least two resins of 20 to 50 mesh particle size usable for Purex concentration step (Amberlite IRA-401 and Permutit SK). Anion exchange shown economically attractive for recovery of plutonium at concentrations as low as 2 mg Pu/l. in Purex 1WW. Design of shielded anion exchange facility initiated.	7a. Continue at same level of effort. Complete design and initiate construction of a shielded anion exchange facility to permit studies with full-level Purex 1WW.
b. Flurex: an alternate aqueous electrolytic method for preparation of UF_4 from UNH without going through UO_3 and UO_2 gas phase reaction steps.	b. 2-3		b. Development data pertinent to anolyte and feed chamber operating conditions near completion. Data on catholyte condition relating to product composition and decontamination in progress. Stainless steels (vice platinum) show promise as anode material for use with anolyte containing ammonium nitrate. Project proposal for 321 Bldg. revisions submitted to AEC. Initiated design of prototype cell.	b. Complete studies on operating conditions of the three compartments during next quarter. Study conditions relating to recycle streams. Anode studies to continue. Upon authorization, begin 321 Building modifications.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
c. Pyrochemical methods for fuel processing.	c. 1	c. High temperature visible and ultraviolet spectrophotometer.	c. Initial equipment procured. Investigations begun in the system $KAlCl_4$ for pyrochemical separation and purification of U + Pu.	c. Program to expand to include one more chemist.
8. Waste Treatment and Disposal - For separations and reactor areas. a. Long-term storage of high-level wastes from separations plants.	8a. 2-3	8a. Brick piles, furnaces, calcination equipment.	8a. The chemical problems associated with the long-term storage of high-level Hanford separations wastes (particularly Purex first-cycle waste) have been surveyed, and preliminary laboratory experiments have been initiated on several promising approaches aimed at improving the safety and economy of waste treatment and storage. Engineering and economic studies are continuing concurrently.	8a. Work will be concentrated on three operations: 1) removal of acid from 1WW, 2) drying and calcination, and 3) high temperature fixation reactions. Emphasis will be on the behavior and control of fission products, particularly ruthenium, and on securing data on variables (such as thermal conductivity) which will permit engineering evaluation. The effort will be increased to two men, a chemist and an engineer, in February. Engineering and economic studies will continue.
b. Laboratory research to evaluate the influence of variables on soil column tests.	b. 1-2	b. Laboratory soil columns and equipment for studying soil-waste systems.	b. Simulated self-sintering experiment was outlined for a gelled blend of Purex neutralized 1WW and coating waste. The influence of temperature on soil column tests was evaluated at several temperatures. Experiments included tests of various saturating ions.	b. Detailed design of necessary equipment to be done. Preliminary laboratory work will be done in order to specify optimum stream ratios. Development of a laboratory technique for soil column tests of wastes is expected to continue at the same level.
c. Study earth science aspects of reactions of wastes in the ground, disposal, specifications, field or pilot scale testing.	c. 3-4	c. Field testing devices for hydrologic research.	c. A ground water tracer study was in progress south of 200-East Area. Special measurements were made of the influence of the new Gable Mountain swamp on the local water table. Assistance was rendered in drawing up specifications for new test structures south of BC disposal sites.	c. Additional pumping tests are planned to extend current knowledge of hydrologic parameters. Research will be initiated to measure specific retention characteristics to permit evaluation of this disposal method. About the same level of effort is planned.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
			Interpretation of ground water monitoring data. Further study of the influence of the proposed Richland Dam was made. A report was issued evaluating potential waste disposal sites in and near the 200 Areas.	Effort is expected to continue at about the same level.
			Field test of gelling coating waste: essentially completed. Gelling of coating waste without subsequent drying does not look promising. Feasibility of drum drying gelled coating waste being studied. Co-60 use test is in progress. Wells have not been started to evaluate the program. Recommended ground water wells at Z-Plant.	Drying of gels to be investigated. Economics to be compared with other proposed processes.
			Laboratory soil column evaluation tests were performed on samples from all major waste streams. The reaction of scavenged wastes with soils was determined as a basis for recommending their disposal.	The evaluation of waste streams and prediction of crib life will continue at about the same level of effort.
d. Identify variables affecting kind and concentration of radioisotopes in reactor effluent. Study factors influencing Columbia River as a disposal site. Reactor effluent disposal, specifications, consultations, recommendations. Analyzing monitor for process control of effluents - application and evaluation.	d. 2-3	d. Counters, electronic equipment, ion exchange columns, laboratory equipment.	d. Plant sampling and data correlating program outlined which is designed to find the origin of As-76 and to suggest corrective measures that can be taken in order to reduce concentration of As-76 in the effluent.	d. Program to start January 1958 and to run at least one year. Effort is to be centered on As-76; however, as program develops other prominent radioisotopes in the effluent will be included in the study.
			Studied effects of fuel element cladding, design, corrosion inhibitors, and increased production. Preliminary study of the effects of Turco completed.	Continue day-to-day plant assistance type work. Initiate studies relative to the suggested opening of the Columbia River to navigation.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
			The reactor effluent monitor was placed in semi-routine operation in 100-F. Improvements incorporated as a result of this experience.	A period of calibration and data collection will follow to evaluate monitor performance and to define optimum operating procedures. Long-time sensitivity and reproducibility will require measurement.
9. Reactor Disaster Consequence Study	9. 0-1		9. Bibliography ready for printing. Most of the equipment received. Necessary flow meters calibrated.	9. Start of experimental work waiting on receipt of furnace. Uranium oxidation experiments will be minimized in view of work at ANL which can be applied.
10. Geological, Hydrological and Advanced Planning Studies Determine the geologic and hydrologic characteristics of the earth below Hanford and their effect upon, and how affected by, radioactive wastes. Guide and advise on the future direction of waste disposal operations on the basis of the geologic and hydrologic factors of importance.	10. 0-1	10. Well drilling, field study data, geologic maps of region.	10. The feasibility of disposal of radioactive liquid wastes to ground at Hanford in other than the post-basalt sediments is contra-indicated by 1) the increasing development of aquifers in the upper 1000 feet of the basalt series for sanitary water supplies for the Columbia Basin Irrigation Project area east of Hanford, 2) the very low permeability and porosity of the basalts below the above-mentioned aquifers, 3) the more than 8400 feet of basalts encountered in the Standard Oil Co. stratigraphic test well on Rattlesnake Hills, which nearly certainly precludes the economic disposal of wastes beneath the basalts even if suitable host rocks may be found there.	10. Maintain geologic and hydrologic studies to assure continuity and desired expansion of waste disposal activities at lowest cost and high degree of radiological safety. Extend geologic studies into environs as necessary and to greater depths by well drilling, geophysical seismic studies, correlation to the well drilling and geologic work of others and by field mapping to evaluate the potential of waste containment at intermediate or great depths. Evaluate the usage rate of real estate for waste disposal activities to assure the maximum, most efficient and economical utilization of the ground for current methods of waste disposal. Provide technical counsel on

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
				geological matters, direct drilling and geophysical exploration programs. Evaluate exploration methods, including rotary drilling, to improve speed of work, reduce costs and provide more and better geologic data. Work will continue at the same level of effort.
4000 ACCOUNT				
11. Plutonium Recycle Reactor Project Fuel processing studies, alternate fuel material preparation, isotopic composition of recycled fuel, use of Hot Semiworks for fuel processing, aqueous and non-aqueous methods.	11. 17-22	11. High temperature equipment, x-ray diffraction facilities, Pu handling facilities.	11. Application of Zirflex process to decladding of Zircaloy-2 clad Pu-Al alloy fuels appears feasible. Preliminary studies indicated considerable promise for completely decontaminating plutonium from PRP fuels in one cycle of anion exchange. Dissolution studies of Pu-Al-Si alloys begun. Processing of PRP fuels via amine extraction was intensively investigated. Completed cryolite process demonstrations using U as stand-in for Pu. Continued pyrochemical processing studies. Preparation of Bi-UO_2 slurries successfully made and qualitative data on stability developed. Studies on thin film deposition begun. Began procurement for laboratory-scale high level alpha, beta, gamma facility.	11. Continue at same level of effort. Complete design and initiate construction of shielded anion exchange facility to permit studies with full-level PRP fuels. Studies on the impregnation of graphite with plutonium will be terminated early in 1958. The mechanism of plutonium extraction with amines to be further investigated. Flowsheets will be devised and tested for use in the Hot Semiworks.

Project or Study	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Normal office and laboratory space and equipment is assumed in all cases)	Status and Progress	Future Status and Comments
			Budget study for Hot Semiworks modification underway. Flowsheet and equipment study for Hot Semiworks completed. Alternate locations for permanent plutonium purification facility about FY-1963 being studied. In interim period, the service to be performed along with some development by the 234-5 Development Operation, CPD; but with small interference with plutonium development program.	Decision on recommended location for plutonium purification facility about September 1958. Alternate solvent systems (e.g., iso-octylamine) for specific Pu recovery to be studied for application to the HSW.

A. Organization and Personnel

Dr. Robert H. Schiffman, a physiologist specializing in aquatic organisms, joined the Aquatic Biology Operation at the end of December 1957.

R. L. Browning rejoined Biological Analyses Operation as a technologist following a leave of absence.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Atmospheric Contamination

Concentrations of I^{131} in thyroid glands of jack rabbits were approximately the same as observed one year ago. Values were as follows:

Collection Site	μc I^{131}/g thyroid Average	Maximum	Trend Factor
Four miles SW of Redox	1×10^{-2}	2×10^{-2}	+ 5
Prosser Barricade	6×10^{-3}	8×10^{-3}	≅
Wahluke Slope	1×10^{-3}	3×10^{-3}	- 3

Concentrations of fission products in rabbits were about the same as one year ago. Values were as follow:

Sample Type	μc FP's/g sample Average	Trend Factor
Bone	4×10^{-5}	≅
Feces	3×10^{-5}	- 2
Liver	1×10^{-5}	≅

Columbia River Contamination

The contamination levels for beta emitters in representative organisms from the river were as follow:

Sample Type	Collection Site	μc/g wet wt. tissue Average	Maximum	Trend Factor
Minnows (entire)	Hanford	5×10^{-3}	6×10^{-3}	-2
Whitefish flesh	Priest Rapids	8×10^{-5}	9×10^{-4}	-3
Whitefish flesh	Ringold	2×10^{-3}	3×10^{-3}	+2
Diving duck flesh	Hanford Reservation	2×10^{-3}	5×10^{-3}	
River duck flesh	" "	2×10^{-3}	3×10^{-3}	
Goose flesh	" "	4×10^{-4}	5×10^{-4}	

[redacted]

During the month the average radioactive contamination in the flesh of whitefish from Ringold and ducks from within the Hanford Reservation increased to 2 x 10^{-3} μc/g. The Ringold station is an area available and popular to sport fishermen. The ducks, which include popular game species, are protected on the Hanford Reservation but they routinely fly to areas where they are harvested by hunters. The radioactivity in the tissues of these animals is almost entirely from P^{32}. Only 0.3 pound of flesh of average whitefish from Ringold or of ducks could be eaten per week without exceeding the MPC of P^{32} as calculated for drinking water for large populations. It is expected that the P^{32} concentration in whitefish will decrease owing to lower metabolic rates associated with seasonal low water temperature.

Effect of Reactor Effluent on Aquatic Organisms

Chinook salmon eggs were incubated in a 4.0 per cent concentration of reactor effluent and in an equivalent amount of effluent which was varied in concentration from 3.0 per cent to 6.2 per cent to simulate the magnitude of the fluctuation which may occur in the Columbia River when power is produced at Priest Rapids Dam. No adverse effect was observed. The test is being continued with the young fish.

Chinook salmon eggs were also incubated in a 4.0 per cent concentration of effluent from experimental tube No. 4963 of the KE reactor and in a like concentration of the gross effluent from this reactor in order to compare the toxicity of the two types of effluent. Neither type of effluent has yet produced an adverse effect. Increased mortality is expected at this concentration after the eggs have hatched.

A second study was completed on the concentration of radioactive materials in fish which were exposed to retained or nonretained reactor effluent under balanced ecological conditions. The gross concentration of beta emitters in entire fish (minus gut and gut contents) which were exposed to nonretained effluent was essentially the same as for fish exposed to retained effluent, whereas the concentration in nonretained effluent was 3.6 times greater than in the retained effluent. Radioactive studies indicated no increase in amounts of short half-lived isotopes in the carcasses of fish exposed to the nonretained effluent although there were significant amounts of short half-lived materials in their gut contents.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM AND TOXICITY OF RADIOACTIVE MATERIALS

Phosphorus

About 13 per cent of the trout fed 0.6 μc P^{32}/g body weight each day died from radiation damage after four months. Many others in this group now refuse food. Some radiation damage is also evident from gross observations in trout fed 0.06 μc P^{32}/g body weight although no deaths have occurred. The number of white cells in the blood of these fish was inversely proportional to the amount of P^{32} ingested.

Zinc

Deposition in the rat of Zn^{65}, fed as a solution, incorporated in bean leaves or liver, or mixed with bean leaves or liver, varied from 12 to 22 per cent of the quantity fed. The form in which the Zn^{65} was administered did not significantly affect absorption and deposition except that the presence of liver appeared to increase deposition by approximately 50 per cent.

Female rats were sacrificed after 100 days on a Zn^{65} drinking water regimen. Concentrations of Zn^{65} are still increasing in all tissues with highest values found in liver, pancreas, bone, kidney and spleen.

Strontium

Tests of the effect of sulfate on uptake of Sr^{90} are being made by Neubauer technique using Barley and with pots using radishes. Cinebar and Ephrata soil was treated with $(NH_4)_2\ SO_4$ in amounts equivalent to 50 and 500 lbs per acre and with gypsum to provide a similar sulfate concentration. Nitrogen concentration was adjusted by adding NH_4NO_3 or $Ca(NO_3)_2$ to control soils. All were contaminated with Sr^{90}.

In nutrient solution studies with beans, increasing the calcium concentration from 0.5 to 5 meq Ca/l reduced the Sr^{90} concentration in leaves threefold. Additional calcium in the nutrient solution produced no further change in Sr^{90} concentration in leaves. OR values (Sr: Ca plants vs. Sr:Ca substrate) remained nearly constant at concentrations up to 5 meq Ca/l but increased markedly with higher calcium concentrations.

Neubauer tests have been completed on soil samples obtained from Dr. Menzel. Leaf soil ratios for Sr^{90} were similar to those obtained with local soils except for one sample, Norfolk soil, which showed the very high ratio of 11. No data on pH, calcium content, etc. are presently available for these soils.

A three-day feeding experiment was performed to determine the effect of lactate, carbonate, phosphate, and calcium concentrations in the diet, on the absorption and retention of Sr^{89} and Ca^{45} in the bone of rats. Calcium, phosphate, and carbonate were all effective in reducing deposition of Sr^{89} and Ca^{45}, but in varying degrees for the two isotopes. The results attest to the complexity of the inter-relationships involved and point up the inadequacy of the commonly accepted concept that calcium will behave simply as an isotopic diluent of strontium.

Statistical analysis of the data from the Sr^{89} lamb-feeding experiment shows that calcium had a significant inhibitory effect on Sr^{89} uptake in bone (37 per cent decrease with three times normal dietary calcium). Further, the gluconate anion had no effect on Sr^{89} absorption at all levels of calcium in the diet, but the sodium cation had significant effect on increasing Sr^{89} uptake at all levels.

Cesium

Observations were continued on the aquatic community of a small pond spiked with Cs^{137} last June. A marked reduction in Cs^{137} concentration in all organisms was associated with lowered water temperatures. The reduction was greater for animals than for plants.

Iodine

The remaining swine in the long-term 45 μc level of I^{131} feeding were sacrificed at varying periods during gestation this month. A total of 57 pigs was obtained from these eight animals. Tissues were sampled and submitted for radioanalysis. (Analysis of tissues not yet complete.)

Plutonium

Partial results are available from an experiment in which intratracheal administration of plutonium was followed by exposure of the animals to an aerosol containing EDTA or chel-330. Excretion of plutonium was markedly increased by treatment with the chelating agents; however, the initial effects on plutonium deposition in bone appear to be slight. Quantitative evaluation of the results must await completion of additional analyses.

Further studies of chel-330, administered acutely or chronically following plutonium administration, have demonstrated its consistent superiority over EDTA. Additional studies will be required to determine the effect of treatment levels, time of administration, etc., but it would appear that as much as 90 to 95 per cent of intravenously administered plutonium may be removed from rats by prompt treatment with chel-330.

Radioactive Particles

Examination of malignant lung tumors found following pulmonary deposition of radioactive particles in mice is complete. Three were found after administration of $Pu^{239}O_2$ and one after administration of $Ru^{106}{}_2$. The latter is the first reported lung malignancy caused by a beta emitting isotope.

For studying the metabolism and toxicity of inhaled $Sr^{90}SO_4$ particles, a single exposure of 320 mice was completed. The initial body burden was estimated at approximately 20 μc and after two weeks at 3 μc.

Daily exposure of mice to air containing $Sr^{90}SO_4$ particles (10^{-9} to 10^{-6} μc/cc) has continued for 8 weeks. A buildup of approximately 0.5 μc $Sr\text{-}Y^{90}$ is detectable in the mice exposed to the highest aerosol concentration.

Exposures of dogs to radioactive aerosols are awaiting completion of the dog monitor. Exposure of mice to I^{131} vapor will be started upon completion of the air breathing system in the laboratory.

Gastrointestinal Radiation Injury

Studies have been made of the effect of radiation on nucleic acid synthesis in the rat intestine. One day following 1500 r of total body X-ray, synthesis of DNA (as measured by P^{32} uptake) is virtually stopped in the jejunum, ileum and cecum. The colon is somewhat more resistant, showing about 30 per cent of control uptake. Synthesis of RNA is decreased to approximately 75 per cent of control level. Additional studies are in progress to determine the effect of other time intervals and to compare whole body irradiation with irradiation of the exteriorized intestine. These studies indicate that P^{32} uptake by DNA is a sensitive and reproducible method for studying radiation damage to the intestine.

Relative Biological Effectiveness

A value of 1.1 was obtained for the RBE of tritium as compared to P^{32} betas, using a non-dividing suspension of haploid yeast. This partially confirms the previously reported low value for tritium when compared to X rays. With X rays the dose was delivered over a very short period compared to the 40 hours needed for the tritium exposure while the P^{32} dose was administered over the entire 40-hour test period.

Studies of biochemical damage to yeast cells show that appreciably more phosphorus leaks out of irradiated cells than out of non-irradiated cells. About 90 per cent of the phosphorus lost from both control and irradiated cells was inorganic.

Of four cytochromeless strains derived from a supposedly homogeneous haploid strain of yeast, three were about 50 per cent and one 75 per cent more sensitive to radiation than was the parent culture. The parent culture shows absorption bands characteristic of cytochromes a, b, and c. No data are available as yet on the mutants.

Research Services

Tissue analyses were completed on the two steers and one bull which had received Zn^{65} for labeling of pancreatic enzymes. Liver showed the highest concentration of Zn^{65} and was followed by kidney and heart. The iris and retina were also among the tissues of major concentration.

R. F. Foster

Acting Manager
BIOLOGY OPERATION

RF Foster:es

[redacted]

C. Onsite Visits and HLO Visitors

Name	Dates of Visit	Company or Organization Represented and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data	Areas and Buildings Visited
VISITORS TO HAPO						
Dr. H. Stanley Bennett	12/11/57	Department of Anatomy Univ. of Washington Seattle, Wash.	Present a seminar and tour Biology facilities.	HA Kornberg	No	100-F, 108-F, 141-M, 146-FR
VISITS TO OTHER INSTALLATIONS						
H.A. Kornberg	12/18-21	Univ. of Washington Seattle	Discuss education and contract	Dean Burd	no	-
V.G. Horstman	11/29-30	Hormel Institute, Austin, Minn. Chicago, Illinois	Discuss purchase of miniature pigs. Attend Annual Mtg. of Soc. for Animal Production.	-	No	-

D. Lectures

a. Papers presented at meetings

None

b. Seminars

Dr. H. Stanley Bennett, "Certain Morphologic Aspects of Active Transport Mechanisms" - December 11, 1957.

E. Publications

Willard, D.H., L. A. Temple, and W. J. Bair, "Turnover and tissue distribution of radioruthenium in the lungs of mice", Document HW-52286 (UNCLASSIFIED) October 1, 1957.

OPERATIONS RESEARCH & SYNTHESIS OPERATION
MONTHLY REPORT

December, 1957

ORGANIZATION AND PERSONNEL

There were no significant changes in personnel this month.

OPERATIONS RESEARCH ACTIVITIES

Economic Studies

Increased effort was directed toward application of economic theory to the management of HAPO. The series of papers discussing pertinent economic concepts was augmented by seminar discussions to which personnel from product departments were invited. To obtain background for the proposed input-output analysis of HAPO operations, discussions were held in New York, particularly with Dr. Martin Shubik, concerning the economic model of Appliance Park.

Document HW-54221 RD, "Evaluation of Capital Expenditures," was issued for comment. Some further work was done on the definition of the information required for the first phase of the program outlined in this report.

A collection of historical and operating capital costs is essentially complete. An analysis of these data has been started.

An examination of supply and price structures which might be associated with the plutonium recycle process was started.

CPD Control Study

Considerable effort was devoted to the preparation of a document defining more precisely the scope of the study and outlining the specific program to be followed. The first part of the proposed program will consist of the preparation of the process flow diagrams, the compilation of the extent of source data available, and the estimation of the reliability of the information obtained through the conversion of source data. This will be followed later by delineation of information flow and a description of the decision structure.

Work progressed during the month on the preparation of flow diagrams and the study of available source data. Proper clearance to permit analysis of Z plant control requirements was received and a flow diagram of possible product flows through this plant is 80% complete. An indication of the origin of all formal basic records is being incorporated on this diagram. Means of recording chronological, as well as physical, relationships in the flow of process information are being considered.

Other

The design of an experimental cost information system has been completed. This system is designed to report costs to individual cost center managers in terms most meaningful to them. The system accomplishes a full report of all significant cost center costs without inflation. It is designed to operate in

conjunction with a matrix cost system which will perform a complete allocation of costs to end functions. A fairly large example of specific cost information as it would be processed by this system is in the latter stage of completion. This example will show typical cost accumulation, flows, and report types.

Assistance was provided Employee Relations personnel in analyzing sensitivity survey results returned by Hanford Laboratories Operation management. Several interesting observations pertaining to the results, and a suggested follow-up approach for use in discussing the results with individual managers, were presented. The suggested follow-up approach was also communicated to the attitude survey task force members in other departments.

It was recommended to Central Stores personnel that no further attempt to revise the formula used in evaluating general supplies inventory be made at this time. It was suggested that the formula be reviewed when data covering 12-15 months of operating experience are available.

STATISTICAL AND MATHEMATICAL ACTIVITIES IN SUPPORT OF RESEARCH PROGRAMS

2000 Program - Metallurgy

Analysis of data from a recent Coating and Corrosion Operation experiment to investigate in-pile corrosive properties of several aluminum alloys was completed in December.

An experimental program to investigate the feasibility of uranium reduction by pyrochemical means was outlined for Heavy Element Chemistry Operation.

2000 Program - Reactor

A pair of 2nd order linear differential equations, defining neutron flux distribution in a spherical fuel element, were solved for Critical Mass Physics Operation.

Results of a statistical analysis of numerical integration techniques used to estimate fuel element cross section neutron flux from empirical indicator pin values were reported to Theoretical Physics Research Operation. (Unclassified letter, "Statistical Comments on Neutron Flux Ratio Estimation," to M. T. Lee, dated December 5, 1957.)

The Critical Mass Physics Operation requested assistance with the determination of confidence limits on the square of the slope parameter in a linear regression scheme involved in the determination of buckling as a result of random dumping of uranium slugs in a bath. A satisfactory approximation procedure was developed and reported orally to interested persons.

2000 Program - Separations

Assistance was given a member of the Engineering Development Planning Operation in preparing a research paper dealing with the time and spacial behavior of materials in a gas absorbant column.

4000 Program - PRP

Data from a recently completed UO_2 capsule irradiation experiment were statistically analyzed to determine the dependency of fission gas activity on packing density, enrichment, neutron flux, exposure time and surface area. Results of the analysis were reported orally to interested persons of Ceramic Fuels Development Operation. Further analysis is contemplated using more complete information on surface area measurements and exposure data.

6000 Program - Biological Research

Experimental data on the deposition of Sr-89 in lambs were statistically analyzed and the results reported to the Experimental Animal Farm Operation. (Unclassified letter, "Effects of Calcium and Sodium Gluconate on Strontium Absorption," dated December 10, 1957.)

Work was begun on a generalized mathematical model of migration to describe the passage of radioactive tracer particles from region to region within an experimental animal.

Seedling harvest data from a current Plant Nutrition and Microbiology Operation experiment to investigate the effects of various in-soil Ca salt compounds on Ca-45 and Sr-90 uptake to plant tissues were statistically analyzed and the results reported to interested persons. (Unclassified letter to R. L. Uhler, "Statistical Analysis - Second Planting Seedling Harvest Ca-45 and Sr-90," dated December 27, 1957.)

Discussion was held with the experimental Animal Farm Operation concerning a possible experimental design to determine the chronic effects on pigs of feeding radioactive strontium.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR THE PRODUCT DEPARTMENTS

FUELS PREPARATION DEPARTMENT

Process Control

A complete review was made of all statistical control charts being currently maintained for I and E fuel element production. The relative importance of each of the variables was considered with the intent of eliminating those of little importance so that the remaining ones can be more effectively utilized. It was pointed out that, in some instances, the use of control charts is not warranted in view of the present extreme lack of control. Primary consideration was given to revamping the existing charts to conform to the newly adopted reject categories. Methods of feeding back information efficiently to responsible sources were also recommended.

Since many of the personnel engaged in quality control work are on rotating assignments, it becomes a problem to acquaint new personnel with the proper use of control charts. For this purpose, an informal list of control chart principles pertinent to the canning line process control has been prepared and distributed to those personnel engaged in the quality control program.

The Penetration Tester designed to reject I and E fuel elements having thin tube walls has also been rejecting a sizeable number of acceptable fuel elements. Assistance was given in designing an experiment to evaluate the efficiency of this instrument. A sampling plan to assist in the disposition of fuel elements rejected by the Penetration Tester was also devised.

Process Experimentation

Assistance was given to design experiments and/or analyze data to determine the effects of alsi concentration on reject rates; to evaluate a special type cleansing agent being considered for use in component preparation; and to determine what variables affect the inclusion reject rate.

Other

Monthly control charts were prepared for absenteeism rates in the level 3 components within Fuels Preparation Department as requested. The control limits were based on historical data for all of HAPO for the past five years and were adjusted for seasonal variation in addition to the numbers of male, female, exempt, and non-exempt employees making up a given component.

IRRADIATION PROCESSING DEPARTMENT

Rupture Analyses

A final report was issued summarizing the results of the discriminant analysis study designed to determine whether or not production lots of metal likely to contain ruptures could be detected by the use of certain reject data. (HW-54234, "An investigation of the Feasibility of Using Reject Data to Detect Rupture Prone Lots," 12-19-57.)

Rupture data are being analyzed to evaluate the effect of outlet water temperature on rupture rates. The thought is that at least a part of what is called a power effect by existing models might be a temperature effect. "Side-Other" rupture data are presently being analyzed. The types of ruptures are being kept separate to determine whether or not one model adequately describes the dependence of all types of rupture rates on reactor variables.

Current estimates of the ratios of rupture rates (factors of improvement as compared with solid fuel elements) for I and E fuel elements and cored fuel elements at H reactor were found, together with limits of uncertainties about these estimates.

Production Test Analysis

A report previously issued which considered the effects of delay time before quenching on warp and diameter change of irradiated fuel elements was recalled since it later developed that the original data sheets were in error with respect to slug identification. The corrected data from this production test (PT-613) were re-analyzed. (HW-54272 RD, "Analysis of Dimensional Change Data: Delay Time Before Quenching," 12-26-57.)

CHEMICAL PROCESSING DEPARTMENT

Radiation Exposure Study

A study is currently underway which has as its goal an understanding of the effects of different variables on the amounts of radiation exposure found at different places within "Z" plant. Statistical assistance is being given in connection with this study, primarily in evaluating past exposure data, and in setting up a sampling program to evaluate the effects of moving across the various tasks within "Z" plant.

OTHER STATISTICAL AND MATHEMATICAL ACTIVITIES

Activities for Other Operations

A firm proposal, signed by the four members of the Task Force on SS Accountability problems, has been submitted to IPD and CPD management for approval and action. It is proposed that a series of two-ton batches with known irradiation history be dissolved in a Redox dissolver, and analyses performed on samples from these dissolvers, primarily in order to obtain added information on the conversion ratio. (Unclassified letter, "IPD to CPD Accountability," 12-13-57.)

The analysis of calibration data from C-1 and E-12 tank calibrations has been completed. Tables have been prepared giving volumes and volume removals as functions of manometer readings, with a discussion of the uncertainties involved being included. The results were reported in a rough draft to W. H. Johnson for comments before issuance of a final report.

The calculation of the bias resulting from using average values to predict Pu formation and U-235 consumption was simplified by the preparation of a table combining three of the terms as a function of MWD. Recommendations were also given for calculating the bias when partial charges are involved, as when natural metal is combined with enriched metal.

The methods for calculating monthly U-235 consumption and ending inventory were reviewed as requested. It was found that, although present methods of calculation are correct, the method of calculating ending inventory is dependent on beginning inventory and, as such, an error or series of errors that occurred in the inventory figure at some past date has resulted in subsequent inventories being in error. A recommendation for calculating inventories was given which does not depend on previous inventories. Alternate ways of calculating monthly consumption were also forwarded. (HW-54205 RD, "Calculating U-235 Monthly Consumption and Ending Inventory," 12-17-57.)

A joint meeting was arranged between representatives of Electrical System Planning Operation, R & U; Electrical Design Operation, CEO; and Data Processing Operation, R & U, to discuss the possibility and feasibility of running many of the routine analyses of Hanford's Electric Network System on our own 702 electronic computer, thereby saving the time and expense of purchasing these services offsite. It was generally agreed that such a plan was possible and a joint committee was formed to study and formulate a program.

[redacted]

Mathematical assistance was given to a member of Data Processing Operation, R & U, in obtaining upper and lower bounds for the magnitude of the latent roots of a certain matrix.

Activities within HLO

Evaluation of FY-1956, 1957, 1958, I_{131} data (stack emission, rabbit thyroid uptake and vegetation) continued this month. Specifically, correlations between rabbit thyroid uptake and vegetation were calculated and the precisions of wet chemistry and gamma scan methods of assaying vegetation I_{131} content were measured.

Statistical evaluation of referee and standard analyses was continued for General Chemical Analysis Operation.

A discussion was held with Radiological Development Operation concerning the design of an experimental program to investigate the fading characteristics of Eastman Personal Monitoring Type II Film.

Statistical and Mathematical Research and Development

Work continued on two formal Hanford reports, Poisson ratio estimation and a table of occupancy probabilities.

The study of stationary time series was continued.

OFFSITE VISITS AND VISITORS

There were no offsite visitors during the month.

J. L. Jaech attended a meeting at Argonne National Laboratory on December 2 to discuss the statistical analysis of analytical results.

J. L. Jaech addressed a combined meeting of the Portland chapter of the American Society for Quality Control and the Portland Industrial Chemists on December 9.

C. A. Bennett discussed "Operations Research at Hanford" at the Advanced Management Conference at Crotonville, New York on December 18.

R. L. Basmann spent December 27-30 at the annual meeting of the Econometric Society in Philadelphia, and December 31 through January 3 with the Operations Research and Synthesis Consulting Service in New York for discussions with Dr. Martin Shubik and others.

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:jbk

RADIATION PROTECTION OPERATION MONTHLY REPORT - DECEMBER, 1957

A. ORGANIZATION AND PERSONNEL

Organization

No significant changes in organization occurred.

Force Summary	11-30-57	12-31-57
Exempt	44	44
Nonexempt	153	152
Total	197	196

B. ACTIVITIES

Radiation Monitoring

Aerosol experiments involving significant quantities of strontium-yttrium-90 were completed without incident at the Biology laboratory. Phosphorus-32 clothing contamination occurred to a laboratory technician's laboratory coat and resulted in an estimated maximum dose of 4.4 rads to a small area on the forearm. This was the only technical overexposure experienced in Biology facilities in 1957.

Airborne plutonium was spread in the 231 building as a result of a power outage. The personal effects of one employee were contaminated.

On two occasions plutonium contamination was detected on the outer surfaces of glove boxes in the 325 Building. In one instance air contamination resulted.

Upon request of AEC-HOO a budget review for radiological defense was submitted for the last half of FY 1958. A review was made of the existing HAPO and AEC-HOO emergency procedures and plans in light of the Windscale incident.

Training and orientation sessions were conducted for new employees of the Plutonium and Metallurgy Operation and Patrol personnel, instrument and electrical personnel in the 300 Area, and transportation personnel.

A detailed report of Radiation Monitoring is contained in HW-54408.

Regional Monitoring

The average daily emission of I^{131} was 1.0 curie. A single emission of 14 curies occurred at the Redox plant early in December. This emission was associated with the decontamination of the canyon crane with solvents. The I^{131} was released from the sand filter by the airborne solvent in the ventilation air. I^{131} and other fission products found on vegetation increased by a factor of three in and around the separations areas.

Burial of grossly contaminated canyon equipment at the Redox plant caused contamination of the operating gallery including electronic stack monitoring equipment owned by Regional Monitoring. Decontamination of the equipment is still in progress.

Monitors in the 614 buildings at the Redox area and the 200-West main gate indicated abnormal airborne contamination.

Raw water analyses at 100-F and Pasco showed 6.6% and 2.7%, respectively, of the continuous occupational MPC_{GI}. Preliminary comparisons between raw and sanitary waters at these locations showed clean-up factors ranging from two to five in the fraction of MPC_{GI}. Analyses of Kennewick sanitary water continued to show little if any removal of radioactive materials by the Ranney water system.

Noticeable fallout of fresh fission products in the northwest was attributed by AEC-HOO to activities at the Arco Test Site.

A detailed report of waste disposal monitoring is contained in HW-54580.

Exposure Evaluation and Records

Two cases of plutonium deposition were confirmed; one as a result of routine bioassay sampling, and the other following a minor injury to an employee's finger from a wire object in a 234-5 process hood. In the latter case, a small piece of skin was excised. Preliminary bioassay sampling indicated an intake of less than 10% MPL in both cases.

A total of 212 plutonium cases is on record. Of these cases, 168 are still on the active rolls and as of the end of the year, these are distributed by level 2 components as follows. These cases include both General Electric and subcontractor personnel covered by the bioassay program.

	Per cent of MPL			
Component	0.5 to < 5.0	5.0 to < 10.0*	10. to < 50.0	50. to > 100
Chemical Processing	98	20	10	6
Construction Engineering	2	0	0	1
Fuels Preparation	2	0	0	0
Hanford Laboratories	15	0	0	1
Irradiation Processing	5	3	2	1
Relations and Utilities	1	1	0	0
	123	24	12	9

*Included in this group are employees for whom an estimate of deposition has not been firmly established but are considered to be in the range of 1 to 10% of the MPL.

Fourteen cases of plutonium deposition are known to have occurred at HAPO in 1957. Preliminary estimates indicate all of these are 10% or less of the MPL. A complete listing of all plutonium deposition cases on the plant was distributed to level 2 management.

Re-evaluation of external dose received was completed for 59 employees in the 234-5 Building. Twelve 234-5 employees have exceeded the annual working limit of 3 r.

Self-service badge racks were installed and placed into operation in the 100 and 200 areas with a minimum of disturbance to employees and good acceptance of the change.

Several requests for procedures and equipment plans fulfilled for other AEC sites and the AEC Division of Biology and Medicine.

Radiological Development

Fabrication of the prototype badge processing machine is approximately half complete. Some design changes have been made in the interest of simplifying the fabrication. Design work on some of the necessary appurtenances to the machine progressed satisfactorily.

A prospectus of the Bioassay-IBM conversion was written, providing a detailed problem and solution definition from which the several groups could work. In preparing the prospectus, several solution modifications planned to improve previously reported solution techniques were developed. A new method of preparing the annual bioassay regrouping cards was developed. This method utilizes IBM cards exclusively and eliminates much of the previously encountered hand work. The regrouping cards, now called the Annual Bioassay Information Request, were produced.

The study of optimum aperture size for the Beckman densitometer was completed and a report is in preparation. An aperture on each side of the film will be recommended of a specific size for best reproducibility.

Calibrations

One of the two 0.5 gm Ra-Be sources was shipped to the National Bureau of Standards for re-evaluation.

Battery check circuits have been installed in two-thirds of the 95 Thyac GM meters. Data collection on the performance of these units was started. Preparation of sources to be used for the battery check was started.

Radiological Consultation

A review was made of the latest draft of the guides for the preparation of NCRP recommendations. The draft separates the recommendations into basic rules and operational guides. This change is viewed as an improvement in format.

A review was started of data on the early uptake of iodine-131 in the sheep thyroid. Equations were fitted to these data so that the total dose to the thyroid could be estimated from fallout isotopes or from a single emission of iodine-131.

Work was started on improving the estimates of gonad dose from internal emitters. Further discussions were also held on radiation exposures during diagnostic examinations at the Kadlec Hospital. Arrangements were made for additional measurements of the gonad dose following recent procedure improvements.

The Division of Sanitation and Engineering, Oregon State Board of Health, requested through the AEC-HOO advice in setting up an initial air and water monitoring program in Oregon. Arrangements were made for assistance in source calibration, sample preparation and counting techniques.

J. W. Healy was requested by the chairman of the NCRP to assume chairmanship of NCRP Subcommittee 6, Safe Handling of Radioisotopes. The assignment was accepted.

Radiological Disaster Studies

Previous calculations on the dispersion and deposition of the plume from a reactor accident were reviewed and prepared for formal issuance.

MPC Evaluation

A table of proposed biological constants and resulting MPC's for the revision of the NCRP internal dose handbook was reviewed and comments forwarded to the committee chairman.

Columbia River Studies

The annual meeting with the Columbia River Advisory Group was planned. The agenda was established, and January 14-15-16, 1958, were established for the meeting dates.

C. EMPLOYEE RELATIONS

Safety and Security

There were five medical treatment injuries for a frequency of 1.60. Two security violations occurred raising the total for 1957 to three.

Suggestions

Seven suggestions were submitted by RPO personnel. Six suggestions were received in RPO for evaluation, and evaluations on 12 other suggestions were completed.

Relations

The combination of self-service badge racks in the outer areas, reduced usage of pocket dosimeters, full use of the home area badge system, and relatively low attrition culminated in a situation which will require the reduction of the RPO force in January, 1958, by 30 employees.

VISITS TO HANFORD WORKS

Name	Dates of Visits	Company or Organization Represented & Address	Reason for Visit	HW Personnel Contacted	Access to Restricted Data	Areas and Buildings Visited
J. M. Smith	12/11-12/57	APED - GE San Jose, California	Discuss latest calculations on the consequences of a reactor accident.	JW Healy	No	3746:300

VISITS TO OTHER INSTALLATIONS

H. V. Clukey	12/13/57	Columbia River Advisory Group Portland, Oregon	Discuss agenda for January CRAG meeting.	HC Clare CM Everts, Jr.	Yes	

REGIONAL MONITORING

The general findings are summarized in the following:

Sample Type and Location	Activity Type	Average Activity Density μc/cc	Trend* Factor
Drinking Water and Related Materials			
Benton City Water Co. Well	alpha	1.1×10^{-8}	--
100 Areas	beta	$(0.01 \text{ to } 1.8) \times 10^{-5}$	--
200 Areas	beta	$(1.4 \text{ to } 5.3) \times 10^{-6}$	+4
Pasco, Kennewick, McNary Dam	beta	$(<0.03 \text{ to } 5.3) \times 10^{-6}$	--
Backwash Solids - Pasco Filter Plant	beta	0.56 μc/gm	+2
Backwash Liquids - Pasco Filter Plant	beta	3.5×10^{-6}	--
Anthracite, Sand Filter - Pasco Filter Plant	beta	6.7×10^{-4} μc/gm	+2
Other Waters and Related Materials			
200 West Wells	beta	$< 2 \times 10^{-7}$ to 2.6×10^{-3}	--
200 East Wells	beta	$< 2 \times 10^{-7}$ to 8.0×10^{-2}	--
Wells Near 200 Areas	beta	$< 2 \times 10^{-7}$ to 1.5×10^{-6}	--
Outlying Wells	beta	$< 2 \times 10^{-7}$	--
Columbia River - Hanford Ferry	beta	5.3×10^{-5}	--
Columbia River - Below Reactors	beta	2.7×10^{-5}	--
Columbia River - Paterson to McNary	beta	8.8×10^{-7}	--
Columbia River - Mud	beta	$(0.2 \text{ to } 3.9) \times 10^{-4}$	--
Raw Water - Operating Areas	beta	$(0.007 \text{ to } 5.4) \times 10^{-5}$	--
Reactor Effluent Retention Basins to River	beta	17,000 to 52,000 μc/sec/reactor	--
		$(0.4 \text{ to } 1.2) \times 10^{-2}$	--
Reactor Effluent Retention Basins to River	alpha	< 0.04 μc/sec/reactor	--
		$< 5 \times 10^{-9}$	--
I-131 in Farm Wastes to River	I-131	6.2×10^{-7}	--
I-131 in Columbia River - Hanford	I-131	1.3×10^{-7}	--

* The trend factor shows the n-fold increase (+) or decrease (-) from last month, where the values of n less than 2 will not be noted.

Sample Type and Location	Activity Type	Average Activity Density µc/cc	Trend* Factor
Atmospheric Pollution			
Gross Alpha Emitters	alpha	(<0.2 to 3.2) x 10^{-15}	-2
Gross Dose Rate - Separations Areas	beta-gamma	0.8 to 2.0 mrad/day	-2
Gross Dose Rate - Residential Areas	beta-gamma	0.3 to 1.6 mrad/day	--
Active Particles - Separations Areas	beta	(1.9 to 4.0) x 10^{-13}	--
I-131 Separations Areas	I-131	(0.16 to 2.0) x 10^{-12}	+5
I-131 Separations Stacks	I-131	1.0 curie/day	--
Ruthenium - Separations Stacks	Ru-103-106	0.01 curie/day	--
Active Particles - Wash., Idaho, Ore., Mont.	--	0.003 to 0.024 ptle/m^3	--
Active Particles - Project	--	0.001 to 0.032 ptle/m^3	--
Vegetation			
Environs of Separations Areas	I-131	1.4 x 10^{-5} µc/gm	+3
Residential Areas	I-131	8.0 x 10^{-6} µc/gm	--
Eastern Washington and Oregon	I-131	$<$ 1.5 x 10^{-6} µc/gm	--
Fission Products Less I-131 Wash. and Ore.	beta	9.4 x 10^{-5} µc/gm	--
Alpha Emitters - Separations Areas	alpha	(0.6 to 2.9) x 10^{-6} µc/gm	-3

* The trend factor shows the n-fold increase (+) or decrease (-) from last month, where the values of n less than 2 will not be noted.

RADIATION MONITORING	Hanford Laboratories	Minor & Major Construction	Others	Dec.	Year to Date
Special Work Permits	1956	78	234	2268	31,191
Routine and Special Surveys	989	32	192	1213	26,231
Air Samples	1833	0	245	2078	27,933
Skin Contamination	4	0	1	5	207
*Class II Radiation Incidents	1	0	0	1	2
**Class II Radiation Incidents	0	0	0	0	8

EXPOSURE EVALUATION AND RECORDS

Gamma Pencils	Pencils Processed	Paired Readings 180-280 mr	Paired Readings Over 280 mr	Lost Readings
December	74,734	18	5	4
1957 to Date	2,301,468	155	120	98
300-L Area				
December	41,432	22	2	2
1957 to Date	149,196	50	16	13

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	Average Dose Per Film Packet mr(s)
December	24,178	982	87	9	47	4.36	7.68
1957 to Date	477,166	8,393	374	76	852	1.93	4.20

Slow Neutron Pencils

	Pencils Processed	Paired Readings 4-12 mrem	Paired Readings Over 12 mrem	Lost Readings
December	3,530	28	2	1
1957 to Date	34,742	429	125	24

Fast Neutron Film Badges	Badges Processed	Readings Above 50 mrem	Lost Readings
December	1,319	11	0
1957 to Date	12,103	20	13

Bioassay		December	1957 to Date
Plutonium:	Samples Assayed	1,205	14,623
	Results above 2.2×10^{-8} μc/sample	41	402
Fission Product:	Samples Assayed	1,279	15,886
	Results above 3.1×10^{-5} μc FP/sample	2	21
Uranium:	Samples Assayed	333	4,822

*HLO Radiation Monitoring Customers
**Other Plant Components

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	29.3	6.31	57	17.0	3.32	39
Hanford Laboratories	39.5	5.15	20	18.1	4.61	11
Chemical Processing	59.4	7.93	56	34.6	6.10	56
Chemical Processing*	55.3	15.6	32	15.3	5.97	10
Special Incidents	0	0	0	--	--	--
Random	5.83	1.02	52	--	--	--

*Samples taken prior to and after a specific job during work week.

Tritium Analyses	December	1957 to Date
Samples Assayed	0	59
Thyroid Checks		
Checks Taken	16	376
Checks Indicating .01 µc	0	1
Hand Checks - Alpha	44,940	617,341
- Beta-Gamma	39,876	566,092

CALIBRATIONS	Number of Units Calibrated December	1957 to Date
Portable Instruments		
CP Meter	865	12,253
Juno	281	4,175
GM	1,148	16,149
Other	197	2,165
Total	2,491	34,742
Personnel Meters		
Badge Film	1,140	23,238
Pencils	9,000	79,286
Other	403	2,830
Total	10,543	105,354
Miscellaneous Special Services	416	6,278
Total Number of Calibrations	13,450	146,374

A R Keene

A. R. Keene, Manager
RADIATION PROTECTION

ARK:bh

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - DECEMBER, 1957

GENERAL

Safety performance of the Operation was considered satisfactory. There were no major injuries; the minor injury frequency rate was 1.95 per cent which is substantially below year to date experience.

The absenteeism rate was 2.97 per cent, a decrease of about 0.71 per cent below November experience.

There were no security violations charged to the Operation for the fifth consecutive month.

One grievance was filed by a bargaining unit employee because bus service was not provided on a scheduled overtime assignment. The Step I answer was not satisfactory and the grievance has been answered at Step II.

FACILITIES ENGINEERING OPERATION

An information meeting was arranged on December 13 for purposes of reviewing some details of designing code pressure vessels. This meeting was requested by the Mechanical Equipment Development component of Reactor Engineering Development Operation.

Project Activity

Budget study work is underway. A total of about 20 studies will be made. About 10 of these are being performed with assistance of CEO.

Project activity in HLO is summarized on the attached report.

Four project proposals were submitted during the month as follows:

CG-660, Modifications and Additions to the Metallographic Cell, 327 Building - Extension of time.
CA-749, High Level Radiochemistry Facility - Construction Funds.
CA-760, Expansion of 3745-B Building - Total Project.
CG-785, In-Reactor Studies Equipment - Preliminary Design.

Two informal requests were completed and exceptions were cleared on a previously completed project as follows:

IR-224 - Biology Controlled Activity Water System
IR-232 - Repairs to Building 747
CG-620 - Vacuum Furnace, 314 Building.

The project proposal for Additions to the 327 Building (CG-784) was returned unapproved by AEC. Long range planning of additions to this building is proceeding.

Following is the status of engineering service work:

Title	Status
Contaminated Waste Chute, 327 Bldg.	Construction work in progress. Job will be completed in Jan.'58.
Thermal Expansion Layout	Sponsor requests job be held in abeyance until after 1-1-58.
Impact Tester	Sponsor requests job be held in abeyance until after 1-1-58.
Hot Microscope	Sponsor requests job be held in abeyance until after 1-1-58.
Modification of Elevator, 327 Bldg.	Inactive at present.
Vacuum Air Sampling System, 108-F Bldg.	Project proposal written. Further action depends upon availability of funds.
Hood Repair and Relocation, 329 Bldg.	Work proceeding.
Winterize 108-F Train Shed Air Conditioner	Work complete.
Installation of Heating Cable and Insulation of Manure Auger, 141-N Bldg.	Work complete.
Whole Body Animal Counting Room, 141-F	Work progressing. Estimated completion date 1-2-58.
Re-route Steam Line, 141-F Bldg.	Estimate received from IPD Maintenance. By agreement of the tenants this work will be deferred until FY 1959 due to lack of funds.
Breathing Air Installation, 141-FS Bldg.	Start-up tests for final acceptance were made 12-20-57. Excessive leakage at all pipe joints prevented a satisfactory test. Because of difficulty with aluminum threaded joints, a back-weld bead was required at each joint. Retest is now scheduled for the second week in January.
Controlled Temperature Room	Deferred until FY 1959.

Title	Status
Correct Leaking Pump Seals in Plating Laboratory - 306 Bldg.	Bids for the Mechanical Seals have been reviewed and an order has been placed with promised delivery date of 1-20-58.
Correct Noisy Heating Coil in 3760 Bldg.	Maintenance was requested to install a venting system for the Zone 5 coil similar to the one installed in Zone 7. This eliminated noise. Recently the condensate return tank and pump were removed and a meter installed. Coincident with the meter installation noise has recurred. Further plans for noise elimination are being made.
Alterations to Rm. 313, 3706 Bldg.	Work initiated.
Eight Station Intercom System, 326 Bldg.	Preliminary studies being made.

Design-Drafting Services

Work backlog is heavy. Approximately 215 drawings were completed or revised. A total of 9,700 square feet of prints were produced.

Major designs completed or in process are:

(1) "Cesium Isolation and Packaging" - an all out effort is being made to complete the scope drawings by 12-31-57 as scheduled.

(2) "Redesign of Hanford Slave Manipulator" - the detail drafting on this project was completed during November but due to the extensive checking and alterations necessary, the completion date was extended from 12-16-57 to 12-23-57.

Minor designs in progress are:

(1) Welding box and drive mechanism for welding co-extruded zirconium clad fuel elements.

(2) Welding box for fuel elements.

(3) Remote operated can sealer.

(4) ELMO 3 slug rupturing loop.

Maintenance and Building Engineering Services

The partitions for the rearrangement of Library and Files arrived on plant site. The arrangements of the magazine routing and binding operations are being firmed up for installation of the partitions.

Freeze preventive programs for 306 and 747 have been completed.

Storm windows and sun screens are being installed on 326 Bldg. as temperature control measures. (Ref: Project IR-234).

A sun screen has been erected on the east end of the gas dock at 325 Bldg.

The removal of the super structure from the existing propane tank is progressing satisfactorily. The new tank will be installed in the near future when the valves are received.

Aluminum tread covers have been installed for test purposes over the grill steps at the southwest corner of 326 Bldg. They have proven very satisfactory in that they prevent high heels from catching in the tread and they are self-cleaning and non-skid. Treads for other grill steps are on order.

The air balance crew completely readjusted the heat and ventilating system in 3706 Bldg.

The power operators are conducting an experiment to reduce the humidity in the buildings without increasing the dust. Only the flooding nozzles are being used in the spray chambers. Improvements of 15% humidity have been noted.

Cambridge Absolute Fibreglass filters are being set up in Stores for HLO's replacement of CWS filters. The new filters are fire resistant and less expensive than the CWS. By establishing the Stores stock, HLO's inventory can be reduced while its source of supply can be assured.

The basis for liquidation of building engineering overhead has been reviewed and distribution adjusted to conform with shifts in work emphasis.

The variances between rental billings and expenses are being liquidated at an accelerated schedule to bring the variances to a minimum.

A comparison is being made of HLO rentals and those of privately-owned buildings.

A floor loading study is being made to determine the required floor bracing for a channel analyzer at 108-B Bldg.

A recommendation was submitted to management for renovating 3707-C Bldg. to provide additional offices. Efforts are proceeding to effect this change.

The procurement and installation of the Shielded Cave in the 325 Bldg. (AR-57-HL2-47) is as follows: Expenditures and commitments on 12-26 were $20,693; balance left is $637; work is estimated to be 98% complete. Unfinished work consists of completing cold run tests and making final adjustments preparatory to the start of the hot runs.

Revisions to the condensate return system in 306 Bldg. were completed on 12-5. Area maintenance has completed the calibration of the 16 recorder controllers for the H & V units. This completes the corrective measures scheduled under this program for this year.

Work on the Engineering Survey and Inspection of HLO Pressure Vessels is estimated to be 70% complete. Thickness measurements and final calculations to determine safe operating pressures are remaining items of work.

Operating procedures, job hazard breakdowns and emergency alarm notices were posted in all HLO elevators.

Work is approximately 50% complete on the disposal of P-11 properties.

TECHNICAL SHOPS OPERATION

Total productive time for the month was 11,775 hours. The total shop work backlog is 19,778 hours of which 40% is required in the current month, with the remainder distributed over a six month period. Overtime worked during the month was 0.8% (129 hours) of the total available hours.

Distribution of time was as follows:

	Man Hours	% of Total
Fuels Preparation Department	1306	11.1
Irradiation Processing Department	1786	15.3
Chemical Processing Department	575	4.8
Hanford Laboratories Operation	7858	66.7
Construction Engineering Operation	-	-
Miscellaneous	250	2.1

Customer demands for service decreased in the carpenter and fabrication millwright fields, and remained firm in all other components. A decrease in requests for priority service resulted in substantial reduction in overtime work. The shops have been requested to assist the Fuels Preparation Department in developing and fabricating non-destructive testing equipment for the production fuel element. A facility for the isolation and packaging of radioactive cesium is being fabricated for Hanford Laboratories.

Safety and security performance was considered satisfactory with no major violations. The minor injury rate was average for the operation.

The absenteeism rate was 2.49% versus a forecast rate of 3.39%.

One grievance was filed protesting the failure of the Company to furnish bus service to an employee who was scheduled to work on an overtime basis. The Step 1 and Step 2 answers indicated transportation would have been made available had supervision been aware of the need.

TECHNICAL INFORMATION OPERATION

Plans have been completed to reduce Technical Information Operation's clerical work force by two additional persons. This will be made possible by (1) the recently introduced modification of the IBM system used in the Classified Files, and (2) the forthcoming transfer of security control of the comprehensive data sheets to the SS Accountability Operation, Relations & Utilities. These data sheets account for 50% of the work load in the 700 Area Files.

The modified IBM system introduced last month is working very satisfactorily, although the delay in the preparation of the master tape of total site accountability is causing some concern. After studying the problem of where the keypunching of the input data for the master tape should be done, the Office Procedures Specialist recommended that Classified Files do the keypunching. A backlog of records, accumulated while this decision was pending, is now being keypunched. It is expected that this will be on a current basis by the end of January.

The Atomic Energy Commission has instructed General Electric to prepare a billing for all unclassified reports shipped to the Office of Technical Services, U. S. Department of Commerce - the AEC's sales outlet for unclassified reports. The billing is based on a charge of $.0025 per page of the report, plus the mailing costs. The first billing, covering the period July 1 to December 20, 1957 was prepared and mailed. Similar billings will henceforth be prepared on each individual shipment.

An information meeting was held on December 13 when the Manager of Technical Information announced a basic change in the policy concerning upgrades in the Operation. Previously, three separate seniority lists had been maintained in Technical Information - one for Classified Files clerks and those concerned with the maintenance of the reports catalog, one for clerks in the library, and a third for the clerks in the technical publications function. Employees appeared on the list in the order in which they went to work in the specific work group. Consideration for upgrades was based on these lists. At this meeting of all non-exempt employees, it was announced that the three seniority lists have been abolished in favor of a single list based on Company service date, which will henceforth be used as the basis for consideration for upgrades. The talk outlined the advantages of the change, and a number of other matters concerning HLO policy on upgrading non-unit personnel.

The September issue of the "Summary Report of Hanford Research and Development" is presently being prepared. The title will be changed to "Excerpts from Hanford Research and Development", and there will be a prefatory statement pointing out that the report specifically excludes information relating to the research and development programs on weapons data, production rates, and operating conditions. The report will include applicable research and development work in the Product Departments. A letter was received from the AEC in Washington commending the Technical Information Operation for the fine quality of the July and August issues, recently reviewed by the AEC's Chief of the Technical Reports Branch.

A number of developments concerned with the Operation's Classification-Declassification responsibility took place during the month:

(1) Revisions of OC-DOC-44, OC-DOC-47, and OC-DOC-48 were completed and forwarded to the HOO Classification Officer on December 13. These revisions are intended to serve as a basis for the revision of the Hanford Classification Guide. The proposed changes in the OC-DOC's were the combined work of the Specialist, Classification-Declassification, and representatives of HAPO Departments.

(2) A letter was prepared for the General Manager's signature which transmitted information to HOO on a number of situations where compliance with the existing Hanford Classification Guide will be particularly difficult. The major difficulties are in the Irradiation Processing Department and only IPD problems were submitted to HOO. Some of the same problems are reported from the other Departments, but resolution of the IPD difficulties should take care of the others as well. The letter also requested an extension of the December 18 date for submitting the revised Guide to the HOO Classification Committee.

(3) First drafts of revised Fuel Element and Hanford Production Reactor sections of the existing Hanford Classification Guide have been prepared by the respective product departments. The format, general arrangement and topic presentations are quite different from those in the present Guide. The revisions proposed by the Departments will necessitate a complete re-write of all sections of the existing Guide in order to achieve a uniform approach.

Seven suggestion awards were received, totalling $65. The topic of the suggestion and the amount awarded are listed below:

"Retirement of Bi-Weekly Lists of Additions to the Classified Files"	$ 5.00
"Reports Catalog Corporate Author Index"	10.00
"Improving Customer Service"	5.00
"Charge Cards for Plant Library"	25.00
"Changing the Windows in the Large Mailing Envelopes from Cellophane to Nylar Film"	5.00
"Physical Improvement of Working Conditions"	10.00
"Typewriter Erasing Shield"	5.00

During the month the total of "unaccounted for" documents on the site was reduced from 135 to 120. This resulted from a review by Security of the circumstances attending the individual losses.

A survey was made of the classified mail received in the 700 Area Files to see if all of it could be sent directly to the 300 Area Files for processing. It appears that practically all the documents are directed to persons outside the 700 Area, and that if the documents are sent directly to 300 Area, much of the material will reach its destination a day sooner. This change will be made in January.

Satisfactory progress was made on the following projects during the month:

1. HW-52271, "Corrosion of Selected Metals under Radiochemical Environment: A Bibliography". This report was given standard distribution under the category "Chemistry - General". Copies were not prepared for the Civilian Application Program.

2. HW-52736 RD, "Hanford Contribution to the Plutonium Notebook". Part I of this handbook, which represents about 50% of the entire job, was issued in November. A goal of April 1, 1958 has been set for completion of the project.

3. "Summary Report of Hanford Research and Development". Several changes are being incorporated in this report prepared for the AEC. The title is being changed to "Excerpts from Hanford Research and Development," and beginning with the September issue, the report will include significant research and development activities performed by the product departments, in addition to those of HLO.

LABORATORIES ADMINISTRATION AND TECHNICAL LIAISON

One new Organization and Policy Guide was issued. Timely revisions were issued on specific sections of ten existing guides. The OPG, Authorization and Performance of Work, is ready for issuance upon approval of the appropriate AEC Manual Chapters.

Specific delegations were issued under OPG No. 02.3.1, Approval Authorizations.

The contract, SA-38 with Swedish Hospital, Seattle, Washington for exchange of radiological services and information was approved.

The contract, DDR-35 with Aluminum Company of America for aluminum tubes, was processed.

Contract renewals were requested with Washington State College for acquisition of swine and with Dr. R. E. Zirkle for consulting service.

The following listing includes active contracts of Hanford Laboratories Operation, December 31, 1957.

Contract Number	Contractor	Services Requested	Completion or Termination Date
		Special Agreements	
G-65	Phillips Petroleum Company	MTR Experimental Work	None
SA-20	Washington State College	Acquisition of swine	2-28-58
SA-34	Future Farmers of America	Care of Sheep	11-30-58
SA-38	Swedish Hospital	Obtaining clinical data on use and application of radioactive materials.	12-31-58
		Consultant Agreements	
CA-153	Dr. P. E. Church	Consult on Atmospheric physics and meteorology problems	3-31-58
CA-154	Dr. R. E. Zirkle	Biological Consulting service	2-28-58
CA-155	Prof. J. L. Powell	Consulting service - physics	3-14-58
CA-159	Dr. M. E. Ensminger	Consult on Animal Husbandry	5-31-58
CA-162	Betz Laboratories Inc.	Provide engineering services for water treatment methods	8-1-57*
CA-167	George Watt	Consult on research, development and plant technical problems	8-31-58
CA-169	M. J. Sinnott	Consultant services - metallurgical problems	9-30-58
		Maintenance and Repair	
MRO-12	RCA Service Co., Inc.	Service RCA equipment	11-30-58
MRO-13	North American Philips	Servicing a Philips Electron Microscope	12-8-58
		Design, Development, and Research	
DDR-4	University of California	Research work on aluminum alloy creep	5-31-58
DDR-5	Superior Tube Co.	Zircaloy tubes	---
DDR-6	Allegheny Ludlum Steel	Zircaloy tubes	---
DDR-11	Allegheny Ludlum Steel	Zircaloy 2 tubes	---
DDR-24	Nuclear Metals, Inc.	Crystal Research	1-10-58
DDR-29	Nuclear Metals, Inc.	Zircaloy Tubing	---

*Subject to extension

Contract Number	Contractor	Services Requested	Completion or Termination Date
		Supply	
SO-7	Aluminum Company of America	Aluminum tubing	---
SO-11	Speer Carbon Company	Graphite	---

One Assistance to Hanford authorization is pending for new work for Chemical Research and Development Operation by General Engineering Laboratory.

The close-out of a purchase order with KAPL and BF_3 counters was reviewed again and additional steps taken to arrange for final payment.

RADIOGRAPHIC TESTING OPERATION

A total of 1,465 tests were made of which 483 were radiographic exposures (including X-ray and gamma-ray exposures) and 982 were supplementary tests. The supplementary tests consisted of work with dye penetrant, dimensional checking, eddy current, magnetic particle, and ultrasonics. Work was done for 20 different organization components representing all of the operating departments and service operations. A total of 19 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 18 different occasions for advice and information regarding general testing theory and applications.

New equipment obtained during the month included an ultrasonic instrument for making thickness measurements on a continuous recorded basis. The 360° radiation X-ray tube previously procured was also satisfactorily operated during the month.

Details of work accomplished are as follows:

A. Construction

Two construction projects were worked on this month. One was a continuation of the work on the charging machine being built in the 100-C Area. Field tests were made to check on installation features. This work has been essentially completed. The other project was concerned with the corrosion testing loop being installed in the 314 Building in the 303 Area. Selected welded joints were radiographically examined for conformance with Code requirements.

B. Fabrication

Work is continuing on the L-cell package. Most all of the work being done is on the scaffolding of the dunnage in which the component parts are being assembled. Primary concern is with the connecting piping tying together the major components for which work has been completed. Two small wet scrubbers were radiographically examined for weld integrity. Unfortunately, examination was not requested until the fabrication was completed, and 100% coverage was not possible.

C. Maintenance

In the straight maintenance category two small jobs were done. One involved evaluation of possible damage to a canned rotor pump head. It appeared that a small crack was associated with a particular weld, but dye penetrant examinations showed the weld to be simply undercut to a small extent. A similar job was the evaluation of bearing supports of the No. 2 pump at 190-H after a bearing had seized. No evidence of damage to the casting was found. In the preventative maintenance category, an investigation was started on the possibility of detecting, in place, the extent of stress corrosion damage to stainless steel pigtails. Preliminary eddy current results are waiting metallographic analysis to allow proper correlation to be made. Chemical corrosion of carbon steel piping also was checked on three different jobs. Working under SWP conditions, steam condensate lines of Purex were examined ultrasonically for wall thickness loss. Similar work was done on the piping for the center blower fans in the power house at 100-D. As part of the pressure vessel survey program, selected vessels and piping in the 200-W area were checked. Concerned with the safety aspects of maintenance were four additional jobs. Two of the 20 ton crane hooks used at Purex were examined. The platform extension piston of an electrical service vehicle was examined for the Transportation Operation for possible defects. In the area of pressure vessels, work was continued in the autoclaves in the 303 Area. An interesting examination was made of a vessel taken out of service at 100-K on the basis of radiographic examination. Subsequent metallographic examinations clearly substantiated the X-ray findings, showing large areas of lack of penetration, interpass fusion, slag cavities, and cracks.

D. Qualifications and Certifications

Welder qualification coupons were examined to determine conformance with applicable codes.

E. As-Received Material

A large program has been started to examine radiographically the longitudinal welded stainless steel pipe now in Stores stock. This is material that has been corrosion passed and would be acceptable for any Class I vessel fabrication work if shown to be radiographically sound. Some 5,000 ft. of welded pipe of various sizes is involved. Another important phase of the as-received material examination is the various sized ZR tubing used for the assorted PRP fuel elements.

F. Research and Development

Three main projects accounted for a major part of Radiographic Testing Operation efforts. Zr process tube development, PRP tube requirements (both in stainless steel and zirconium), and the MTR fuel element program. For the Zr tube program, work is continuing, along with current evaluation, of developing automated tests to speed obtaining results. The PRP tubing

program is being carried along concurrently. For the MTR program, work has progressed from the alloy investigation stage with some of the first fuel element plates being made. Preliminary results in segregation and core location have been very good and the program is going ahead rapidly. Assistance was rendered on some small jobs involving swaged thermocouples, "corregated" I and E fuel elements, and eddy current penetrameter development.

Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces	Description
A. Chemical Processing Dept.	252	277½	110	CS & SS process vessels & piping. Crane hooks.
B. Construction Engrg. Oper.	6	1½	12	SS Welder Pipe Qualifications Coupons.
C. Fuel Preparation Dept.	18	25½	18	CS Pressure Vessels.
D. Hanford Laboratories Oper.	1001	1508½	88	SS Piping. Zr & CS process and PRP tubing. Thermocouples. I & E and MTR fuel elements. Canned Pump
E. Irradiation Processing Dept.	91	37	14	CS castings & machined parts. Zr process tubing. CS piping.
F. Relations & Utilities Oper.	97	280	15	SS Piping. CS machined parts.

Manager
LABORATORY AUXILIARIES

JL Boyd:lt

UNCLASSIFIED

MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW-54286
December 1957

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
General Plant Projects - FY 1956 AEC-2-23X-56-L-2		Reactor & Fuels	$ 132,000	$ 140,000* 4-4-57	100 100	52 77	5-23-56 12-7-56	As Completed	9-28-56 5-1-58
CG-664	350°C Flow Loop - 314 Building Engineer: R. W. Dascenzo								

REMARKS: The pressurizer with insufficient wall thickness was corrected. Procurement difficulties on the two inch gate valves and one-half inch globe valves are being experienced. They are due 12-31-57. Testing of the loop will follow valve installation. Some tubing installation was performed.

*Includes $350 transferred equipment.

General Plant Projects - FY 1957 AEC-23-57-N-2		Radiation Protection	$ 150,000	$ 150,000 2-4-57	100 100	N.S. 0	2-18-57 2-1-58*	8-15-58	12-19-57 8-15-58*
CA-658	Shielded Personnel Monitoring Station - 747 Building Engineer: D. S. Jackson								

REMARKS: Design by the A-E is complete. Bid assemblies are being prepared for the construction phase. The Commission contacted a steel mill for confirmation of the use of virgin ore and scrap only in the steel to be used in the outer 3" of the cell. The vendor could not guarantee the use of all virgin stock, but did indicate no tracer materials will be added. Negotiations are currently underway to obtain samples of present heats to determine the acceptability of the steel produced at this mill.

* The Commission has not revised the project schedule, however, the dates shown are the estimated starting and completion dates for construction.

CG-680	Corrosion Testing Facilities - 314 Building Engineer: R. W. Dascenzo	Reactor & Fuels	$ 108,000	$ 135,000 5-2-57	100 100	90 98	10-3-56 5-2-57	As Completed	1-25-57 3-2-58

REMARKS: F. H. Lohse, contractor has completed all mechanical and electrical work. Insulation of lines and equipment is near completion. Preparation of floor and equipment for painting and identification is in progress. A new solenoid valve is required for PRV Station and is on order for installation by C. O. Construction Operation repaired leakage of steam condenser. Beneficial use of the facility is expected the first week of January, 1958.

CA-700	Geological and Hydrological Wells - FY 1957 Engineer: D. S. Jackson	Chemical Research	$ 118,000	$ 122,000 6-27-57	100 100	100 97	11-8-56 10-24-56	As Wells Completed	1-15-57 2-1-58

REMARKS: USGS - 100% complete, 15 wells, 5869 feet. Fixed Price Contractor - After the addition of one more well to the contract, the contract is 94% complete. He has completed 19 wells and is currently drilling the last two. He has completed 6221 feet of hole. The revised contract calls for 6640 feet compared to the original project proposal depth of 5400 feet. This necessitated extending the completion date to February 1, 1958.

BM-7300-005 (11-56) AEC-GE RICHLAND, WASH.

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MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW-54284
December, 1957

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
CA-728	High Level Exposure Facility Addition - 141-H Building Engineer: J. T. Lloyd	Biology & Research	$ 29,000	$ 26,000 2-11-57	100 100	100 100	3-11-57 7-16-57	10-1-57	6-20-57 11-29-57
		REMARKS: Project was accepted on November 19, 1957.							
CG-729	Ventilation System Improvements - 222-U Building Engineer: L. W. Hervin	Chemical Research	$ 73,000*	$ 73,000* 3-12-57	100 100	53 63	4-23-57 7-15-57	2-15-58* 5-1-58	5-28-57 5-1-58
		REMARKS: The fixed price contractor is approximately 70% complete. The architectural work has been completed except for cleanup. The contractor has completed the North unit to the point where it is presently in service. The South unit removal work has been completed and the sheet metal fabrication started. The contractor is approximately 95% complete on his portion of the exhaust system and is approximately 80% complete on the electrical installation. The CPFF construction contractor performed no work during December. Plant Forces is approximately 10% complete, however, no additional work will be performed until a decision is reached on the refrigeration equipment. *As indicated in November report there is a possibility of an over-run due to the condition of the refrigeration equipment, this also changes the projected beneficial use date. (CG-729 - Continued)							
CG-733	Plutonium Metallurgy Facility Engineer: J. T. Lloyd	Reactor & Fuels	$ 295,000	$ 295,000 5-10-57	100 100	57 78	5-14-57 6-10-57	As Completed	10-1-57 6-15-58
		REMARKS: Lump Sum work is 85% complete. Other work is concentrated on equipment installation. Architectural work is complete except for hanging 4 doors and painting. Exhaust system is 60% complete. Filters and fans are installed. Piping is 85%, power is 30%, lighting 50% and alarm system 90% complete.							
IR-224	Biology Controlled activity Water System - 100-F Area Engineer: D. S. Jackson	Biology Research	$ 19,900	$ 19,900 6-27-57	100 100	N.S. 99	1-2-57 7-22-57	1-15-58	4-11-57 1-15-58
		REMARKS: All construction is complete except for the installation of drain valves at the base of the irrigation risers and an extension of the greenhouse line to provide an outside hose bib.							

1247334

UNCLASSIFIED

MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW-54281
December 1957

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
General Plant Projects - FY 1958 AEC-2-23-58-L		Chemical Research	$ 77,000	None to date / None to date	To be est. / 0	To be est. / 0	1* / 7*	12*	4* / 13*
CG-757 Now CG-781	Coolant Radio Analysis Laboratory Addition - 1706-KE	REMARKS: This project was combined with two IPD projects; CG-755 and CG-781 into one project, "Service Building Additions - 1706-KE, Project CG-781". The project proposal was returned by the AEC because they felt the costs were too high. The Project Engineer from IPD is re-studying the project for possible cost reductions. An engineer from HLO is studying available laboratory space in 200-E Area. This study will be complete 1-6-58. *Months after authorization.							
	Engineer: R. W. Dascenzo								
CG-760	Expansion of the 3745-B Facility	Physics & Instr.	$ 193,000	None to date / None to date	To be est. / 0	To be est. / 0	1* / 9*	16*	6* / 16*
		REMARKS: Project Proposal and Plant and Equipment Analysis Report have been submitted to Contract Administration. *Months after authorization.							
	Engineer: R. C. Ingersoll								
CA-765	Additions to the 313 Building	Reactor & Fuels	$ 46,000	$ 6,800 / 10-3-57	100* / 100*	To be est. / 0	10-14-57 / 4-20-58	10-4-58	3-4-58 / 10-4-58
		REMARKS: The Architect-Engineer, Carson & Moe, has started work on the design of the building. *C.E. Co., portion only, including only design criteria & preliminary design.							
	Engineer: A. W. Hervin								
CA-769	Additions to the 622 Building	Physics & Instr.	$ 80,000	None to date / None to date	0 / 0	0 / 0	2-1-58 / 2-1-58	2-1-59	8-15-58* / 3-1-59**
		REMARKS: Project Proposal awaiting AEC approval. Survey of space in 200-W, as an alternate to that proposed for project, was made at AEC request. Resulting information including estimate was submitted to the AEC with the request that the project proposal be approved as presented.							
	Engineer: J. T. Lloyd								
CA-778	Expansion of the 305-B Building	Physics & Instr.	$ 55,000	$ 55,000 / 12-11-57	To be est. / 0	To be est. / 0	3-15-58 / 7-1-58	10-15-58	6-15-58 / 10-15-58
		REMARKS: Directive No. AEC-122 was issued on 12-11-57 authorizing $55,000 for design and construction. A Work Authority to General Electric Company was issued by the Commission on 12-16-57 authorizing $4,290 for preparation of design criteria and review of A-E's work.							
	Engineer: R. C. Ingersoll								

UNCLASSIFIED

BM-7300-005 (11-56) AEC-GE RICHLAND, WASH.

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
CG-779	Alterations to the 321 Building Engineer: J. T. Lloyd	Chemical Research	$ 65,000	None to date None to date	0 0	0 0	2-17-58 4-17-58	6-17-58*	4-17-58 8-17-58

REMARKS: The Project Proposal was transmitted to AEC-HOO on 10-17-57. The request for approval was sent by AEC-HOO to Washington on 12-3-57.

*Based on AEC approval by January 15, 1958.

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
CA-734	Alterations to the 327 Building Engineer: A. W. Hervin	Reactor & Fuels	$ 80,000	None None	0 0	0 0	--- ---	---	--- ---

REMARKS: The Commission returned the Project Proposal unapproved. They did not feel that the benefits justify the expenditure under present circumstances.

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
[illegible]-230	Repair Damage and Additions to Heating System - [illegible] Building Engineer: J. T. Lloyd	Laboratory Auxiliaries	$ 13,350	$ 15,000 8-29-57	100 100	100 100	7-1-57 10-24-57	11-15-57	8-12-57 12-26-57

REMARKS: Inspection and acceptance was made on 12-26-57. There were three minor exceptions; (1) small opening between ventilation hood and building wall, (2) protect insulation from damage by door, and (3) cleanup. Final acceptance papers and estimate are being prepared.

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
IR-234	Storm Windows and Sun Shades - 325 Building Engineer: J. T. Lloyd	[illegible]	$ 14,000	$ 14,000 10-31-57	100 100	50 56	8-1-57 12-3-57	As Completed	11-15-57 1-16-58

REMARKS: Work started on installation December 12, 1957. Installation of storm windows is 57% complete. All on the north side and all but one on the south side have been installed. Only three shades have been installed.

Equipment Not Included in Construction Schedule - Regular Class 2001

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
CG-[illegible]	Vacuum Furnace Engineer: R. C. Ingersoll	Reactor & Fuels	$ 103,500	$ 120,000 2-7-57	100 100	100 100*	5-1-56 6-1-57	12-20-57**	4-1-57 9-30-57

REMARKS: *The Physical Completion Notice dated 9-30-57 was issued with accruals to complete exceptions. The centrifugal casting mechanism is being installed. A successful uranium melt was made 12-19-57.

**Actual beneficial use date. Estimated beneficial use date was 12-15-57.

UNCLASSIFIED

MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW-54287
December, 1957

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED / ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
CG-660	Modifications and Additions to the Metallographic Cell - 327 Building Engineer: D. S. Jackson	Reactor & Fuels	$ 135,000	$ 135,000 3-15-57	100 100	100 95	3-27-57 5-14-57	2-15-58	4-1-57 3-15-58
		REMARKS: A revised project proposal was submitted requesting an extension of the completion date to March 15, 1958. The extension is required because the metallograph was received in a damaged condition and had to be returned to the vendor for repairs and realignment. The vendor shipped the metallograph again on 12-26-57. All other work is essentially complete except testing and startup.							
CG-661	Additional Heat Generation Facility - 189-D Building Engineer: A. W. Hervin	Reactor & Fuels	$ 664,000	$ 664,000 9-13-57	30 39	0 0	12-6-56 1-15-59	9-30-59	11-1-58 8-31-59
		REMARKS: At the request of prospective bidders, the bid opening on the Direct Current Power Supply has been postponed until January 15, 1958.							
CG-672	Monochromatic Neutron Beam Facility - 105-KE Building Engineer: H. Radow	Physics & Instr.	$ 195,000	$ 195,000 3-7-57	100 100	22 22	5-21-56 11-1-57	5-1-58	10-1-57 5-1-58
		REMARKS: Installation of the Beam Shutter is complete. Castings are in place, shimming and leveling are underway. Electrical panel work is nearing completion in the shop.							
CA-681	Hanford Equipment in the ETR Engineer: H. Radow	Reactor & Fuels	$1,200,000	$ 900,000 8-12-57	100 100	0 0	9-17-56 2-15-58	8-15-58	5-29-57 8-15-58
		REMARKS: Scheduled installation starting date is still 2-15-58. The question of process tube removal has been raised. A meeting at Arco has been scheduled for January 6 & 7, 1958 for the purpose of resolving this and other operating problems as well.							
CG-682	High Level Cut-Off and Examination Cell - 327 Building Engineer: A. W. Hervin	Reactor & Fuels	$ 430,000	$ 430,000 8-20-57	100 100	0 0	7-18-56 3-1-58	10-1-58	6-25-57 10-1-58
		REMARKS: The drawings on the Hanford Master Slave Manipulator Model #3 have been completed by HLO. The Purchase Requisition for the manipulator is being prepared. The order for the lead glass windows has been placed with Penberthy.							

UNCLASSIFIED

MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW-54284
December, 1957

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED	PROJECT PROGRESS IN PER CENT DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED	PROJECT PROGRESS IN PER CENT CONST. ACTUAL	STARTING DATE DESIGN	STARTING DATE CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN	PROJECT COMP. DATE CONST.
CA-595	Radio Telemetering Network	Physics & Instr.	$ 89,000	$ 89,000	1-20-57	100	100	Not Sched.	Not Sched.	2-22-57	7-25-57	7-15-58	5-27-57	8-15-58
	Engineer: J. T. Lloyd	REMARKS: Bids for construction and installation of 20 units were opened on 12-3-57 and award was made to Instrument Laboratory, Inc., for $55,400. Our prototype unit is being shipped to the contractor at their request. The AEC has requested the R. C. A. to quote on the Telemetering Repeater Station and quotes on the balance of the equipment will be received soon.												
CG-758	Ceramic Fuels Development Press and Furnace Additions	Reactor & Fuels	$ 200,000	$ 200,000	8-1-57	94	75*	0	0	8-22-57	1-20-58	As Completed	2-8-58**	10-1-58
	Engineer: R. J. Ingersoll	REMARKS: Bids for furnace installation are scheduled for opening 12-30-57. *Completion of installation design is dependent upon receipt of detailed design from hydraulic press vendor. **Tentative dates.												
CG-785	In-Reactor Studies Equipment - 105-KW Building	Reactor & Fuels	$ 15,000	To be est.	To be est.	0	0	0	0	To be est.	To be est.	To be est.	To be est.	To be est.
	Engineer: H. Radow	REMARKS: Project Proposal was submitted to the Commission on December 23, 1957. *For preliminary design only.												
IR-233	Badgehouse Alterations for Self-Service - 100 and 200 Areas	Radiation Protection	$ 15,000	$ 18,500	8-29-57	100	100	N.S.	90	7-1-57	12-2-57	As Completed	9-15-57	1-15-58
	Engineer: D. S. Jackson	REMARKS: Badge racks were installed in all gatehouses and are in use. Light fixtures were relocated to provide adequate light over racks. Portions of counter were reinstalled adjacent to patrol offices. Alterations to patrol facilities to provide more room or replace lost counters is continuing.												
New Construction - FY 1958		Physics & Instr.	$2,000,000	None to date	None to date	To be est.	0	To be est.	0	None est.	None est.	As Completed	None est.	None est.
CG-791	Critical Mass Laboratory 1247338	REMARKS: The Project Proposal for $175,000 total design money was approved by the local AEC Board of Review on December 5, 1957. It was sent to AEC - Washington, D. C. for further approval.												
	Engineer: R. W. Dassenko													

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MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW-54287
December, 1957

PROJECT NUMBER	TITLE	USING COMPONENT	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED ACTUAL	STARTING DATE DESIGN / CONST.	BENEFICIAL USE DATE	PROJECT COMP. DATE DESIGN / CONST.
CG-744	Metallurgical Development Facility Engineer: R. W. Dascenzo	Reactor & Fuels	$2,600,000	None to date None to date	To be est. 0	To be est. 0	None est. None est.	As Completed	None est. None est.
		REMARKS: Preparation of a revised project proposal with a reduced scope of work is awaiting a document to be prepared by personnel of the using component. This document is in support of justification for the new facility.							
CA-749	High Level Radiochemistry Facility Engineer: R. W. dascenzo	Chemical Research	$1,070,000	$ 20,000* 9-27-57	100** 100	To be est. 0	7-11-57 5-1-58***	7-1-59	6-1-58***
		REMARKS: The AEC has not yet approved the preliminary design or design criteria submitted on 11-22-57. The project proposal for total funds was submitted to Contract Administration on 12-24-57. The AEC has authorized expenditure of an overrun of preliminary design funds for additional design details. This work is in progress.							
		*Interim Authority. **Preliminary Design. ***Estimated.							
		REMARKS:							
		REMARKS:							
		REMARKS:							

1247339

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LABORATORY AUXILIARIES MONTHLY REPORT

VISITS TO HANFORD WORKS

Name	Dates of Visit	Company or Organization Represented & Address	Reason for Visit	Personnel Contacted	Access to Restricted Data	Areas & Buildings Visited
All AEC employees and new employees	12-16-57	AEC	Learn about technical information facilities.	CG Stevenson	No	3760
Local teachers	12-21-57	Local schools	Learn about technical information facilities.	No one in Tech. Info.	No	3760
Local high school students	12-23-57	Local schools	Learn about technical information facilites	No one in Tech. Info.	No	3760

VISITS TO OTHER INSTALIATIONS

None

GENERAL

On December 31, 1957 the staff of the Hanford Laboratories Operation totalled 1158, including 507 exempt and 651 nonexempt employees. Of the total exempt employees there were 440 with college degrees including 422 technical degrees as follows:

BS	MS	PhD
222	103	97

In addition, there were 37 nonexempt employees with college degrees.

Distribution among the nine level 3 components is included in Table I.

PERSONNEL DEVELOPMENT AND COMMUNICATIONS

The administration of the Nonexempt Personnel Development Program and Progress Report procedure was transferred to the Specialist, Employee Placement and Records.

Detailed planning for the Armed Forces Special Weapons Project personnel training was completed. The group of nine medical people will arrive on January 6, 1958 for a six-weeks' course.

We were notified informally that our proposal for the 1958 Summer Institute has been approved by the AEC. As in 1957 the 1958 session will require "Q" clearance.

HLO Management approved the Short Course Proposal and it was forwarded to the AEC for consideration.

Twenty-seven Technical Graduates and seven Technician Trainees were on assignment within HLO at month's end. These numbers are the same as last month's.

Ten exempt employees completed HLO's first presentation of PMS & L, nine exempt employees finished "Understanding People", seven employees attended "Data Processing", and nine employees participated in R & U's "Management Orientation".

Twelve nonexempt employees attended the "Secretarial-Clerical Training" course.

AEC approval has been given for presentation of PBM-1 to HLO exempt employees through calendar year 1958.

Twelve HLO employees participated in the December Area Tour for Women.

Seventeen technical papers and articles were processed for publication during the report period.

Members of a Columbia Basin College science class visited HLO facilities on December 21 and Richland science students toured the facilities on December 23.

PERSONNEL PRACTICES

Employment

There were no Reduction in Force Notices given during the month. Two Servicemen were removed from the payroll due to HAPO "bumping". Notices were given during November.

Hanford Laboratories transferred four Radiation Monitors from Radiation Protection Operation to IPD as a result of their transfer request. Five new nonexempt transfer requests were received during the month of December.

Three 1-year, one 2-year, and one 3-year Attendance Awards were issued during the month of December.

Service Recognition	5 Yrs	10 Yrs	15 Yrs	20 Yrs	25 Yrs	Total
Pins issued this month	1	9	-	-	-	10
Total pins out	469	237	1	2	1	710

Benefits and Services

The Thirteenth Hanford Laboratories Suggestion Board Meeting was held on December 12, 1957. Eighteen suggestions were reviewed and fourteen were approved for awards of $490.

A total of $4652 in suggestion awards was paid by Hanford Laboratories Operation in the year of 1957. The average award was $37.22 and the ratio of awards to savings was 9%.

During December twenty-one suggestions were received from Hanford Laboratories employees.

Five pre-retirement personal contacts were held during the month with Hanford Laboratories employees who have reached optional retirement age. This completes all of the pre-retirement contacts scheduled for the year of 1957.

Hanford Laboratories participation in the Employee Benefit Plans as of December 31, 1957, is listed below:

Insurance	99.5
Pension Plan	98.3
Savings & Stock Bonus	60.3
Savings Plan	7.7

Military status of HLO employees is as follows:

STATUS	Non-Tech. Other than 1A	Technical	Non-Technical 1A	*Critical	TOTAL
Reservists					
Standby	13	33	0	0	46
Ready	16	21	6	1	44
Total	29	54	6	1	90
Non-Veterans	29	38	21	42	130
TOTAL	58	92	27	43	220

*Refers to those employees for whom deferments are currently being requested.

Deferment Requests Pending	7
Deferments Denied, Appealed and Pending	0
Deferments Pending at Presidential Appeal Level	0

UNION RELATIONS

Negotiations with the Field Inspectors continued during the month. The proposal of the HAMTC that we use a Y-type seniority arrangement appears to offer many disadvantages and has not received acceptance by the Company to date.

Three grievances were received during the month of December. One grievance was filed by a Radiation Monitor who claimed that laboratory personnel in the 325 Building were setting dosage rates for each other. The second grievance concerns a Serviceman in Technical Shops who grieved because the Company failed to furnish transportation to his work location. The third grievance was filed by a Painter in FPD claiming that a Carpenter in Technical Shops was performing work that belongs to the Painters. All three grievances are at the Step II level and answers will be written shortly.

The grievances processed by this Operation since January 1, 1957 total 23. This number includes one non-unit grievance. The following is a breakdown as to the status of these grievances.

Step I

Answered satisfactorily*	11

Step II

Pending Step II answer	3
Answered	
Satisfactorily**	9
Pending time limit	0

* Step I grievances which Council indicated a desire to discuss at Step II not scheduled for discussion within three months are considered settled at Step I.

** Step II grievances in which the Council formally applied for arbitration but for which no further action is taken within three months are considered settled at Step II.

TECHNICAL PERSONNEL PLACEMENT

PhD Recruiting

During the month six candidates visited Richland for employment interviews; two offers were extended; one offer was accepted; one offer was rejected; and two were placed on the roll.

PhD - HLO - 9/1/57 to date

Cases Considered	Visited	Offers Extended	Accepted	Open	Rejected	On the Roll
376	23	27	8	9	10	8

Offer totals include 14 offers extended during the last recruiting season which were open on September 1, 1957.

Offers accepted do not include seven acceptances received during the last recruiting season from people who were not on our payroll on September 1. Four of the seven carry-over acceptances have reported on the roll to date.

A summary of PhD recruiting statistics appear in Table III.

BS/MS Experienced recruiting

During the month one candidate visited Richland for employment interviews; three offers were extended; two offers were accepted; and one was placed on the roll.

BS/MS - HLO 9/1/57 to date

		Offers				
Cases Considered	Visited	Extended	Accepted	Open	Rejected	On the Roll
51	7	6	2	2	2	3

Two people reported on the roll during September as a result of offers accepted prior to September 1, 1957.

A summary of BS/MS experienced recruiting appears in Table III.

Exempt Transfers

There were no new transfer requests received during the month. Two cases were closed during December, one by transfer within HLO and one request was withdrawn.

Exempt transfer statistics appear in Table IV.

The attrition of exempt personnel for HLO for December:

Transfers	0
Terminations and deactivates	2

HEALTH, SAFETY, AND SECURITY

Since September 1, 1956, a total of 3,007,244 hours have been completed with no disabling injuries. (This accomplishment of exceeding the 3 million hour mark qualified HLO for the National Safety Council Award of Honor, for which application was made on January 2.) During December Laboratories personnel worked a total of 186,174 hours with no disabling injuries.

There were 33 medical treatment injuries giving a frequency of 1.77 as compared to 1.49 last month. For the total calendar year, the frequency was 1.71.

There were no fire incidents reported.

There were seven security violations bringing the total for the year to 88. For the last four months the total was 15 violations.

A summary report on the beryllium powder explosion in connection with low temperature facilities at the neutron spectrometer was completed for distribution to groups that could benefit from the experience.

Medical examinations were 99.7% completed for the year.

Supervision was notified of three new medical work restrictions, one continuation, and one discontinuation.

Six HLO and two outside safety suggestions were evaluated; three were recommended for adoption.

SALARY AND WAGE ADMINISTRATION

At month end, each Level 3 Manager had discussed his respective salary review with the Manager, Hanford Laboratories. Pertinent statistics for total HLO are currently being prepared and will be forwarded to Relations & Utilities for HAPO-wide consolidation and subsequent submission to W. E. Johnson for his review and approval.

The following position changes were made during the month:

Positions Added	1
Positions Deleted	3
Position Titles Changed	2
Position Levels Changed	1

During the month, the following audits were completed:

Financial	1
Chemical Research & Development	1
Physics & Instruments R & D	1
Reactor & Fuels R & D	4

A coordinated HAPO-wide study of the semi-technical jobs was undertaken during the month following a comprehensive review of the data received from the Northwest area and AEC wage surveys. Conclusions and a recommended course of action will be forwarded to appropriate managers in the near future.

A revised upgrade listing of Machinist Journeymen to Instrument Maker and/or to Tool and Die Maker was issued by the Specialist, Wage Administration during the month.

ATTITUDE SURVEY

An analysis of the scores of 35 selected attitude survey questions was plotted using a scattergram method. The per cent favorable scores were plotted for each of the three personnel classes by level 3, 4 and 5 organization component. In addition, the questions were grouped by theme or category and additional questions were developed to assist in planned discussions with all HLO managers and supervisors. From these discussions, we will be able to (1) assist HLO managers and supervisors in a better understanding of their attitude survey results, (2) develop ideas for future attitude surveys, (3) give Employee Relations a better insight to some of the "problem areas" in HLO, and (4) guide Employee Relations Operation in developing programs and recommendations for HLO managers and supervisors.

The sensitivity survey results were analyzed by Roy Waters. Distribution and displacement curves were developed from each participant's returns.

T. G. Marshall

Manager,
Employee Relations

TG Marshall:tr

VISITORS TO HLO

Name	Date of Visit	Company or Organization Represented	Reason for Visit	Personnel Contacted	Access to Restricted Data	Areas and Buildings Visited
T.W. Zebley	12/4	General Electric Company	Consultation re Engineering Personnel Register	T.G. Marshall	None	300 - 3760

TABLE III. EMPLOYMENT - TECHNICAL PERSONNEL STATUS

I. Employment

Non Exempt employment status	Nov.	Dec.
Requisitions		
At end of month	4	7
Cancelled	0	0
Received during month	3	5
Filled during month	11	2
Candidates Considered		
Total applications	24	52
Total transfer requests from other at HAPO	0	4
Total interviewed	0	0

Non-Exempt Transfer Requests	Nov.	Dec.
Transfer Requests		
Active cases at end of month	54	45
Cancelled	2	10
New during month	7	5
Transfers effected	0	4
Planned Transfers		
Effective during month	0	0

II. Technical Personnel Placement

Ph.D. Recruiting - HLO - 9/1/57 to date

	Cases Considered	VISITS TO RICHLAND				OFFERS			On The Roll
		Extended	Visited	To Visit	Open Invite.	Extended*	Accepted	Open	
Engineering:									
Chemical	48	17	2	7	4	4	1	2	0
Electrical	12	2	0	2	0	2	0	0	0
Mechanical	23	8	1	4	1	2	0	0	0
Met-Ceramics	41	20	4	7	6	4	0	3	1
Other	6	2	0	1	1	0	0	0	0
Science:									
Chemistry	177	29	8	8	7	8	4	3	3
Physics	180	64	7	17	28	6	2	1	1
Math - Stat.	24	2	0	2	0	0	0	0	1
Other	25	3	1	0	2	1	1	0	2
TOTALS	536	147	23	48	49	27	8	9	8

*Offer totals include 14 Ph.D. open offers as of 9/1/57.

BS/MS Experienced Recruiting - HLO - 9/1/57 to date

	Cases Considered	VISITS TO RICHLAND				OFFERS			On The Roll
		Extended	Visited	To Visit	Open Invite.	Extended	Accepted	Open	
Engineering:									
Chemical	4	2	1	0	0	0	0	0	0
Electrical	6	1	1	0	0	0	0	0	0
Mechanical	9	4	3	0	0	2	0	0	0
Metallurgy - Cer.	5	1	1	0	0	1	1	0	0
Other	5	0	0	0	0	1	1	0	1
Science:									
Chemistry	9	0	0	0	0	0	0	0	2
Physics	4	0	0	0	0	2	0	2	0
Math - Stat.	1	1	1	0	0	0	0	0	0
Other	8	0	0	0	0	0	0	0	0
TOTALS	51	9	7	0	0	6	2	2	3

TABLE IV. Exempt Transfer Cases

			December	November	Total
Active cases at beginning of month			25	19	
New cases:	Initiated by employee				
	Initiated by management*			7	
Cases reactivated					
			25	26	
Cases closed:	Transfers:	Within HLO	1		4
		Within HAPO		1	4
		Other GE			7
	Withdrawn		1		8
	Terminated				9
			23	25	32
Active cases at end of month			23		23
Total cases - January 1, 1957 to date					55
Initiated by employee 25					
Initiated by management*30					

*Includes ROF's, transfers proposed by employee's management, and requests from other G. E. departments.

TABLE V. Union Relations

Grievances Processed - January 1, 1957 to date

Total Processed	23	(includes 1 non-unit grievance)
Step I		
Answered satisfactorily*	11	
Step II		
Pending Step II answer	3	
Answered		
Satisfactorily**	9	
Pending time limit	0	

* Step I grievances which Council indicated a desire to discuss at Step II not scheduled for discussion within three months are considered settled at Step I.

** Step II grievances in which the Council formally applied for arbitration but for which no further action is taken within three months are considered settled at Step II.

FINANCIAL OPERATION MONTHLY REPORT

Personnel

There were no personnel changes in the Financial Operation during December.

General Accounting Operation

A request was received by Hanford Laboratories from SS Accountability Operation for information necessary to implement Part II of HOO-AEC Survey No. 15 of SS Materials. Custodians within Hanford Laboratories were requested to submit this information to the Manager - General Accounting for consolidation and transmittal to Relations and Utilities. A forecast of requirements for diversions of Nuclear Materials outside production channels was prepared by various members of Hanford Laboratories Operation and submitted through the Manager of General Accounting to SS Accountability Operation.

Decision was reached to transfer responsibility for accounting for equipment and construction work in progress from Cost Accounting to General Accounting. The change is scheduled to take place during January. Coincidentally with this transfer, a realignment of responsibilities within General Accounting will take place. As a result of these two changes, the acquisition of capital assets will be controlled from budgeting through the point of transfer to property accounts by one group under the Specialist - Acquisitions.

The problem of securing proper authorization for work being conducted by our engineering representative at Arco, Idaho is still in the process of discussion and has not been resolved. A meeting will be held early in January by representatives of Reactor and Fuels, Financial and the Counsel's office in an attempt to reach agreement as to proper procedure. The representative of the Counsel's office is concerned about indemnity implications with respect to our working arrangement with the Phillips Petroleum Company.

As a result of the Internal Revenue Service taking the position that all reimbursements of business expenses represent gross income to employees and must be reported in returns for 1958 and later years, we will maintain for each employee such detail information as is required. This information will be provided at the end of each year to all employees who have been reimbursed for travel and entertaining expenses.

Continuity of service accrual rates have been reviewed and it has been decided that we will continue to use the present overall rate of 10% of gross salaries during 1958.

As a result of Traffic Operation's discontinuing travel and hotel reservation service on December 15, 1957, travel advances now include funds for employees to pay for transportation on a cash basis. The local working fund has been increased to $5,000.00. In addition, a proposed revision to the present "Travel Order, Reservations Request and Cash Advance Receipt" form has been drafted.

At the request of the Specialist - Emergency Monitoring, Radiation Protection Operation, consideration is being given to making cash available on a twenty-four hour basis for emergency monitoring trips off-site.

We have processed and are reporting all non-reimbursable expenditures incurred through December 31, 1957. Those expenditures incurred but not paid or billed will be accrued and applied against the 1957 budget for Charges Against the Fee.

A report of findings in connection with the annual physical inventory of uninstalled cataloged equipment in the custody of Reactor and Fuels Research and Development and Chemical Research and Development was distributed in December. The inventories consisted of 2,227 pieces of equipment valued at $3,185,039 and 2,169 pieces of equipment valued at $1,822,804 respectively. Equipment physically located during the inventory, for which no record could be found, were 403 items valued at $228,117 for Reactor and Fuels and 298 items valued at $109,018 for Chemical Research. In both inventories, it appeared that custodian cards were too far removed from the personnel actually responsible for the equipment, and are not being used to full advantage for control purposes. It was recommended that responsibility of maintaining control cards be transferred to level 5 operations to strengthen control of equipment. This would enable custodial personnel to become better acquainted with their assigned equipment.

Listings of equipment, found missing in the current HLO physical inventory of uninstalled cataloged equipment, were prepared and distributed to Level 3 Managers, requesting that the equipment be found or a missing equipment report and a property disposal report be prepared. A summary report of findings, in connection with the HLO physical inventory of uninstalled equipment, will be issued upon completion of the missing equipment reports.

Missing equipment reported to Level 3 Operation and items physically located for which no record could be found during the HLO physical inventory of uninstalled cataloged equipment are as follows:

	Missing Equipment		Unrecorded Equipment	
Operation	Number	Value	Number	Value
Radiation Protection	12	$ 2 131	146	$ 51 500
Laboratories Auxiliaries	1	101	50	31 929
Biology	28	17 018	57	24 700
Physics & Instruments	22	6 642	124	35 334
Reactor & Fuels	105	89 664	403	228 117
Chemical Research	57	25 692	298	109 018
Total	225	$141 248	1 078	$480 598

The substantial adjustments indicated in the above schedule are due in large measure to a write off of equipment which followed a physical inventory of plant and equipment taken several years ago (1953). Although it cannot be definitely proven because of lack of detailed identification in the previous inventory, it is reasonably certain that many of the items currently being added to record are the same items not located during the previous physical inventory and subsequently written off. Many of the items reported as missing in the above tabulation will be located before a final adjustment of the accounts is accomplished. We are confident that physical inventories of uninstalled capital equipment in the future will reveal a substantial improvement in property accounting procedures and result in adjustments of much smaller magnitude.

Arrangements were completed for the regular quarterly physical inventory of other special materials as of December 31, 1957, to be conducted by custodial personnel. Property Accounting will not witness the count but will reconcile the results to Property Accounting records. A report of results will be issued upon completion of reconciliation.

Cost Accounting Operation

Several meetings have been held by the Specialist - General and Consolidations Cost with representatives of Data Processing concerning new work order procedures. A change has been requested in the format of one of the IBM runs so that more and better information concerning work orders can be provided for the operation personnel as an attachment to individual operating cost reports. The pilot run is to be recieved in January for review.

Copies of letters from Nuclear Metals, Inc. to Reactor and Fuels R&D Operation, regarding cost incurred on Procurement Directive 57-2, were forwarded to the HOO-AEC. The letters and our telephone discussions resulted in billings totaling $25,300 from NYOO-AEC to HOO-AEC. Billing to HLO was not made before cost transfer cut-off between AEC and GE, therefore, an accrual was booked in December for the same amount charging Reactor and Fuels R&D Operation as a direct charge to FPD Research and Development. The accrual covers costs for the months of July, August and November; September and October having been billed at an earlier date.

Current authorizations for approval of purchase requisitions, store orders, overtime lunches and work orders were recorded on a newly designed form for all authorized personnel of Hanford Laboratories Operation. Periodic audits will be performed to check for proper authorization signatures on source documents. During December an audit of store order approvals was conducted.

A cost coding and paper flow procedure has been written for Facilities Engineering concerning the use of Engineering Requests, formerly called Work Requests. A written procedure was deemed necessary for indoctrination of new employees within Facilities Engineering Operation as well as consistency in manner of preparation.

Work simplification studes are underway in three general areas by the Cost Accounting Operation: (1) Improved budgeting procedure which will reduce the amount of detailed preparation of data needed to justify the funds requested from HOO-AEC, (2) mechanization of cost accounting system, and (3) review of all procedures within cost accounting function to simplify or eliminate if determined not required.

Personnel Accounting Operation

Eight patent awards were paid and stock delivered during the month. These payments cover all notices of awards received during 1957. During the year 1957, 24 awards were granted, of which 9 were to inactive employees.

Modification No. 11 to Appendix B was approved during the month. This modification changes the provisions of Article 3, (Absences for Personal Reasons). The new O. P. G. on absences as in the process of being issued.

Approval Letters Nos. 75 and 144, "Revisions to Salary Administration Manual", were received during the month. Approval Letter No 144 modified the exempt salary structure by an increase of approximately 2% effective December 1, 1957.

Procedures

Extensive efforts have been undertaken concerning R&UO's suggested consolidation of plant delivery services by Classified Files and Area mail forces. Contacts have been made with Office Facilities, and Security and Patrol, R&UO; Duplicating and Mail, FPD; and affected groups in Technical Information, HLO. In addition, a preliminary meeting has been held with CEO, with regard to the mutual delivery problems of Classified Files and Engineering Files. Evaluations are continuing of all aspects of this problem, including the costs of deliveries, security controls and the maintenance of necessary service.

A study was completed for Technical Information evaluating the alternative methods for keypunching records to be used in the EDPM procedures for site accountability of classified documents. Recommendations were made to perform this work by Files' personnel basically to effect cost savings and improve efficiency and accuracy in the handling of the data.

An examination was made of the new microfilm routines used in Engineering Files, CEO. The latest "Recordak" filming, mounting, viewing, and reproducting equipment has been acquired by that Operation to be used in the system for accountability and record keeping of all engineering drawings on the project. Of special interest is the application of Filmsort cards; i.e., the mounting of individual microfilm frames on IBM cards coded to identify each frame. Duplicate microfilm copies of all 300 Area drawings are to be maintained in a 300 Area file. A total of 60,000 drawings have been microfilmed to date out of a total of 300,000 on the plant. This application of new techniques in microfilming will continue to be followed as an example of improved data handling methods.

A meeting was held with a West Coast representative of Eastman Kodak Company to get information concerning the latest types of their Verifax office copying equipment. Arrangements were made to receive additional data from them on systems applications of this equipment.

Auditing

The Cost Accounting Audit field work has been completed and the report is being written. Field work on the Administrative Services Audit has been started.

Measurements

The measurements report for CY 1957 was issued on December 4.

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 157	504	653
Additions and Transfers in	13	5	8
Removals and Transfers Out	(12)	(2)	(10)
Transfers from Exempt to Non-Exempt	-	-	-
Employees on Payroll at End of Month	1 158	507	651

Overtime Payments During Month	December	November
Exempt	$1 966	$1 208
Non-Exempt (five weeks in November)	2 773	6 321
	$4 739	$7 529

Gross Payroll Paid During Month		
Exempt	$377 188	$376 823
Non-Exempt (five weeks in November)	270 768	342 559
	$647 956	$719 382

Participation in Employee Benefit Plans at Month End	Number Participating		Percent Participating	
	December	November	December	November
Pension Plan	1 120	1 109	98.3	98.3
Insurance Plan				
Personal Coverage	1 183	1 187	99.5	99.6
Dependent Coverage	731	729		
U.S. Savings Bonds				
Stock Bonus Plan	698	701	60.3	60.6
Savings Plan	89	90	7.7	7.8

Insurance Claims	December		November	
Employee Benefits	Number	Amount	Number	Amount
Life Insurance	0	$ 0	0	$ 0
Weekly Sickness & Accident	9	596	8	585
Comprehensive Medical	55	5 251	38	3 115
Dependent Benefits				
Comprehensive Medical	77	8 293	95	8 495
Total	141	$14 140	141	$12 195

Good Neighbor Fund	December	November
Number Participating	753	749
Percent Participating	65.0	64.7

Other Statistics

Travel	No.	December	No.	November
Accounts Outstanding at beginning		$21 548		$20 004
Charges:				
Cash issued - by checks	25	5 714	28	4 842
by currency	32	3 259	51	5 876
Transportation		7 080		18 827
Other - (Billings from other GE components, moving expense, etc.)		2 854		2 722
		40 455		52 271

Travel (Cont'd)

Less:				
Expense vouchers processed				
Travel expense accounts	94	25 540	80	20 252
Other (moving expenses, conference expense, etc.)	38	2 867	30	2 353
Refund of advances	62	5 768	78	7 112
Billings to and from HAPO Components-Net		(763)		1 006
		33 412		30 723
Accounts outstanding at close	20	$ 7 043	61	$21 548

W. Sale
January 13, 1958

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
W. G. Spear	A Transistorized Linear Pulse Amplifier
D. D. Marsh	An Improved Curve Follower
J. L. Swanson	The Use of Mixed Ammonium Fluoride-Ammonium Nitrate Solutions in the Processing of Zirconium-Containing Fuel Elements
H. E. Hanthorn	Automobile Speedometers
D. R. Metcalf	Lunch Box Accessories
D. E. Rasmussen	Maintenance Tools
W. L. Wyman	Arc Welding in a Vacuum

H M Parker