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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
SEPTEMBER, 1957

Classification Cancelled (Change to Declassified C Deletions

By Authority of CG-PR-2

Dx Lewis 6/11/92

By B. Clevenger 8/5/92

PM Ech

Compiled By
Operation Managers

October 15, 1957

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

CLASSIFICATION REVIEW FOR DECLASSIFICATION BUT LEFT UNCHANGED

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5/17/75

U.S. AEC Division of Classification

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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 I. HLO-FORCE REPORT AND PERSONNEL STATUS CHANGES

FORCE REPORT

Date September 30, 1957

	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	125	94	219	127	90	217	3	5	5	1
Reactor & Fuels Research & Development	149	96	245	154	91	245	1	6	6	1
Physics & Instrument Research & Development	54	25	79	56	25	81	0	1	2	1
Biology Operation	34	42	76	33	41	74	1	1	0	0
Operations Res. & Syn.	13	3	16	13	3	16	0	0	0	0
Radiation Protection	44	179	223	42	185	227	2	2	0	8
Laboratory Auxiliaries	44	182	226	44	180	224	0	6	0	4
Financial	16	35	51	15	34	49	1	1	0	0
Employee Relations	14	11	25	13	11	24	1	0	0	0
General	1	1	2	1	1	2	0	0	0	0
TOTALS	494	668	1162	498	661	1159	9	22	13	15
Totals excluding Internal Transfers	494	668	1162	498	661	1159	8	18	12	11

Composite Separation Rate -1.979

Separation Rate (based on separations leaving G. E.)- -1.721

Controllable Separation Rate- .258

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

Date September 30, 1957

Component	PROMOTIONS			EXEMPT TRANSFERS (2)				NON-EXEMPT TRANSFERS	
				To HLO		From HLO			
	Exempt	Non-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	5	3	3	2	0	2	0
Reactor & Fuels	0	0	5	0	0	0	0	2	0
Physics & Instrument	0	0	2	0	0	0	0	1	0
Biology	1	0	0	0	0	0	0	1	0
Operations Res. & Syn.	0	0	0	0	0	0	0	0	0
Radiation Protection	0	0	0	0	0	0	0	0	0
Laboratory Aux.	0	0	1	0	0	0	0	1	1
Financial	1	0	2	1	0	0	0	0	0
Employee Relations	0	0	0	0	0	0	0	0	0
TOTALS	2	0	15	4	0	2	0	7	1

(1) Data through 9/30/57
(2) Transfers within HLO not included

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SUMMARY

BUDGETS AND COSTS

In the absence of a firm financial plan, it may be misleading to quote performance against budget. With this reservation, however, over-all expenditures for the first quarter came to 22% of the annual budget.

A vigorous internal adjustment needs to be made in the spending rate on behalf of weapons research and development for CPD, and process technology for IPD and FPD.

September costs increased about $62,000 over August.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

The detail design of the Plutonium Recycle Program Reactor (PRPR) is estimated to be 14% complete for the project as a whole and 90% complete for Phase I only.

A generalized plutonium fuel cycle analysis has been formulated for programming on the IBM 650 computer. Maximum allowable fuel exposure, plutonium material balance and isotopic composition are obtained as functions of a number of predetermined lattice properties, and modes of reactor and fuel cycle operation.

In preliminary experiments vacuum injection casting of aluminum into long (6-7') cylindrical and annular sections of stainless steel jacketing appeared to be feasible. Intimate contact with the jacket walls and a low incidence of casting voids were observed. Injection casting into zirconium jackets will follow. This method could drastically reduce the costs of Pu-Al fuel element fabrication.

The equipment list and equipment procurement priorities for the Plutonium Fabrication Pilot Plant have been revised to maximize the degree of beneficial use of the facility by the summer of 1959, a year in advance of completion of the total project.

The first irradiation of cold swaged, zirconium-clad, UO_2 capsules has been conducted uneventfully in the MTR. Forebodings of poor thermal conductivity of material compacted by cold swaging were not confirmed.

Developmental work by off-site zirconium fabricators has yielded experimental PRPR and B,D, F-size process tubes which, although not without defects, represent substantial technological progress and lend encouragement that future commitments will be met.

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A fuel element design believed to be amenable to mint production with coolant water at a temperature of 300° C is under preliminary study.

The AEC is actively supporting the over-all HAPO interest in eliminating a threatened delay of the order of six months in the installation of Hanford loops in the ETR; such delay would materially affect the Laboratories' support of several programs.

Extensive comparative studies of fuel element closure by several different welding methods indicate that electron beam vacuum welding is outstanding for use with reactive materials such as Zircaloy-2, as well as a cheap and effective method for closures of aluminum.

Cans for a 24-element charge of aluminum alloy clad, tubular UO_2 fuel elements have been fabricated preparatory to KER loop irradiation at 240° C. This will be the first large-scale irradiation of a tubular UO_2 element.

In preliminary corrosion tests the new ANL alloy, 198X, continues to surpass all other aluminum alloys tested.

2. Chemical Research and Development

Optimism concerning adequate uranium decontamination in a two-cycle Purex process continues.

Dissolution of the hollow I and E fuel elements will be faster than for solid elements, but not in proportion to the surface area.

CPD will be helped in the UO_3 Plant operation by:

(1) new understanding of stresses in the troublesome calciner paddle arms.

(2) potential increase in throughput by a higher temperature UNH feed stream.

In support of the plutonium recycle program, there is progress in:

(1) ion exchange treatment of simulated recycle fuel solutions.

(2) cryolite reduction preparation of Pu-Al alloy.

(3) appropriate bleed-off of higher plutonium isotopes in reprocessing.

(4) recovery of plutonium from the possible PuO_2-impregnated graphite matrix fuel.

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The Zirflex process does not handle well the dissolution of zirconium or Zircaloy end plugs of fuel elements; the surface to volume ratio is unfavorable, and the parts also acquire a protective uranium coating.

The use of M-388 fuel element jackets in production reactors would not seriously affect the distribution of radioisotopes in the effluent.

Improved monitoring methods have shown up radioactive zinc, manganese, and cesium in vegetation in the irrigated area where water is taken from the Columbia River below Hanford. There is some transfer to milk and to humans; this will require careful follow-up.

Coating wastes, mixed with sodium silicate, can be caused to gel rapidly upon discharge to an open pit. If the gel proves to be stable, this may be an attractive disposal method.

There is a small scale effort to study methods of recovering Kr^{85} from dissolver off-gas.

3. Physics and Instruments

Two large pieces of apparatus to gather data pertaining to the nuclear safety of present production reactors were put in place in the Experimental Reactor Building and theoretical studies to be used in interpreting results were advanced.

The program to provide reactivity data for various lattices for IPR design scoping neared completion of the first phase:- measurements on a large diameter (1.66 inches) solid, metallic, natural uranium fuel element.

Construction has started on two, heavy isotope, mass spectrometers; one for the CAD program, and the second for use in other HLO programs. Concurrent construction of the two instruments allows efficient use of professional manpower.

The temperature coefficient measurements on the PRPR lattice with cluster elements were extended to a fuel temperature of 400° C but no significant differences from projection of lower temperature measurements were observed.

The fast effect, and resonance escape probability, needed to calculate the conversion ratio, were determined for a cluster oxide element in the PRPR lattice but experimental difficulties have thrown doubt on the validity of the results. The experiment will be repeated using improved techniques.

Doses of the magnitude of those received from cosmic rays have been measured with pocket ionization chambers using the pulse method.

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An outsize counter (100-pound plastic scintillator, 14-inch photomultiplier tube) has been constructed for possible use in truck, boat, or airplane contamination surveys.

4. Biology

A malignant tumor developed in the lung of a mouse given 0.003 μc Pu as oxide in the lung; this is the third malignancy out of 300 animals.

Zn^{65} shows late accumulation in the hair. As extrapolated to the human, it is unlikely that the hair will be treated as the significant critical organ; if appropriate quantitative relationships exist, sampling of hair would be much simpler than trying to determine the bone deposit of Zn^{65} directly.

Technical and Other Services

Of the four cases of suspected tampering with badges reported last month, one has been fully resolved.

Progress was made toward company-wide uniformity in radiation protection at a New York meeting of the Radiation Protection Study Group.

There was another case of minor plutonium deposition in an employee, for a total of 207 cases.

The average weekly emission of I^{131} was 3.5 curies.

The final report on Operation Pool was submitted to the AEC.

Progress on the Laboratories' projects was substantially on schedule, with two exceptions:

1. CA-658 - Shielded Personnel Monitoring Station.
2. CG-581 - Hanford Equipment in the ETR.

In both cases, the delay was in portions of the project work outside the direct control of the Laboratories.

The new weather forecasting service, giving recorded forecast by telephone, received 4,670 calls in September.

Supporting Functions

1. Financial

A schedule of objective, program, goal and measurement highlights for the balance of this year has been distributed to Level 3 Operations.

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APED, San Jose has submitted their plan for charging HAPO for consulting services. The plan considers our Prime Contract requirements and establishes the basis for billing as salaries plus approved rate of overhead for government work. The proposal is being studied and procedures for authorizing work to APED drafted.

Preliminary analyses of test questionnaires issued in connection with the paperwork survey indicate there are no uniform opinions as to the paperwork conditions in HLO except that the feeling of being excessive is more frequently expressed at higher levels of management. The results of the two alternate questionnaires are being studied by Financial and Operations Research to decide on the most appropriate procedure to follow for all of HLO.

Better Living Program pay increases effective October 1 are estimated to increase the annual payroll of HLO by $84,000.

2. Employee Relations

At month's end the staff of the Hanford Laboratories Operation totaled 1162, including 494 exempt and 668 non-exempt employees.

Preparations are underway for HLO participation in the 1958 Radiological Physics Fellowship Program, the AEC-ASEE Summer Institute, and AFSWP Program.

Courses on "Understanding People", "Data Processing" and "Management Orientation" continued.

Forty-eight exempt employees started the fall PBM-1 series and 3 PBM-1 instructors began the one-week instructor refresher course.

Twenty-five technical papers, articles, and speeches and 4 press releases were processed for publication.

The HLO Suggestion Board did not meet during the month of September. There are currently 30 suggestions pending Board action.

The Wonacott case was judged to be subject to arbitration; the outcome may affect the Laboratories Operation indirectly.

There are no new developments in the negotiations with the Regional Monitors and the Maki grievance case.

One grievance was received during the month from a Radiation Monitor. Grievances processed since January now total 17, including 1 non-unit grievance.

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There were no disabling injuries during the month. Thirty medical treatment injuries were recorded with a frequency of 1.68 as compared to 1.35 last month.

There were 6 security violations in September.

H M Parker

Manager
HANFORD LABORATORIES

HM Parker:lt

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REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

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1. METALLURGY PROGRAM

Corrosion Studies

Corrosion Tests of Aluminum in Superheated Steam. As the resistance of newly developed aluminum alloys to intergranular corrosion in deionized water and steam increases, the evaluation of the alloy resistance in a reasonable length of time requires drastic test procedures. A corrosion test using 500 psi steam at 500 C currently in use has given good discrimination and reproducibility. The following table compares several new alloys with the more familiar M-388 and M-400.

Comparison of Aluminum Alloys in 500 C, 500 psi Steam

Alloy	1 Day	3 Days	7 Days	10 Days
M-388	Failed	--	--	--
M-400	Failed	--	--	--
A203X(Alcoa)	OK	OK	Blistered	--
A203X(Kaiser)	OK	Blistered	--	--
198X(ANL)	OK	OK	OK	OK
GL(Chalk River)	OK	OK	OK	Blistered
GK(Chalk River)	OK	OK	OK	Blistered
GG(Alcoa)	Failed	--	--	--
GH(Alcoa)	Failed	--	--	--
GI(Alcoa)	Partially Failed	--	--	--

Nominal Compositions

M-388	1% Ni, 0.5% Fe, 0.2% Si
M-400	1% Ni, 1% Fe, 0.2% Si
A203X	5.5% Ni, 0.3% Fe, 0.2% Ti
198X	1% Ni, 0.1% Ti, Balance 99.9% Al
GL (10182)	0.5% Ni, 0.5% Fe, 0.2% Si, 0.2% Ti, 0.05% Be
GK (10197)	2.0% Ni, 0.5% Fe, 0.2% Si, 0.2% Ti, 0.05% Be, 0.05% Zr
GG(192263)	1.4% Ni, 1.4% Fe, 0.1% Si, 0.02% Ti, 0.02% Cr
GH(192264)	2.6% Ni, 0.3% Fe, 0.1% Si, 0.02% Ti, 0.35% Cr
GI(192265)	4.3% Ni, 0.4% Fe, 0.8% Cu, 0.1% Si, 0.03% Ti, 0.02% Cr

Four samples of each alloy were exposed. In all cases the results were the same among the four samples.

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The excellent results with alloy 198X were gratifying in several respects. In view of demonstrated fabrication experience with M-388, the alloy can undoubtedly be formed into cans by the usual techniques. This alloy does not contain Be, found in the Chalk River alloy, which might prove a health problem. It should be noted, however, the current test material is part of a small test lot from Argonne. In view of the wide variation in lots of A203X, experience with larger melts of 198X will be required for confirmation. Large lots of A203X procured by two different vendors were markedly inferior in corrosion resistance to samples obtained from small ANL melts, even though both large melts were carefully made and in excellent agreement with chemical analyses of the ANL melt.

Irradiation of Aluminum Clad Fuel Elements Autoclaved in Chromic Acid. The first two tubes of fuel elements autoclaved in chromic acid and irradiated under PT-IP-59A were discharged on schedule at about 200 MWD/T. These pieces were examined visually for unusual corrosion. The original film appeared to be nearly intact on all the pieces except Nos. 10 and 12 from the rear face. No localized corrosion was observed.

Ceramic Coating of Uranium. Considerable progress has been made in the laboratory in delineating and understanding the large number of process variables which must be controlled to produce a sound ceramic coating on four-inch uranium slugs. Typical variables of importance include: surface preparation of the uranium, wetting of the uranium surface by the molten glass, pre-grinding of the glass to the proper powder size, spraying techniques, coating thickness and composition, and firing temperature and time. The surfaces of slugs now being coated experimentally in the laboratory are 95 percent perfect. Future work will be concentrated on eliminating the remaining defects.

Radiometallurgy Examinations

Examination of M-388 Jacketed Hot Spot Failure (RM-197). Examination was continued on the can wall segments from the M-388 jacketed slug, from tube 3578-D, which failed July 4, 1957, at about 300 MWD/T. Samples, for Chemical and Powder Camera studies, were removed from points near the rupture. The diffusion compound on the inside of the can wall in the heat affected area was identified as UAl_3 by x-ray (Powder Camera) techniques.

Post-Irradiation Examination of Thorium Oralloy (RM-154). The first of three 0.388-inch diameter by 1.50 inches long thorium containing 2.1 w/o Oralloy samples which were irradiated in the MTR according to GEH-3-17, were tested in simple bend over a one inch gage length. The sample failed at a 5060-pound load with a center deflection of 40 mils. The broken surfaces of the samples were rough and brittle in appearance.

The hardness of the sample was approximately 59.4 R_A compared to an unirradiated hardness of 40.5 R_A.

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Basic Metallurgy Studies

Electron and Optical Microscopy. The study of the microstructure of reactor cladding and fuel materials is a direct way of detecting radiation damage in these materials; optical and electron microscope techniques are being utilized. Replicas of the fracture surfaces of uranium irradiated to nominal exposures of 150, 300, 600, and 1000 MWD/T (0.02, 0.03, 0.07, 0.1 a/o burnup) have been prepared. The rectangular specimens were broken at room temperature by impact in a special remotized facility. Examination and study of the replicas has just begun.

Metallographic specimens of uranium which were precharacterized and replicated prior to irradiation in the MTR are still being studied. The surface roughness, as might be expected, definitely increases with reactor exposure. Hardness values for a control specimen and the specimens irradiated to 0.03, 0.07, and 0.1 a/o burnup, respectively, have been determined. The values are 68, 76, 78, and 75 Rockwell G. Fourier coefficients which characterize the (154) x-ray diffraction broadening have been determined for the three irradiated samples. Although the broadening was very slight, the first five coefficients for the three specimens are different and indicate different strains. The (154) Fourier coefficients are being used for calculating the average strain associated with each of the irradiated samples.

Two technical papers entitled: "The Etching of Refractories and Cermets by Ion Bombardment," and "A Technique for Studying the Identical Area in Pre- and Post-irradiated Uranium," were presented at the Fifteenth Annual Meeting of the Electron Microscope Society of America at MIT. Four posterboards of photomicrographs were selected for inclusion in a traveling display. A technical paper entitled: "A Study of the Effect of Reactor Irradiation on the Microstructure of Uranium," has been prepared for presentation at the AIME session at the Second World Metallurgical Congress. Photomicrographs have also been prepared for the Twelfth ASM Metallographic Exhibit.

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. Due to a lack of such information, a program of measuring thermocouple stability in-reactor is currently in progress.

Bench testing of the fourth aluminum thermocouple capsule has been done during the last month. Some minor variations have been made in the capsule for the purpose of reducing its overall weight and, consequently, the gamma heating. The capsule now operates properly and is felt to be satisfactory for in-reactor testing.

Heat Treating and Metal Quality Studies. Uranium specimens* are being cooled from the beta phase in different ways to determine the nature of columnar-grain formation during solid-solid phase transformation. Samples step-cooled from 730 C in a 635 C salt bath for different times prior to

- -

*Prepared from low-carbon "ingot" strip in the "as-rolled" condition.

final quenching to -5C were examined metallographically. Columnar grains were observed microscopically at the surface after 100 seconds holding time, but were not observed macroscopically until after 1000 seconds holding time.

Centrifugally-cast uranium fuel elements containing large additions of silicon and carbon were examined metallographically to observe if structural defects were present. Further, dissolution tests were conducted to determine the rates of dissolution. Microcracks were observed in all specimens; however, the larger densities of microcracks, 40 per cm^2, were observed in specimens having high silicon contents (about 1000 ppm) coupled with high carbon contents. Fewer microcracks were observed in specimens having high contents of one constituent, in excess of 1000 ppm, coupled with low contents of the other constituent. Large pockets of segregated carbon and silicon were observed in specimens containing over 1200 ppm total additives. Dissolution rates were in excess of 1.5 $gm/cm^2/hr$ compared with 0.7 $gm/cm^2/hr$ for production "ingot" uranium. This rate increases very noticeably with silicon content.

Uranium reeds are being vibrated transversely under free vibration to measure variations in the modulus of elasticity and damping behavior with heat treatment. A damping curve was obtained at a frequency of 138 c/s for hot-rolled, recrystallized uranium. Young's modulus was calculated to be 22.9×10^6 psi compared with 25.5×10^6 psi reported by N. Grossman and S. Priceman* for hot-rolled uranium tested in compression. The decrement at room temperature was 1.1×10^{-2}, and the damping curve was amplitude independent between 0.6 to 0.01 the original amplitude.

Recrystallization and Recovery of Zirconium Alloys. The kinetics of recrystallization and recovery in zirconium, Zircaloy-2, and Zircaloy-3 are being determined to establish the optimum conditions of heat treatment during fabrication operations. Percent cold work, temperature, time, and heat treat atmosphere have been selected as variables.

Hardness tests were completed during the month for Zircaloy-2, vacuum melted Zircaloy-3, and argon melted Zircaloy-3 specimens that had been annealed in vacuum for 10, 100, and 1000 minutes at temperatures from 300 to 800 C. These data indicate essentially the same trends as for previous helium and air anneals.

Corrosion tests in 680 F water are being run on specimens of Zircaloy-2 and Zircaloy-3 in the as-worked and heat treated conditions at the Bureau of Mines, Albany, Oregon. Corrosion test results for specimens of Zircaloy-2 and argon melted Zircaloy-3 heat treated in air and helium from 400 to 800 C for 10 to 1000 minutes were reported to 140 days. Samples in the annealed condition continue to show lower weight gains than the worked specimens. No detrimental effects of high temperature annealing in helium have been observed with either material, although the Zircaloy-3 treated at 800 C in air exhibits lowered corrosion resistance. A group of vacuum melted Zircaloy-3 specimens annealed in air

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*Grossman, N. and Priceman, S., "Compressive Properties of Uranium," Nucleonics, 12, No. 6, pp. 68-9 (June 1954).

and helium for 10 to 1000 minutes at 300 to 800 C have been in test to 84 days. These specimens are exhibiting corrosion behavior similar to the argon melted Zircaloy-3 thus far. An additional group of 90 vacuum annealed specimens were submitted for corrosion tests during the month.

Reaction Layers Formed with Uranium During Lead-Dip Canning. Metallographic examinations are being conducted to determine the behavior and identity of reaction layers formed when uranium is dipped in AlSi and Pb baths. Uranium specimens reacted with lead at 600 C to form the pyrophoric compounds UPb_3 and UPb. These compounds scaled off into the bath but were not transported by the bath as has been previously reported. Rather, they formed a UPb_3-UPb eutectic which adhered to the specimen adjacent to the U-Pb interface. In addition, specimens were dipped in AlSi for different times following a Pb-bath preheat. Microphotographs have been taken illustrating the following: the breakup by the AlSi of a compound layer formed during the Pb-pre-heat and transport cycles, the diffusion of uranium into the AlSi prior to reaction, and the progress of the reactions occurring among uranium, silicon, and aluminum. These specimens are being further studied and the photographs interpreted.

New Fuel Element Development

Coaxial Tube Fuel Element. The coaxial tube fuel element is of interest for reactor application because it offers promise of having the increased split failure resistance of a large inner diameter cored element but without the accompanying reactivity deficiency. The examination of a specimen of this design that was irradiated to 200 MWD/T at 70 kw/ft showed it to be essentially unchanged as a result of the irradiation. Hardness measurements indicated that the central tube probably operated as gamma uranium, although the microexamination did not show the usual characteristic columnar structure. In order to confirm the maximum temperature, a duplicate specimen of the coaxial tube design has been prepared with a thermocouple for irradiation in the Materials Testing Reactor.

Self-Supported Fuel Elements. Self-supported fuel elements with supports attached to the jacket of the element are designed to accurately position the fuel elements in a smooth bore process tube. The fuel elements for Production Test IP-84-A have been completed and are ready for reactor charging.

KER Wafer Elements. Twenty-five KER I & E wafer type fuel elements were canned and subjected to existing testing techniques to determine their metallurgical quality. Ten elements were destructively etched with caustic to reveal a minimum can wall of 0.029". Ten of these elements were acceptable and are awaiting pre-irradiation measurements before submission to the KER loop facility. Work is continuing on the necessary tooling to handle the segmented core during canning and to improve testing methods.

Hot Press and Vacuum Canned P.T. One tube of 8" I & E slugs from Production Test IP-105-44A (Vacuum Canned Slugs) and one from Production Test IP-105-45A (Hot Press Canned Slugs) were discharged at an exposure of

approximately 400 MWD/T. By visual examination, both types of test slugs and the alternately loaded lead-dip-canned control slugs appear in excellent condition. Although no evidence of deterioration is apparent, further evaluation will continue.

Fuel for Organic Cooled Reactors. A practical fuel element for an organic cooled reactor can be assured if certain improvements in materials, property measurements, and designs are made. These improvements involve problems of hydrogen permeation of the jacket, thermal ratcheting of the jacket, diffusion between the jacket and uranium, contact conductance of unbonded jackets, and design of the various fuel element components.

Uranium nitride (UN_x) was added to the list of materials being tested as barriers to the diffusion between uranium and aluminum when a nitride case 0.0001" thick was produced on a small specimen by reacting it with purified nitrogen at 750 C for 16 hours. Improved methods of nitriding are being sought. Graphite, AlSi, nickel, zirconium-uranium alloy, uranium carbide, and uranium nitride are currently under study as diffusion barriers. Performance measurements were made in two facilities: (1) an autoclave operating at 450 C and 1000 psi nitrogen pressure, a condition conducive to diffusion and thermal ratcheting; (2) the ORA-1 ex-reactor loop in which MIPB is circulated past the specimens at 370 C.

Two features in the design of an unbonded fuel element were found to reduce or prevent thermal ratcheting. One was mechanical keying of the jacket to the uranium which was roughened by diamond knurling and the other was elimination of end caps. The end caps were eliminated by machining elliptical ends on the fuel rod and swaging a tubular jacket down over the ends of the rod to a point closure.

Restraint of Uranium Swelling by Zirconium Cladding - GEH-3-27. Basic data on the swelling rates of unalloyed uranium irradiated in the 600-700 C temperature range have been reported in British publications. Experiments on unrestrained specimens of unalloyed uranium irradiated in the 400-500 C temperature range have been performed in the United States. To date, no data are available on 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 initial experiment to measure the swelling in a 0.570" uranium rod co-extruded with a cladding of 0.030" Zircaloy-2 is now being designed.

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 coaxial tube and rod element, with a coolant water annulus between the tube and rod, has been proposed as a possible element for tritium production in a water-cooled reactor operating at a bulk coolant temperature of 300 C. The design proposed calls for the rod or target element in which the tritium is produced to consist of an aluminum clad Al-3.5 percent Li alloy, with the tube comprising the fuel-bearing portion of the element. Because the major portion of the tritium production and separations

technology has been developed using the aluminum alloy containing 3.5 percent Li, this composition was chosen for the target material.

The geometry of the tritium producing element was chosen so as to be compatible with proposed Hanford reactor designs. Furthermore, the cylindrical design will allow development tests to be made on the element in the present Hanford fuel element testing facilities. The separation of the target rod from the fuel tube will allow the target material to operate in the 310-375 C temperature range instead of at the higher fuel temperatures. As the fuel tube will extend the normal active zone length of the process tube, there will be very little loss in tube power.

If the tritium producing element is to have a satisfactory in-reactor service life, the target cladding must have a low corrosion rate in the coolant water so that it does not rupture before the controlled extraction of the tritium is made.

Furthermore, from a reactor safety and an economic consideration, the cladding must be capable of resisting large scale permeation of the gases produced in the target material for the irradiation period and until the tritium extraction operation.

Therefore, in selecting a target element cladding material, consideration was made of the following necessary properties:

1. Low neutron cross section.
2. Low corrosion rate in 300 C coolant water.
3. Low rate of permeation by tritium in the temperature range 300-350 C.

Discussions with Hanford corrosion engineers indicate that either zirconium or two new aluminum alloys will have the necessary corrosion resistance.

A literature search provided very little data on the permeation rates of tritium through various materials; however, it did reveal that tritium and hydrogen permeation rates are of the same general order of magnitude for a given material. It is known from published data that zirconium has a tremendous affinity for hydrogen, whereas it was found that aluminum has one of the lowest hydrogen permeation rates of the common metals. Thus, the aluminum alloys, either M-388 or the new one containing one percent Ni and 0.5 percent Ti appear to be the best candidates for the target cladding. However, the literature search also revealed that alloying additions, such as are made in the aluminum alloys, can change the permeation rates of hydrogen, and undoubtedly tritium, through aluminum. To date, no data on the permeation rates of tritium or hydrogen through either of these alloys have been reported. In the initial phase of this study, it is planned to investigate experimentally the permeation rates of hydrogen through the two aluminum alloys.

ETR Installation. The installation of the two Hanford high-pressure testing facilities in the ETR was dealt a serious setback in September. Because of questions involving construction and maintenance labor forces, AEC-IOO decided to delay the start of the Hanford loops installation until approximately February 15, 1958. Since the ETR initially reached criticality September 19, it had been expected that sponsored test facility irradiations could start about the middle of December. Following the revised installation schedule, however, completion of the Hanford facilities cannot be expected much before the first of June.

Thermal Stresses in Piping Systems. In order to analyze the thermal stress in the proposed Army gas loop, a general method of analyzing the flexibility of piping systems is being sought which can be adapted for machine calculation. A tensor flexibility analysis of piping systems should be adaptable for machine calculation of any general piping system and is being studied in order to formulate the computer program.

Cable Clad Fuel Element Evaluation. A cable clad fuel element has been subjected to a series of mechanical and metallurgical tests to determine the bond properties and merits of the cladding process. Bond strengths were found to vary from 3,500 psi to 10,000 psi in a random pattern. Microscope examination revealed that a metallurgical bond had been formed, although considerable debris was found throughout the bonding layer. The aluminum to aluminum diffusion welds, formed during the cladding operation, were of considerable interest from the standpoint of corrosion resistance. Microscopic examination failed to locate these welds. Complete evaluation of the process is pending further mechanical testing.

Phosphate Base Drawing Lubricants. An evaluation of the phosphate base-sterate soap surface conditioners has been conducted to determine the merits of the process as an aid to cold forming aluminum. A complete sequence of metal conditioners and a sterate soap lubricant were received from the Parker Rustproof Company for this evaluation. Aluminum specimens were prepared by the method specified by the vendor. These specimens were subjected to drawing and sizing operations to compare this lubricant with conventional methods of lubrication. The process gave excellent lubrication properties, and the finished product presented an extremely fine finish. The disadvantages of the process were extensive surface preparation and extremely critical temperature and pH control of the solutions. This process will be reserved for projects which require processing a fairly large number of pieces.

Welding Development. A new welding process, electron beam vacuum welding, which potentially offers a superior method of fusion welding reactive materials such as Zircaloy-2, and a cheaper and better way of effecting a closure on aluminum fuel elements, is being developed. Corrosion test on Zircaloy-2 in 680 F static water for a period of 90 days resulted in less weight gain for welds made with this process than gains exhibited by parent metal specimens under the same conditions. From the standpoint of corrosion resistance, welded fuel elements should have a corrosion rate in the fusion region equal to or better than the parent metal. A temperature

of 6100 F has been generated with this process, and some work with the melting of non-conductors has been done. Refractories such as zircon and silica have been successfully melted. Some of the materials of interest in the atomic energy field which have been welded with this process are aluminum, stainless steel, titanium, tantalum, uranium, and zirconium. In the welding of aluminum on both AlSi bonded and unbonded standard Hanford size fuel elements, visual examination and preliminary microsections indicate the welds are of excellent quality.

With the growing use of Zircaloy-2 as a fuel element jacketing material, a determination of the best method of welding this material is required to assure that welds made on these fuel element jackets can meet the requirements of in-reactor exposure. Three methods being evaluated are heli-weld torch with trailing gas shield, backfilled inert gas chamber with heli-weld torch, and the electron beam vacuum welding process. Test specimens to determine mechanical and physical properties have been made of 0.015, 0.030, and 0.060-inch thick Zircaloy-2. Transverse and longitudinal bend tests of the three processes and three thicknesses indicate that the weld metal ductility in all cases is equal to the parent metal used in this test. The ductility of welds made with any of the three processes is satisfactory with respect to fuel element fabrication. After a 72-hour autoclave test at 750 F, the 0.015" thick heli-welded trailing gas shielded specimens showed a white corrosion product which indicates accelerated corrosion. All other specimens exhibited only a thin black corrosion film. This indicates that the 0.015" specimens welded with the heli-weld torch and a trailing gas shield are not suitable for fuel element closures.

Co-extruded U-Zircaloy-2 fuel rods for cluster fuel elements require a welded end cap attachment. A joint design and welding procedure has been developed for this application which requires machining a small ring of uranium away from the Zircaloy-2 jacket. This machining consists of removing the uranium to a depth of 1/16" and a width of 1/16" in the welding joint area. With this joint design, welds made with the electron beam vacuum welding process have 100 percent penetration, no uranium contamination, and are of exceptional high quality.

Rod Cluster Fuel. The rod cluster design meets many of the requirements for an extended surface fuel operating in high temperature water. Four-rod clusters of varying geometry clad in both stainless steel and Zircaloy-2 have been irradiated during the past two years. Only one irradiation has been carried out in high temperature water, a 100 MWD/T, 200 C coolant test at H Reactor. To extend the high temperature irradiation data, fifteen feet of four-rod cluster fuel elements were charged into Loop 3 KER at 100-KE on September 19. These elements contain natural uranium rods of 0.570" diameter clad in 0.030" stainless steel cladding. A rigid internal ring support spaces the rods and spring clips center the fuel assembly in the process tube. This fuel is now generating 40 kw/ft of assembly. Due to thermocouple and pump failures, the maximum outlet temperature reached at KER was 225 C, and for the majority of the accumulated exposure, outlet temperature has been 80 C. The calculated maximum uranium temperature is 260 C with the bulk outlet temperature at

80 C. Both operating difficulties should be overcome in early October, allowing 240 C outlet temperature operation until January, the termination date of the experiment. A four-rod stainless steel clad cluster irradiated to 550 MWD/T at the MTR has been examined in a radiometallurgy cell. No external dimensional changes occurred, but the uranium rod dimensions are yet to be measured.

The irradiation of a Zircaloy clad four-rod cluster fuel element is continuing at the MTR at a power density of approximately 25 watts/gm. The present exposure is 800 MWD/T. Two seven-rod cluster fuel elements were irradiated to an exposure of 1075 MWD/T in KE. These fuel elements were discharged and examined through the periscope in the KE basin. The fuel elements appeared to be in excellent condition. No changes in physical appearance were noticeable except a slight corrosion film on the surface of the element. Further examination is now being done at Radiometallurgy Operation. Accurate measurements will be made as well as fuel burnup analysis. These fuel elements consist of 0.500" uranium rods clad in 0.030" wall stainless steel jackets.

Nuclear Metals, Inc., has produced additional co-extruded Zircaloy clad uranium for use in cluster fuel testing. The work of the past month has concentrated on producing an integral end closure in twelve-inch length fuel rod with 0.030" clad thickness. Fuel rods with ten inches of uranium in the twelve-inch length have been made. However, with the integral end closure limited to one inch on each end, clad thinning occurs in spite of many efforts to prevent it. Nuclear Metals engineers think that rod with no clad thinning can be produced if the uranium length per rod is reduced to nine inches. Co-extruded rod with 0.020" clad has been produced without end closures and will arrive at Hanford in early October for installation of welded end plugs and for heat treatment.

Welded end closures are being developed both for co-extruded Zircaloy clad fuel rod and for Zircaloy tubing clad fuel. Nuclear Metals co-extruded fuel rod was cut and fitted to plug type end caps and to flat butt end caps. Weld closures were made by heli-arc technique and by vacuum electron beam welding. Uranium diffusion occurred in the case of heli-arc-welded flat butt end plugs, but the other three types of closures proved satisfactory in 350 C, 100-hour autoclave tests. Some distortion of the rod clad occurred in samples where the end cap did not fit as intended. Some of the heli-arc welds were not corrosion resistant. Both of these problems can be controlled by careful assembly and better welding atmosphere. Four fuel rods of 0.610" outer diameter were made by cold swaging 0.020" thick tubing over uranium rods. End plugs were welded in by heli-arc and electron gun technique prior to swaging. Very good weld geometry and metallurgical structure resulted. These rods were autoclave tested in the as-swaged condition and in the beta heat treated condition. The 350 C autoclave test produced no change in the electron gun welded fuel rod other than a light black oxide surface. The heli-arc welded fuel rod suffered premature and severe white oxide corrosion. Additional electron gun welded Zircaloy tubing clad rod is being completed for KER testing.

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2. REACTOR PROGRAM

Coolant Systems Development

Low Temperature Corrosion Studies. The 1706-KE single pass tubes are operating at pH values 6.0, 6.5, and 7.0, in accord with PT-105-550-E, to determine the effect of pH on slug corrosion rates in present reactors. The average outlet temperature has varied between 70 and 80 C. During the past month one fuel element ruptured as a result of a core failure. No excessive corrosion was noted but an examination of some of the discharged pieces has shown a high incidence of hot spots.

A six-month test to determine the corrosion of carbon steel at temperatures corresponding to the inlet water (about 14 C) was completed. The corrosion rate was found to be about 1.5 mils per year. It appeared to be slightly less in pH 6.5 water than in 7.0 water.

Organic Coolant Studies. The ORA-1 corrosion loop was started up after revisions to install greater capacity for testing samples. Presently in the loop are coupons of 1050 carbon steel, 2S and M257 aluminum, A231 and pure magnesium, and Zircaloy-2. Along with the coupons are hot pressed, nickel diffusion barrier slugs, and a dag (graphite) barrier slug. The loop ran for 10 days at 370 C at which time a pump bearing burned out. Following repairs the loop was placed in operation again.

Ex-Reactor High Temperature Loop Studies. To determine the corrosion rates of aluminum alloys and other materials, loop ELMO-2 is operating at 180 C and pH 4.0 with H_3PO_4 addition. Examination of coupons discharged after four weeks exposure disclosed nothing unusual. Corrosion rates have not been determined yet. The stainless steel coupons, both sensitized and non-sensitized, were in good condition. The test is scheduled to continue for approximately four more months.

In the ELMO-5 facility a test is under way to determine corrosion rates in high pH water with silica addition. The first two weeks operation at test conditions of SiO_2 approximately 7 ppm, pH 9-10, 290 C, 20 fps velocity and continuous clean-up showed that the aluminum coupons had severe corrosion. A new test is to be started about October 1 with increased SiO_2 concentration, possibly as high as 350 ppm.

Corrosion tests with high concentration of phosphate are being performed in the ELMO-6 facility. The current test at 300 C, pH 4.5 with H_3PO_4, and 150 ppm $PO_4^{\equiv}$ has been operating for 1609 hours. The severe erosion-corrosion of M-388 and M-400 is still occurring. The ALCOA alloys 192263, 192264, and 192265 are holding up relatively well with only a minor amount of pitting in the 192263 alloy. Chalk River alloys 10182 and 10197 have been charged into the semi-static portion of the loop. The test is scheduled to run for about two more weeks.

Two elements each of Elephant and Cow types were run for one week in the ELMO-7 facility at 200 C, 1200 psi, in 4.5 pH water to determine if the M-388 aluminum "suitcase handle" shaped element supports would bend at

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this temperature. No bending was observed although several of the rails were damaged during discharge. No blisters were formed at the welds attaching the supports to the slugs as was observed on previous elements tested at 300 C. To check on this phenomenon, the same elements as run at 200 C plus an additional Elephant slug for a check piece were run at 300 C, 1600 psi, for a week. Blisters were formed at this temperature. Metallographic examination of the blisters formed in the initial 300 C test indicated that the metal had flowed to form the blister. It is presumed the blisters were formed by gases entrapped during welding expanding and forming the pockets when the aluminum was weakened at the 300 C temperature. There was no indication of the weld attachment being appreciably weakened by the formation of the blisters.

High Temperature In-Reactor Loop Tests. Loop KER-1, which is made of carbon steel, was out of service owing to its being re-converted for use with water as a coolant.

Pile operating difficulties continued to hamper the operation of loop KER-2 at temperature during the first week of September. The tube is charged with ten Cow slugs and is operating at 180 C and a pH of 4.5 with H_3PO_4. The loop was on process water twice during the month, once due to electrical fluctuation caused by a broken conduit in a neighboring loop and the second time because of a high neutron fluctuation and a need to replace packing on several of the loop valves.

Repair of the faulty pump in loop KER-3 was completed and the equipment was checked out. Twenty-four-rod stainless steel clad cluster fuel elements were charged into the loop on September 19, 1957. The test is designed for loop operation at 240 C and a pH of 6-7 with high purity water. The suggested operating time is approximately three months. As a result of equipment failure the water temperature will be only 80 C for the next two or three weeks.

Loop KER-4 now serves to expose aluminum clad fuel elements at 200 C with deionized water with sufficient phosphoric acid to keep the pH at 4.5. The loop is still operating with Cow slugs at 200 C. The loop was on process water three times during the month: (1) broken electrical conduit in loop #3 caused power fluctuation which caused rupture proceedings, (2) for packing of a valve, (3) high false reading on neutron counter caused rupture proceedings plus the fact that the packing on several valves needed to be replaced. As soon as enough Cow type oxide slugs are available, the current test will be terminated and the loop will be recharged with these slugs. Operation will then begin at 235-240 C with a pH of 4.5 with H_3PO_4.

Radioactivity of Water in the In-Pile Recirculating Loops. The radioactivity study for the KER loops was continued. The first samples of water drawn from the loops under reactor equilibrium conditions have been analyzed for short half-life isotopes. There is a noticeable change in the relative amounts of activity contributed by the short half-life isotopes. Approximately sixty percent of the activity in both the K2 and K4 loops under pile equilibrium conditions comes from Mn-56. Samples

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taken shortly after start-up show a five to fifteen percent contribution to the total activity by Mn-56. During reactor equilibrium conditions about ninety percent of the total radioactivity in Loop 2 comes from Si-31, Na-24, Mn-56, and P-32. The same four isotopes gave seventy-five percent of the activity in Loop 4. The total beta activity for K2 and K4 has not reached equilibrium. Studies are under way to determine if the activity in the KER loops will reach a fairly constant value.

Decontaminating Solutions. Studies were made to evaluate the consequences of flushing H Reactor rear face with Turco 4306-B. The corrosion rate was sufficiently high that the use of Turco is not being considered as a routine decontaminating agent. Some additional tests are being made in the mockup tubes.

Mechanical Equipment Development

Installation of the Mechanical Organic Test System (MOTS-1) continued during the month. The instrument panel, instruments, and service lines were completed. As soon as the cooling water lines are connected to the pump, preliminary start-up tests will begin.

Preliminary MIPB fire tests were conducted under the supervision of the 300 Area Fire Department. These tests were carried out in the open air to obtain ignition and extinguishing data for use in the planning of further tests on a small loop. The test results are as follows:

1. MIPB would not ignite at room temperature. It was necessary to heat the fluid almost to the boiling point.

2. The fluid gives off a dense black smoke and burns with a considerable amount of heat.

3. The first action of any extinguisher produces a flare-up of the fire and an increase in the amount of heat.

4. While dry powder, carbon dioxide, and fog extinguishers will put out the fire, the fog type extinguisher was the most effective.

5. MIPB fires are more difficult to extinguish than gasoline fires.

Thermal Hydraulic Studies

Flow Hazard Studies. The experimental heat transfer studies of the transient response of a reactor process tube to imposed hazardous operating conditions were continued. A simulation was made of the response of a K process tube to the sudden loss of power to K process pumps with the subsequent decay in flow and power, for tubes at an initial power level of 1250 KW and with initial outlet water temperatures of both 90 and 125 C. No unstable flow conditions were encountered. Steady state boiling curves were determined for a C process tube at tube powers of

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500 and 1250 KW. Experiments were extended to flows considerably lower than previous runs and were terminated near the point of burnout as indicated by heater rod surface temperatures on the order of 450 C. The resulting curves were quite similar to those for K Reactor as reported in HW-51358 and indicate that tubes in the fringe zones are not subject to unstable flow conditions. Extended boiling curves were also determined for BDF type process tubes at several tube powers between 300 and 1250 KW. The results, reported in HW-52284, indicate that there is more pressurization at the tube inlet for low flows with BDF type process tubes than for K or C tubes. Thus, BDF process tubes are more subject to unstable flow conditions but are also more likely to experience a high pressure Panellit trip after an accidental flow reduction. Five transient heat transfer experiments were performed using a C type process tube and a heater rod which simulated solid slugs. Sudden plugging events were simulated in these runs with initial conditions of 1250 KW tube power and 125 C outlet water temperature. Excessive heater rod temperatures were not encountered even following initial flow reductions as severe as 80 percent.

Hydraulic Studies. An attempt was made to determine the interjunction flow encountered in I & E slug trains when a pressure differential exists between the internal and external cooling channels due to partial plugging of one of the channels. This was done by introducing water into the hole channel of a four-slug train and allowing the water to discharge to atmosphere through three slug junctions when the downstream end of the hole channel was plugged. Determinations were made of flow rate as a function of inlet pressure for various forces holding the three slugs together. It was found that interjunction flow was very sensitive to slug positioning. Even small amounts of slug cocking changed the results substantially. However, it was possible to use the results to size holes to be drilled in I & E heater rods to allow simulation of interjunction flow in transient heat transfer experiments.

Experiments were completed where tube inlet screens were intentionally plugged on the hydraulics apparatus. The flow and pressure drop relations were determined for a large variety of plugging occurrences. It was observed that for K screens a blockage of approximately 95 percent of the free area of the screen would be necessary to cause a decrease in flow of 50 percent. As a comparison it was found that at normal conditions of front header pressure the K screens allow about twice as much flow as the CG-558 screen or crosswire for the same percentage of area plugged.

Experimental work has been completed to determine the ability of C and K tube temperature monitors to indicate the actual water temperature at the end of the active section. It has been concluded that both the C and K temperature monitors, at their present location, cannot indicate true values of outlet water temperature if the temperature is above the saturation temperature corresponding to the rear header pressure. Considerable improvement can be realized at C Reactor if the location of the temperature monitor is moved upstream near the rear nozzle barrel, as is being proposed in the revised CG-666 zone temperature monitor assembly.

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Organic Heat Transfer Coefficients. Additional data were obtained concerning heat transfer coefficients for unirradiated MIPB. These data were obtained at wall temperatures up to 705 F, heat fluxes up to 432,000 B/hr sq ft, and velocities up to 35 ft/sec. The measured coefficients were higher than those calculated by the Dittus-Boelter equation by amounts of from 6 to 27 percent.

Irradiation Testing Engineering

Shielding Studies. Foils from the first test of unheated ordinary concrete and of the second test of Magnetite heated to 200 C were removed and counting is about 90 percent complete. The ordinary concrete was reloaded and the Magnetite was moved to the oven for heating to 300 C.

Data from the 100 C Magnetite tests were analyzed and plotted. The fast neutron relaxation length increased from 8.7 cm (unheated) to about 9.5 cm (100 C), with corresponding (but larger) increases in thermal and resonance neutron flux. Front to rear traverses on each layer indicate a good possibility that leakage up the sides of the well is seriously affecting measurements in the outer part of the well. A special loading carrying many more foils than usual has been prepared to investigate this effect by means of more detailed side to side and front to rear traverses.

Surveys with the neutron dosimeter were completed at the D, C, and KE Reactors to determine the relative effectiveness of the shielding on the front face and the top of the reactors. Additional measurements were taken at test holes at the different experimental levels at each reactor. Results are being analyzed and prepared for documentation.

To measure the temperature distribution in the hottest portion of the C Reactor Shield Test Facility, ten thermocouples were installed behind the cooling panel of the nose piece. At thermal equilibrium the temperature ranged from 16 C behind the cooling panel to a maximum of 52 C in the steel eight inches from the nose piece. This and other temperature distributions to be obtained will be used as a basis for evaluating other thermal shield designs.

A preliminary survey of methods available for counting foils was made. The costs and expected results of each method were included. The methods evaluated were (1) purchase of service of foil counting from the Radiochemical Laboratory of the Analytical Laboratories Operation, (2) continue the present technique of using GM tubes, considering also the infinite life halogen quenched tubes, and (3) convert to gas flow proportional counters. The latter method appears to offer the greatest advantages. To evaluate this method a windowless gas flow proportional counter and necessary amplifiers and discriminator were assembled and placed in operation.

The mathematical procedures used for correlating counting data have included a correction factor for foil weight. To determine if such a factor is really necessary, twenty 1/4" gold foils were irradiated in the same flux in the 305 Pile. The weight of these foils varied as much

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as 30%; however, the activities of these foils varied only ±5%. If the weight of the foil is selected in the range from 0.0860 gram to 0.0890 gram, which includes 98% of the foils, the standard deviation would be only +1.4%. Correction factors for variation of foil weights for 1/4" foils do not appear necessary. A similar check is being made on the 7/8" gold foils. New instrument factors for the counters in the counting room have been obtained. They are approximately a factor of two greater than those used in the past.

Irradiation Testing. The monthly status report, "Status of Production Tests of Special Interest to Hanford Laboratories Operation - September 15, 1957," HW-52741, was issued. There were no irradiation tests completed or charged during the month.

The low goal exposure fuel elements from test IP-59-A, corrosion of chromic acid autoclaved fuel elements; IP-44-A, irradiation of vacuum canned fuel elements, and IP-45-A, irradiation of hot press fabricated elements were discharged during the month.

Nonmetallic Materials Development

Irradiation of Candidate Organic Coolants. Exposure of monoisopropyl biphenyl (MIPB), monomethyl biphenyl (MMBP), and biphenyl (BP) in the Snout II Test Hole of KW Reactor at temperatures between 50 and 340 C has given some preliminary clues as to the nature of the radiolytic decomposition of these materials. Gases evolved from BP contained only small amounts of hydrocarbons at all exposure temperatures. A continually increasing amount of hydrogen and tar formation resulted as the temperature was increased. In the case of MMPB and MIPB, the effect of increasing the exposure temperature was primarily an increase in the amounts of hydrogen produced. Only slightly greater amounts of hydrogen were produced at the higher temperatures while the viscosity and the percent tar formed actually decreased. Either the hydrogen evolved is not accompanied by an increase in polymerization to any great extent or the increased temperature results in the thermal decomposition of the polymer formed. A report, "The Effect of Reactor Irradiation on Candidate Organic Coolants," HW-52814, described the results in detail.

Infrared Studies of Plastics. Relative oxidation values of Marlex 50, a highly crystalline polyethylene, indicate that it is more resistant to oxidation in a gamma field than Alathon 3, NC-10, which is less crystalline. However, radiation damage to the useful mechanical properties is more severe in Marlex 50. For example, after 10^8 r, thin films of Marlex crumble to the touch whereas Alathon 3, NC-10 can be handled easily. This indicates that oxidation is not a principle factor in causing radiation damage to the mechanical properties. This point will be further clarified when results are obtained for polyethylene irradiated in a vacuum.

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Gamma Irradiation of Plastics and Elastomers. Of all the elastomeric materials evaluated to date, the polyurethane type elastomers are superior in their resistance to gamma irradiation. They are still flexible, do not break when bent 180 degrees, and possess a marked degree of their original toughness after an exposure of 10^9 r. However, the resistance of the common polyurethane elastomers to water above 100 C is poor. Other types of polyurethanes and methods of compounding which may result in better hot water resistance have been suggested by these tests, and such materials are currently being fabricated.

It has been found that the properties of practical and commercial silicone elastomers of a given chemical type approach the same value at about 10^8 r, regardless of their cure schedule, curing materials, or filler loading. Certain silicone materials become hard and brittle at 10^8 r. A softer material of the same type will not have improved properties after an exposure of 10^8 r.

Report HW-49560, "Elastomers for Use in Radiation Fields, IV. Effect of Gamma Radiation on Heat Resistant Elastomers," has been issued.

Ceramic Coated Graphite. Graphite which was coated with a 0.010-inch layer of alumina to test its possible application to reactor use has recently been irradiated in an uncooled graphite channel at KW to determine the stability of the coating and oxidation inhibition afforded in an actual graphite burnout experiment. The appearance of the coating was unaffected by irradiation at about 600 C for 1300 MWD/AT. The weight loss of the sample was 0.32 percent per 1000 operating days. This result may be contrasted with a weight loss of only 0.12 percent per 1000 operating days for uncoated graphite samples in the same location. Although no explanation of the greater weight loss of the ceramic coated sample is confirmed, one possibility that is being investigated is that the graphite in the coated sample ran at a significantly higher temperature due to the greater gamma heat generation in the alumina and the poor thermal conductivity of the coating.

High Temperature Graphite Irradiations. Preliminary design for a high temperature graphite irradiation facility in the Engineering Test Reactor has been started which will supplement the badly needed data now being obtained at a limited rate in the Materials Testing Reactor.

The MTR irradiation of graphite, GEH-9-5, is continuing in the fourth and final cycle at controlled temperatures of 975, 750, 750, and 600 C. This assembly will be discharged the week of October 7, and the samples will be recovered in mid-November.

Exposures of GEH-9 samples have been reported as the best estimate of an equivalent Hanford dose in MW/T. These estimates were made from a comparison of damage accumulated in Hanford reactors and the MTR at ~40 C. The estimates are considered accurate enough to indicate any gross changes in the damage rate of graphite in going from 500 C to 750-1000 C, but more accurate estimates cannot be made until further experimental correlations at the same high temperature are made. These are planned.

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MTR exposures are more accurately known in terms of the integrated neutron flux above and below 1 mev as given in the table.

Neutron Exposures of GEH-9 Irradiations

Experiment	MTR Exposure Megawatt Days	Sample 1	Sample 2	Sample 3	Sample 4
GEH-9-2	1373.7	1.0×10^{21} Total	8.3×10^{20} Total		
		1.6×10^{20} Fast*	7.9×10^{19} Fast	2.4×10^{19} Fast	4.8×10^{18} Fast
GEH-9-3	1009.4	7.6×10^{20} Total	6.1×10^{20} Total		
		1.2×10^{20} Fast	5.8×10^{19} Fast	1.7×10^{19} Fast	3.5×10^{18} Fast
GEH-9-4	1621.2	1.2×10^{21} Total	9.8×10^{20} Total		
		1.8×10^{20} Fast	9.3×10^{19} Fast	2.8×10^{19} Fast	5.6×10^{18} Fast

*Fast flux in nvt greater than 1 mev.

Graphite Burnout Monitoring - PT-IP-25A. The first set of samples monitoring graphite burnout rates at KW Reactor was discharged from 1880-KW on 9/17/57, after an effective exposure of 139.4 operating days. The average burnout rates are tabulated as a function of position in the channel.

Graphite Burnout - KW Reactor

Distance in feet from front van Stone flange to centerline of boat	Average burnout rate in percent per 1000 operating days
15.75	0.076
17.6	0.074
19.4	0.112
21.25	0.122
23.1	0.120
24.9	0.129
26.75	0.100
28.6	0.139
30.4	0.128
32.25	0.133

These data show that the rate of burnout of the graphite moderator in KW Reactor during this period was quite low.

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Structural Materials Development

Zircaloy-3, BDF Process Tubes. Superior Tube Company was successful in tube-reducing eight, 50-ft tubes without apparent cracking of the Zircaloy-3. Two of the extruded blanks exhibited a twist due to an error in extrusion and these tubes exhibited excessive twist after tube reducing. Tubes reduced from uniform wall, extruded blanks exhibited a relatively uniform wall after tube reducing, varying from 0.038 to 0.045 inch. The tubes were somewhat bowed and Superior will attempt to straighten them using short lengths produced during experimental tube reducing operations. If the straightening problem is not solved within two weeks, the slightly bowed tubes will be shipped to HAPO and efforts will be made to install them in a reactor.

The 13 billets remaining on this order will be extruded with an external rib to produce a uniform wall, extruded tube. It now appears possible that this contract can be completed during January 1958.

Allegheny Ludlum has successfully extruded the balance of the tube blanks for the production of 15 to 20 process tubes. External surface conditioning has been completed and tube reducing will start in October.

KER Type Process Tubes. Allegheny Ludlum has successfully extruded five of 12 blanks to be used in experimental tube reducing of ribbed and ribless, KER size process tubes. Tube reducing of these extruded blanks should be completed during November, and if the experiments are successful, new full length KER process tubes will be ordered at that time.

Zircaloy Quality Control. A series of three tests of selected Zircaloy-2 and 3 samples in 800 psi steam at 400 C for 24 hours was completed. Analyses of the results of samples of the same lot of material exposed in each test revealed a marked difference between tests. In a particular test the weight gain of Zircaloy-2 was equal to that of samples of Zircaloy-3 to be used in PRPR jacket tubing. All samples corroded more severely than would be expected from data published by Lustman and Kass of WAPD. A new series of tests was initiated to compare the corrosion rates of Zircaloy-2 and -3 at 360 C and 400 C for periods of time up to two months.

B. WEAPONS - 3000 Program

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C. CUSTOMER WORK

Corrosion of Reactor Rear Face Materials

The use of a proprietary cleaner (Turco 4306-B) containing sulfamic acid, chloride, fluoride and wetting agents was of interest for decontaminating the rear face piping, pigtails and nozzles of 100-H Reactor. The corrosive nature of this compound led to a quick laboratory investigation of its effects on stainless steel and aluminum. Although the material should be useable on a non-routine basis, frequent periodic use for rear-face decontamination is not encouraged because of fairly rapid corrosion of aluminum (0.33 mil in 10 minutes), and because the vapors from the solution cause rusting of 18-8 stainless steel.

Radiometallurgy Service

Hunter-Douglas Hot Spot Failures (RM-201). The examination of the first of four hot spot failures in Hunter-Douglas aluminum cans was continued. Metallographic examination of a jacket section taken near the edge of the hole revealed severe intergranular corrosion. No evidence of operation above the beta transformation temperature was observed in a uranium wafer taken from the hot spot area.

Examination of Split Rupture from 1178-KE (RM-202). A typical example of a split rupture from the rupture experience of KE during July and August was selected by Irradiation Processing Department for examination to determine the cause of failure.

Visual examination showed the uranium and can were split along the diameter for the full length of the slug through one of the rib marks. Only the aluminum base and cap ends held the slug intact. The slug was bowed at right angles to the split at the center of the slug from corrosion product formation but no warp was noted.

Five transverse wafers were removed along the length of the slug from 2-1/2" from the base end to 2" from the cap end for metallography and hardness samples. Microscopic examination of three wafers revealed impurities in the form of inclusions and stringers. The impurities were not distributed randomly but were concentrated in several pockets throughout the length of the slug. Macro viewing of the three etched wafers showed a fine grain structure at the central axis of the slug approximately 3/16 inch in diameter surrounded by a large grained band approximately 1/8 inch across. This formation is 1/8 inch off center (toward the rib side) with respect to the central axis of the slug. Hardness testing of the wafers showed a decrease of approximately four points R_A when crossing the border of the affected area at the center of the slug.

Metallography Service

Examination of some additional Edison resistance thermometer elements recently removed from the K Reactors revealed a poor surface condition on the stems as described in HW-49756. Two "leakers" were suspected as evidenced by the soggy appearance of the interior components of the elements when they were sectioned.

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The use of "Spotcheck" dye penetrant located a hairline crack in each of the element stems in areas of unusually poor surface appearance. Process coolant water had entered and short-circuited the elements. An examination of a number of resistance thermometers produced by the Lewis Engineering Company is presently being conducted. Lewis units are monel whereas the Edison are stainless steel. Previous examination of a prototype model (HW-49756) disclosed that the as-fabricated Lewis units exhibited a far superior surface appearance.

Additional aluminum jacket defects were investigated for FPD during the month. Three defects showed the appearance of those described in last month's report, i.e., a longitudinal scratch running the entire length of the jacket. Two of the three examined were merely superficial scratches, while the other was a lap or fold as described previously. Another defect similar in nature was discovered when, after canning, a line of small blisters two to three inches in length was detected on the jacket. Five to ten mils beneath this line of blisters was a small seam caused by a defect in the original blank which increased in magnitude under each individual blister as the result of an increase in void spaces or dirt content. The expansion of entrapped gas in these void spaces, or the volatilization of some entrapped material (such as a lubricant used during the fabrication process) apparently caused the blisters to form when the jacket was heated during the canning operation.

Samples Processed During the Month

Total samples processed: 199

Photographs:

Micrographs	168
Macrographs	42
Total	210

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-52859 A2.

F. W. Albaugh

Manager, Reactor and Fuels Research
and Development Operation

FW Albaugh:kb

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VISITS TO OTHER INSTALLATIONS (CONT)

Name	Dates of Visit	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
KR Merckx	9/23-24	GE - GEL, Schenectady	Consultation on thermal stress & contributor at Co. symposium on Numerical Methods	H Portisky	No
	9/25	KAPL, Schenectady	Consultation on cyclic strain tests, thermal stresses.	E Baldwin Mr. Fritz	Yes
DC Kaulitz	9/17-18	AEC-IOO & Phillips Pet. Co., Idaho Falls, Ida.	Discussions pertinent to installation of ETR loops	Mr. Phillipson RJ Nertney	Yes
GT Geering	9/23-24	Nuclear Metals, Inc., Cambridge, Mass.	Discuss progress on development contract	HR Sawyer	Yes
	9/25-27	ANL, Lemont, Ill.	Consultations on U fabrication	JF Schumar	Yes
HJ Pessl	9/23-24	Nuclear Metals, Inc. Cambirdge, Mass.	Consultation re fuel development work	P Loewenstein	Yes
	9/25	GE Research Lab., Schenectady	Discussion of facilities and orientation	DW Lillie	No
LD Turner	9/13	WAPD, Bettis Field, Pittsburgh, Pa.	Attend Hot Lab. Operation Round Table Meeting	RC Westphal	Yes
HP Oakes	9/9-12	Damascus Tube Co., Greenville, Pa.	Consult on Zr welding	BB Burd	No
JW Riches	9/4	Allegheny Ludlum Steel Corp., Albany, N.Y.	Consult on Zr fabrication	RE Rohrabaugh	No
	9/5-6	Damascus Tube Co., Greenville, Pa.	" " " "	BB Burd	No
PJ Pankaskie	9/9-10	Western Pneumatic Tube Co., Seattle, Wn.	" " " "	Mr. Eckman	No
	9/19	Superior Tube Co., Norristown, Pa.	" " " "	HW Cooper	No
	9/20	Allegheny Ludlum Steel, Watervliet, N.Y.	" " " "	RE Rohrabaugh	No

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VISITS TO OTHER INSTALLATIONS

Name	Dates of Visit	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
JA Ayres	9/9-11	New York City	Attend ACS meeting.	--	No
	9/12-13	ANL, Chicago, Ill.	Attend meeting of Aluminum Task Force Committee and to confer on corrosion problems.	JE Draley	Yes
DR deHalas	9/4-6	AEC, Div. of Reactor Dev., Washington, DC	Discuss organic coolant fouling tests	CT Ewing RP Schmitz	Yes
RJ Anicetti	9/3	GE, Philadelphia, Pa.	Discuss high temperature technology	L McCreight	No
	9/4	WAPD, Bettis Field, Pittsburgh, Pa.	Attend UO Panel Meeting	J Belle	Yes
B Mastel	9/9-11	MIT, Cambridge, Mass.	Electron Microscope Soc. of Amer. Mtg., present paper	--	No
	9/13	Franklin Institute Philadelphia, Pa.	Discuss mutual problems in metallography & electron diffraction	H Wilsdorf	No
	9/16	GE Research Lab., Schenectady, N.Y.	" " "	J Newkirk	No
HW Newkirk	9/9	Alfred U., Alfred, N.Y.	Present paper at Amer. Ceramic Society	--	No
	9/10	Natl. Bureau of Stds., Washington, DC	Conference on ceramic fuel element fabrication, ex-reactor thermal studies.	S Zerfoss	No
	9/11	GE Research Lab., Schenectady	Same as above.	DW Lillie	No
	9/12	Sylvania Corning Corp., Bayside, L.I., N.Y.	" " "	B Kopelman	Yes
	9/13	ACS Meeting., New York City	Present paper	--	No
DR Stenquist	9/9-10	Alfred U, Alfred, N.Y.	Present paper at Amer. Ceramic Soc.	--	No
	9/11	Induction Heating Corp., Brooklyn, N.Y.	Consult on dielectric heating as applied to drying & sintering of UO_2	TJ Stanton	No

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VISITS TO OTHER INSTALLATIONS (CONT)

Name	Dates of Visit	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
VH Troutner	9/30	GE X-Ray Dept., Milwaukee, Wisc.	Demonstration of x-ray microscope application to HAPO research projects	SM Summer	No
FW Albaugh RM Fryar JR Triplett	9/13 9/13-17 9/13-17	AEC, Washington	Discuss PRPR	UM Staebler	Yes
JM Skarpelos	9/16-20	UCRL, Livermore, Calif.	Consult on Project Whitney	LA Fitzgerald W Harford	Yes
		True Trace Co. El Monte, Calif.	Conversion of Axelson milling machine	LM Cross	No

VISITS TO HANFORD WORKS

Name	Dates of Visit	Company & Address	Reason for Visit	HW Personnel Contacted	Access to Restricted Data	Bldgs. & Area Visited
JA Fellows RS Hartmann AE Ruehle	9/9-12	Mallinckrodt Chem.Wks., St. Louis, Mo.	Metal Quality Working Committee Meeting	JJ Cadwell JE Minor EA Evans	Yes	326, 300
KR James	9/18	Metallizing Eng.Co., Seattle, Wn.	Instruct in welding techniques on flame spraying & metallizing	LJ Chockie	No	326, 300
IF Zartman	9/27	AEC, Div. of Reactor Dev., Washington, DC	Discuss organic coolants & effects of irradiation on graphite & elastomers	LH McEwen FW Woodfield RE Nightingale JM Davidson	Yes	328, 300
E Zebroski	9/23	General Electric Co., San Jose, Calif.	Technical information re PRPR	FW Albaugh RM Fryar EA Evans MD Freshley	Access Permit	328, 300 713, 700 325, 300 231-Z, 200 W

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PLUTONIUM RECYCLE PROGRAM

MONTHLY REPORT - SEPTEMBER 1957

REACTOR & FUELS RESEARCH & DEVELOPMENT OPERATION

Plutonium Fuels Development

Al-Pu Capsules for MTR Irradiation (GEH-3-24). Two capsules of Al - 1.65 w/o Pu and two capsules of Al - 12 w/o silicon - 1.65 w/o Pu alloy have been irradiated in the MTR to determine the irradiation behavior of this material. The four capsules successfully completed the in-reactor exposure periods; however, monitoring of the flux wire indicated that the samples were exposed to a lower flux than was requested. Instead of 25 percent burnout of the Pu atoms, capsule #1 received only 15-19 percent and capsule #3 only 9-12 percent. The capsules were inspected and measured and no abnormalities were detected. It was decided to recharge two of the capsules into the MTR and irradiate each for an additional two cycles in order to more nearly approach the desired Pu atom burnup of 50 percent. Arrangements were completed in the MTR for the reinsertion of the capsules in an effective thermal neutron flux of 2.9×10^{14} nv and the samples were charged into the reactor on September 16, 1957. The remaining two capsules are currently undergoing radiometallurgical examination. During removal of the capsule jackets the alloy cores were deformed and the surfaces were galled and scored. Reliable post-irradiation physical measurements could not be made; however, there was no visible indication of any dimensional instability.

Al-Pu Alloy Clusters for KER Irradiation. In an effort to approach the actual fuel element operating conditions of the PRPR, four-rod clusters of Al - 8 w/o Pu and Al - 12 w/o silicon - 8 w/o Pu alloy will be irradiated in the high temperature (250 C) KER loop facility. The increased Pu concentration (from 1.65 w/o Pu to 8 w/o Pu) is required in order to duplicate the specific power generation expected in the PRPR because of the lower neutron flux in the KER loop.

The fuel rods will be PRP size, i.e., 0.504" OD cores with 0.030" thick Zircaloy cladding. The following clusters will be prepared for this test: (a) one cluster with stainless steel clad aluminum cores for hydraulic tests, (b) one cluster with Zircaloy clad Al or AlSi alloy cores for high temperature in-pile tests in the ELMO loop, (c) one cluster with Zircaloy clad Al-Pu and Al-Si-Pu alloy cores for 305 Pile tests, and (d) two clusters with Zircaloy clad Al-Pu and Al-Si-Pu alloy cores for irradiation testing in the KER loop facility.

The four-rod clusters will be quite similar in appearance to the stainless steel clad closures with uranium cores that have been fabricated at Hanford. The overall length of the clusters will be 11" maximum, which is the longest length that the radiometallurgical examination facility can accommodate. Casting of the fuel core material and examination and fabrication of the jacketing components is currently under way.

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Impregnated Graphite Test Assembly. Three test assemblies containing PuO_2 impregnated graphite have been fabricated for PCTR testing. Initial attempts to fusion weld the end closures were unsuccessful and sound closures were effected by soldering. The end cap design was changed to accommodate this type of closure and the final closures were leak tested in a vacuum bubble tester.

Vacuum Injection Casting. Preliminary experiments have successfully demonstrated the feasibility of vacuum injection casting 2S Al into stainless steel tubing. Experiments with casting Al-Pu alloy fuel material directly into Zircaloy tubing will follow the successful development of the process using pure Al. An appreciable effort will be put into the development of these processes for the fabrication of the fuel elements for the PRPR. If successful, this method of fuel element fabrication has a decided economic advantage over normal fabrication methods. Stainless steel tubing, 3/4" OD with a 0.035" wall thickness has been filled with Al by this method in lengths up to 7' and concentric or I & E type fuel elements have been fabricated in lengths up to 6' 10". These pieces were made by pumping on one end of the tube while inserting the other end into a bath of molten Al. Another method was successfully used in filling a stainless steel tube with Al, 3/4" in diameter and 8' 4" long. In this method, one end of the tube was closed with a stainless steel plug and a short length of Al tubing was soldered to the other end of the tube. The jacket was evacuated and the Al tube was sealed off by cold pressure welding, thus leaving the interior evacuated. The fusable plug on the end of the stainless steel tube was submerged beneath the surface of the molten Al. The plug immediately melted and atmospheric pressure forced the molten Al to the top of the tube. Radiographs of two, 3/4" diameter tubes, filled with Al by these methods, showed that the Al was relatively sound with some micro-shrinkage voids and a few gas voids which were probably caused by improper degreasing.

The pattern of the micro-shrinkage shows that the Al apparently feeds into the tube through a tube of solidified metal which is on the surface of the tube walls. The x-ray also showed that the Al was in intimate contact with the jacketing with no gap existing between the two. Since the Al conforms to the exact shape of the tube, it is possible that the tubing tolerances could be relaxed, thus resulting in a considerable cost savings. Several techniques for producing vacuum injection cast fuel elements with contamination-free external surfaces are being considered.

Pressure Injection Casting. The development of a method of casting Al-Pu alloy fuel material directly into the can by pressure injection casting is progressing. The design and detailed drawings of components for the pressure injection casting machine were completed. The fabrication of the major components has been completed and the other necessary parts are being assembled.

Powder Metallurgy Extrusions. Billet preparation by powder metallurgy techniques is being considered as a method of producing homogeneous billets. A mixture of Al powder and PuO_2-UO_2 mixed crystals is cold or hot compacted into an homogeneous billet. This billet is then hot extruded either bare or in an uncontaminated Al jacket. Work is under way to determine the optimum density for extrusion and the effect of extruding several short compacts at once rather than single long billets. Plain Al powder of a -100 mesh was cold compacted at several different pressures at a 1.416" diameter die. These compacts will be hot extruded in the near future.

Roll Cladding. Contamination is one of the major problems in fabricating Al-Pu fuel elements. To minimize this problem, it has been proposed to clad Al-Pu fuel materials with uncontaminated Al sheaths during fabrication to prevent the spread of contamination. Hot rolling of such component billets is one possible method of fabrication. The Al-Pu core material is cast directly into an Al jacket and then hot rolled to size. Three cores were cast directly into 1.428" OD Al cans with 0.035" wall thickness and metallurgical bonds were formed in two of the casting operations. All three were hot rolled at 300 C to a reduction of approximately 50 percent. Reductions were made in an octagon pattern on flat rolls and in all cases the bond formed by casting was broken up. Work will continue on this fabrication method.

Fuel Material Corrosion Studies. Metallographic examination is continuing on the autoclaved capsule which had been intentionally defected. The Zircaloy clad specimen had a composition of Al - 1.5 w/o U - 1 w/o Ni - 0.5 w/o Fe. The U was used as stand-in material for Pu. Hydrogen embrittlement of the Zircaloy cladding occurred due to the gas evolution of the Al water reaction. Two samples of Al - 12 w/o Si - 5 w/o U alloy are awaiting fabrication of the jacketing components. This alloy is of interest since the silicon addition is reported to improve the corrosion resistance of the fuel material.

Fuel Element Cluster Studies. A simulated full size NPD type 19-rod cluster fuel element using pure Al as the core material in stainless steel jacketing is being fabricated for hydraulic flow tests. Several new end fitting designs are being considered for improvement of the flow characteristics and assembly techniques.

Zircaloy-3 Tubing for PRPR Fuel Element Development. Examination of the six pieces of Zircaloy-3 tubing received from Wolverine Tube Company to be used for PRPR fuel element development is continuing. All specimens have been radiographed and inspected with a probalog. A report of the test results has not yet been received, and the spectrographic, metallographic, chemical and surface finish examinations are in progress.

Extrusion Press. All tooling fabrication alterations and installation for the 125-ton extrusion press were completed. The press was temporarily installed in the 272-Z Building until adequate room is available in the 231-Z Building. Design of a hood for this press has been initiated.

Facilities. Room has been made available for the oxide preparation hood which is being installed at the present time. Installation should be completed by October 15. The purchase requests for the accessory equipment required for the operation of the hydrogen sintering furnace have been submitted.

PRPR Fuel Examination Facility. Discussions have been held concerning the requirements of the fuel element examination facility in the PRPR. The Ceramic Fuels Development (CFD) and the Plutonium Fuels Development (PFD) groups have jointly outlined their requirements of such an examination facility.

Plutonium Fabrication Pilot Plant. Several building plans and designs were considered prior to the submission of the Plutonium Fabrication Pilot Plant scope for approval by the AEC. The facility, as scoped, will be a two-story structure with approximately 24,000 sq ft of process area on the first floor and about 9,000 sq ft of

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useable space on the second floor. A single story 7,000 sq ft structure, containing office, change rooms, lunch room, cold laboratory facilities, etc., will be attached to the front of the two-story structure. A scope package containing preliminary drawings and estimates for the building, utilities, and equipment has been submitted to the AEC for their approval. Equipment details necessary for formulating bid specifications and building design features are being supplied to CEO.

U-Pu (PCTR) Test Elements. The tooling required for the fabrication of the traverse section monitoring assemblies has been completed. Casting is continuing on the second, 40 U-Pu 8" slugs which simulate 2000 MWD.

UO_2 Fuel Development

M-388 Clad, I & E Cooled Uranium Dioxide Thermocouple Slug, GEH-4. The two most accepted values for the thermal conductivity of uranium dioxide vary by a factor of two. Neither of these values probably approximates the thermal conductivity of the extensively cracked uranium dioxide in a fuel element heated to high, varying temperatures under irradiation. To check calculated core temperature, power generation, and heat transfer characteristics of a tubular uranium dioxide fuel element, a Ni-Al clad I & E slug was designed, fabricated, and shipped to the MTR for irradiation. External dimensions of the element were 1.474" OD x 0.374" ID x 8.850". A swaged MgO, stainless steel clad thermocouple was located in the uranium dioxide core at a position of 0.434 ± 0.002" from the longitudinal axis of the slug, and 4.140 ± 0.050" from the top end of the slug. It is in intimate contact with the uranium dioxide core. The thermocouple passes through a swage-lock fitting in the end of the slug. This fitting is covered with lead to insure a gas-tight closure in the event the fitting is inadequate. The slug was inserted in an MTR B-block basket in such a way that the tip of the internal thermocouple will be located at the maximum flux position of this facility during irradiation. Thermocouples were located above and below the slug to measure inlet and outlet water temperatures. Completion of the irradiation is expected in October.

Fabrication of KER Fuel Elements. Uranium dioxide cores for twenty-four, eight-inch, I & E fuel elements to be tested in the KER loop were fabricated to the required dimensions of 1.705" OD and 0.670" ID. The density of twelve of the oxide elements is 92 percent of the theoretical. The remaining twelve have a density of 94 percent. To save the time and money required to fabricate a die for cold pressing the KER elements, the fabrication technique involved: (1) pressing uranium dioxide powder into solid cylinders in an existing die, (2) isostatically pressing the cylinders to give them sufficient green strength for machining, (3) boring holes in the center of the pieces, (4) sintering for five hours at 1600 C, (5) honing the ID to 0.670", and (6) grinding the OD to 1.705", using a hard wheel grinder.

Sintering Studies. The use of activated uranium dioxide powders reduces fabrication costs by lowering the forming pressure and sintering temperature required to produce massive uranium dioxide fuel element cores. Variables relating to activation treatments and sintering temperatures were previously investigated. During the past month the effect of various compacting pressures and sintering times was examined. The objective was to determine densities obtainable by

sintering activated (2.3 m^2/g surface area) "PWR grade" uranium dioxide at 1600 C. Representative results were:

Time at 1600 C (hrs)	Compacting Pressure (tons/in^2)	Density (% of Theoretical)
1	35	92
8	5	92
8	35	96

A formal report was issued entitled: "Correlation of Surface Characteristics with the Sintering Behavior of Uranium Dioxide Powders."

Fabrication Studies - Tubular Oxide Cores. Massive uranium dioxide fuel elements have been sintered at 1600 C to densities as high as 94 percent of the crystallographic density. Typical data are summarized below:

Densities of UO_2 Tubes Pressed From 48-Hr Ball Milled Powder and Sintered at 1600 C

Method of Fabrication	Approximate Tube OD (inches)	Density, % of Theoretical Green	Density, % of Theoretical Sintered	Sintering Time(hrs)
Isostatic repressing at 48,000 psi	3.4	65	94.0	8
Same as above	3.4	65	92.5	4
Cold pressing at 30 tsi	1.6	64	94.2	8

The reduction in temperature from 1750 C to 1600 C was realized principally by increasing the time for which the UO_2 was ball milled.

Fabrication of "Garbage Can" Fuel Elements. A fuel element has been proposed in which the Ni-Al cladding is first filled with uranium dioxide powder and then isostatically pressed, forming an internally and externally cooled, ribbed element in one operation. Preparation of such an element, using enriched uranium dioxide for irradiation testing in the MTR, has not been successful because of non-uniform loading of the powder. Powder loading is not expected to be difficult when extruded, integral cladding components become available. Until then, it will be necessary to form the uranium dioxide in a mold and, after decarbonizing at 800 C, insert the oxide shapes into aluminum containers formed by machining. The final step will be to isostatically press to form the complete element. It has been determined that uranium dioxide shapes retain sufficient green strength for the subsequent handling required upon volatilization of the binder, and that an acceptable fuel element for MTR testing apparently can be fabricated by the process described.

Swaging of Uranium Dioxide. A study is in progress to determine the important variables in the swaging process and the reproducibility of results. During the past month various samples of uranium dioxide were hot swaged in stainless steel at 600 C. Densities of approximately 90 percent of the theoretical were achieved, compared to densities of approximately 80 percent obtained by cold

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swaging. A density of 94 percent was obtained with powder sintered and ground to simulate arc-fused oxide now on order for swaging studies. The hot swaged powders showed evidence of massive recrystallization, which may be a very significant factor in decreasing fission gas release from the uranium dioxide during irradiation. This recrystallization or sintering phenomenon has thus far not been adequately explained. Cold swaged samples are being subsequently heated to various temperatures to determine whether sintering of cold swaged oxide is possible at unusually low temperatures, without the simultaneous heating and compacting which occur during hot swaging. In preliminary experiments, cold swaged specimens apparently sintered at only 1000 C. This indicates that it is not necessary to postulate high, localized temperatures during hot swaging in order to explain the sintering observed.

Irradiation of Swaged Oxide Elements. The irradiation of two Zircaloy-2 clad, swaged oxide capsules was terminated after an exposure of 10^{20} nvt in the MTR, because radioactivity was detected in the regions of the reactor in which these elements were located. From leak tests and sectioning of the capsules in Radiometallurgy, it is now apparent that: (a) neither capsule was defective, and (b) the thermal conductivity of the swaged oxide is much better than had been expected, since none of the anticipated melting actually occurred.

Welding of I & E Cooled Aluminum Fuel Element Cans. In order to irradiate large numbers of uranium dioxide fuel elements, it has become necessary to clad the oxide in standard I & E aluminum cans which were originally developed for bonded slugs. Since no bonding layer exists to transmit heat away from the weld area, it was very difficult to achieve a gas tight weld at the point where the inner tube welded to the can cap. At this weld there was usually "hot tearing" which produced cracks in the weld area. To overcome this problem, an aluminum plug has been forced into the inner tube for a distance of approximately one quarter inch. The weld is made at this point with the plug in place to retard cooling of the tube in the weld zone. After the weld has cooled, the plug is drilled out. Preliminary leak tests and radiographs indicate this system to be satisfactory, but none of these welds have yet been irradiated.

Alternative Ceramic Fuel Materials. Uranium compounds other than uranium dioxide are being investigated as possible core materials for future PRPR fuel element loadings. Fifty grams of UC and UN were synthesized in cooperation with the Corrosion and Coatings Operation and the Chemical Research Operation. Corrosion resistance of the compounds to various reactor coolants and jacketing materials will be studied. Cladding components for capsules 0.50" OD x 0.750" long were fabricated from stainless steel, 2S aluminum, Zircaloy-2, and M-388.

Stresses in Perforated Plates. The top of the PRPR is a perforated plate which has high web stresses. A study of theoretical methods used in calculating the stresses and deformations of perforated plates has been initiated. Equations for the deformations and equilibrium of the individual webs were derived. No general method of directly converting these equations into difference equations which could be approximated by the equations for solid plate has been found. The method of determining the stresses in an equivalent solid plate developed by Horvay is presently thought to be the best approximation for determining the stress condition in perforated plates.

Mechanical Equipment Development

Construction of Phase I of the Single Tube Prototype Facility progressed to approximately 15% of completion. The estimated start-up time of the facility is now May 1, 1958, based on the promised delivery time of the instrument panels and the primary pump. Design of Phase II, comprising testing of a full-size PRPR pump, was started. Completion is scheduled for November 1958. An outlet packing fitting assembly was completed and is now ready for test. The process tube inlet fitting was reworked and pressure tested preliminary to functional testing on the ELMO-7 facility. A second set of built-up shoulders was welded on the Zircaloy-2 process tube section of the nozzle-to-process tube assembly. The first set of shoulders was contaminated during the welding and could not be machined. The nozzle cap assembly fabricated from 304 stainless steel and using solid stainless steel "O" rings failed to meet the 2500 psi hydrostatic test requirement for testing on ELMO-7. A second cap assembly employing different seals was fabricated for further testing.

A working prototype model of the proposed PRPR electrical releasing charging hook was evaluated for remote operation. Modifications to secure more positive hook operation and better centering and alignment were incorporated into the design of a working model. The miniature electric motor for use in the charging hook turning device was received and is in process of being mounted in the working model. Fabrication of the full scale mock-up of the calandria and moderator storage tank continued. Alterations to the 185-189-D Buildings to accommodate the mock-up were completed.

Test procedures to carry out the requests outlined in Test PR-51, "Reactor Piping Structural Integrity," were established. Detailed drawings of the outlet jumper piping were completed and drawings of the inlet jumper piping are being prepared. Construction Operation's Shops and the 200 Area Maintenance Shops are currently trying to fabricate the compound bend in the outlet jumper. Little success has been obtained to date. Off-site vendors were contacted concerning forming this compound bend. Construction of a quarter scale model of a portion of the reactor top face has begun. Design work on the full scale mock-up of one-sixth of the reactor top face is continuing.

Coolant Systems Development

The testing of the 19-rod cluster type mock-up fuel element made by Ceramic Fuels Development Operation at approximately PRPR conditions indicates no obvious defect in the proposed design although a few problems peculiar to the element mock-up did arise. The test results are reported in HW-51181 and HW-52010. Flow testing is ready to begin on the three-component concentric type element in the vertical Lucite PRPR size tube.

Lucite models of the 19-rod cluster and three-component concentric type are being fabricated for use in flow distribution studies on the polariscope.

The two tentative inlet connection designs for the PRPR process tube have been reworked twice at Technical Shops and are ready for testing on ELMO-7. Two types of nozzle cap designs would not seal sufficiently to hold standard water-line pressure so they are being modified.

The scale build-up test on raw water cooled heat exchangers has run about 600 hours. No decrease in heat transfer rate has been noted.

Thermal Hydraulics Studies

The preliminary tests of candidate flow nozzles which will be used to feed the moderator into the calandria were completed. The tests were performed in a large water filled tank by using one nozzle placed in the center of a five-tube array conforming to the shroud tube geometry. The results, which were obtained with the aid of dye injection, indicate that a large number of plain orifices will produce sufficient mixing of the moderator to prevent the formation of hot spots. As a consequence, it has been decided to use 114 orifices, each 3/8 inch in diameter, in the full scale calandria mock-up which is being constructed in 189-D. Further moderator flow tests will be made in that installation.

A report, HW-52313, was issued presenting the results of a study of transient conditions following failure of an inlet or outlet header on the PRPR.

Process Tube Development

Two PRPR type Zircaloy-2 process tubes were received from Chase Brass and Copper Company. One of the tubes had been severely damaged during Medart straightening. The second tube had good ID and OD surfaces but was slightly undersize at two points along its length caused by ellipticity produced during press straightening. The better of the two tubes was cut into five short lengths and shipped to the Le Fiell Manufacturing Company for flanging and tapering experiments. Chase is confident that the damage done to these tubes during straightening can be eliminated for future orders. They are currently investigating new lubricants for drawing and sizing of the extruded tubes.

Allegheny Ludlum was successful in extruding three tube blanks for subsequent tube reducing. The extrusions have been surface conditioned and tube reducing should be performed during October.

An inquiry was prepared and sent to interested vendors for the fabrication of process tubes, complete with flange and taper, to be ordered in lots of five from each of two vendors. Delivery was requested for March 1958, to permit time for thorough evaluation prior to placing a 100-tube order.

Jacket Sheathing.

Orders have been placed for 30-mil wall, Zircaloy-3 jacket tubing in sizes from 1/2" to 1" ID with the Wolverine Tube Company and Carpenter Steel Company through Electric Steel Foundry. Carpenter will form and weld tubing early in October from strip fabricated by the Mallory Sharon Titanium Corporation.

The Damascus Tube Company has encountered serious problems in the forming of Zircaloy-3 strip into 2.1" ID tubing. The problem stems from improper roll design and is not inherent with Zircaloy-2. The fabricator of the mill is working directly with Damascus personnel to redesign the rolls to enable the production of good tubing.

Western Pneumatic Tube Company was successful in forming and welding short lengths of Zircaloy-2 strip into tubing. Developments at HAPO determined that the badly cambered strip received from Superior Steel Corporation could be salvaged by stretch straightening and slitting to a slightly narrower width. Because Western Pneumatic is equipped to salvage this strip and has demonstrated the ability to form and weld tubing, a contract is being negotiated with them to produce 1.4" ID tubing from this strip.

NTH has been successful in forming and welding strip into 3" ID tubing. Difficulties were encountered in straightening the welded tubes. They have developed a method for stretch straightening; however, the existing equipment is limited to tubes smaller than 3" diameter. Larger equipment is being ordered; however, delivery times are excessive. NTH has continued to search for new lubricants to eliminate scoring during sizing. Early in October they will perform experiments with new die materials and lubricants which they believe will solve this problem.

External ribs are required to maintain the proper spacing between the fuel components in the nested tubular fuel element. Two methods are being developed to provide ribbed tubing. The first involves direct extrusion of the finished tube with integral ribs. A development contract was negotiated with Nuclear Metals, Inc., to develop this method. The second method involves welding ribs on tubing. Two welding techniques were selected for investigation; resistance seam welding and the Thermatool process.

Radiometallurgical Examination of Plutonium Fuels (RM-193)

Two plutonium-aluminum and two plutonium-aluminum-silicon alloy capsules have been irradiated in the MTR by the Plutonium Metallurgy Operation to determine the irradiation behavior of these new fuel element materials. All of the 1/2" diameter by 2" long alloy cores contained 1.65 w/o plutonium and were jacketed in Zircaloy-2. Since the irradiation exposures were estimated to be considerably less than desired, one capsule of each alloy was returned to the MTR for further irradiation following the completion of visual examination and dimensional measurements. All of the capsules appeared to be in good condition and no significant dimensional changes were observed. The two capsules not returned were dejacketed in order to examine the fuel cores. Difficulties encountered in removing the cores from the jacket caused them to undergo some mechanical damage. Consequently, dimensional measurements of the core are not felt to be completely reliable. No evidence of interdiffusion between the cores and jacket was observed. Both cores have been sectioned to provide samples for metallography, hardness tests, burn-up analyses, isotopic purity, and separations studies.

Plutonium Fuel Cycle Analyses

During the month of September the generalized plutonium fuel cycle analysis was readied for programming. Most of the necessary expressions have been formulated and a flow chart has been drawn. This analysis, which will utilize the IBM type 650 MDDPM covers the following situations:

a) The reactor may be of the uniform recycle type, or of the feed region, spike region type.
b) Recycle process losses may be accounted for.

c) Pu bleed-off is possible, the reactor may be reduced to a non-cycle type of bleeding off all of the Pu formed.
d) Spike and feed regions need not receive the same exposure.
e) Depleted U may or may not be used as the carrier for the spike Pu.
f) U-236 may be initially present.
g) Any reactor temperature may be considered.
h) Any initial U-235 concentration may be specified.

Experimental Reactor Design

General. No major scope changes were incorporated in the PRPR design during the month. Three minor scope changes to the building structure, representing cost reductions or operational simplifications, were issued. One minor scope change in the secondary (light) water cooling system, based on a report by Betz Laboratory recommending a decreased steam blowdown rate, was issued. The design for the Phase I bid package is 90% complete. The estimated design completion for the entire PRPR project is 14%. The scale model of the PRPR is estimated to be 80% complete.

Core Components. A design test request was issued covering the calandria shroud tube bellows. These bellows will be tested for installation techniques, shroud tube replacement feasibility, and bellows soundness after repeated flexure at elevated temperatures. Sample shroud tubes have been ordered for use in various design tests.

Process Tubes. As back-up for zirconium process tubes, alternate aluminum process tubes for temporary or emergency service will be made to the same dimensions as the Zircaloy so that they will fit in the reactor with minimum modification to other parts.

Process Piping and Equipment. Revision Request No. 114-1 (Blowdown and Feedwater Rate Changes), submitted in August for approval, was approved. Economic balance of primary loop parameters was completed and results plotted. Assistance to R & D was given regarding requisition for pumps for a test loop.

Alternate Reactor Site. Criteria for boiler plant and auxiliaries were completed in rough draft form.

Control and Safety Systems. Discussions on the automatic control system were held with representatives of the Minneapolis-Honeywell Regulator Company. Descriptions of the system were sent previously to this firm and to other interested vendors. Comments and recommendations of Minneapolis-Honeywell as regards the controller are expected within 60 days.

Calculations of dump rates were made assuming the use of various types of valves, and assuming failure of various combinations of valves. The results indicate that, using any of several types of 8-inch valves, the criteria for the dump system can be met. The major emphasis in selection of valves should be placed on speed of opening and reliability. A number of valves and actuators of varying types have been selected for testing on the calandria mock-up. Purchase requisitions for these have been submitted by Reactor Engineering Development Operation. Inquiries have been made as to the feasibility of borrowing, for test purposes,

a fast-opening valve which has been used at Lynn Works as a test fuel cutoff valve.

Design and fabrication of the shim control assemblies will be performed by an off-site vendor. The design will probably be done on a CPFF basis, with option to order fabrication by the designer at a negotiated price. It is intended to prove the design by environmental testing of prototype models.

Instrumentation. The Physics and Instrument Research and Development Operation has been requested to review the PRPR primary coolant activity monitoring system. Design of this system has been deferred until the recommendations resulting from this review are received.

Shielding. Samples of steel shot have been ordered for corrosion testing. A letter of inquiry about density, availability, and cost has been sent to a supplier of iron shot.

Charge-Discharge System. The reactor fueling vehicle will be designed and fabricated by a vendor according to our design criteria. It is intended to request bids for design for a fixed fee with option to order fabrication by the designer at a negotiated price. Arrangements have been made with Purchasing to contact interested manufacturers.

Design drawings for the fuel transfer system have been reviewed. An alternate scheme utilizing hydraulic pistons instead of winches and cables is being considered.

Helium System. A design test request was issued concerning tests of the proposed leak detection system. Workability of the system and establishment of the desired sample flow rates are the goals.

It has been established that the General American Transportation Corporation can supply a dry seal gasometer of the desired capacity within suitable overall dimensions.

Another possible supplier of high pressure diaphragm type compressors was discovered. Andreas Hofer of Mulheim-Ruhr, Germany, manufactures diaphragm compressors very similar in design to the Corblin compressors made in France. Hofer is represented in the United States by Autoclave Engineers Sales Corporation. A letter of inquiry has been sent to this firm.

Building and Site. The major effort for the month was spent in reviewing of Phase I construction contract drawings and specifications.

Use of Organics in PRPR Primary Loop. A preliminary feasibility study was made to investigate the use of MIPB in the PRPR primary loop. The study, completed in rough draft, indicates that, with relatively minor changes, the reactor could operate at nameplate rating, provided that development studies affirm the suitability of an aluminum alloy in thin wall sections operating at approximately 600 F. In addition, fuel elements used would have to be suitable for operation with a 730 F surface temperature. Organic reclamation requires considerable development to assure economic operation.

Reactor Physics

Neutron Spectra and Effective Cross Sections. An investigation of the influence of epi-thermal resonances (particularly in the region of 0.3 ev) on neutron spectra in both hydrogen and heavier moderators has been undertaken. The Wigner-Wilkins model for hydrogen moderation and the Wilkins formulation for heavy moderators is assumed. In place of the usual assumption of 1/v law absorption we have incorporated absorption obeying a Breit-Wigner single level description as well. Reduction of the integral equation by expansion of the differential scattering cross section in moments of the energy transfer results in a second order, linear inhomogeneous differential equation which does not afford simple analytic treatment. Solution of this equation is being attempted on the Goodyear differential analyzer.

PRPR Cell Calculations. Twelve additional P-3 cases have been carried out in the current study which is aimed at the interpretation of the PCTR experiments. Of these, two are for the Pu-enriched 19-rod cluster, the remaining 10 for annular fuel elements. Further analysis will be carried out in cooperation with Nuclear Physics Research Operation and American Standard Atomic Energy Division, who plan to utilize the experiments in the development of the RBU calculations.

Advance Evaluation. The use of Westcott cross-sections as a practical means of calculating reactor characteristics has been adopted for reactor survey purposes. An IBM-650 computer program based on this method is being prepared to calculate effective neutron reproduction factors for a wide range of reactors. Formulation is complete and flow charting and coding are under way.

This method also has been used in calculation of data relating η to burnout, as a basis for comparison of uranium and plutonium fuels. The data are presented in the document, "Effective Neutron Reproduction Factors for Recycled Plutonium and Uranium," (HW-51966).

Calculations were continued for two long-range surveys, concerning multiple-hole fuel elements and the effects of fuel element variables. The first program is 40% completed; the latter is approximately 10% completed.

Improved Cell Flux Approximation. The possibility of using the Richards* method of analysis to determine local flux values in a reactor cell is being investigated. The Richards approximation consists of a formalism for isotropic scattering resembling diffusion theory but yielding results more accurate in regions near a source or in highly absorbing media. It also eliminates certain ambiguities in some poorly defined constants. Equations for cylindrical geometry have been obtained, and results are being compared with the accuracy obtained using conventional diffusion theory and P_3 calculations. Blackness values found using Richards approximation fluxes are also being compared with those found using successive generations.

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*Richards, Paul I., "Multiple Isotropic Scattering," Physical Review, October 15, 1955.

Safeguards Analysis. A preliminary discussion of the PRPR Reactor Safeguards was held with the AEC Hazards Evaluation Staff in Washington on September 17, as a prerequisite for approval of reactor construction and of the proposed 300 Area site. Although on-the-spot reactions appeared favorable, no decisions have been transmitted by AEC.

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

SEPTEMBER 1957

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FISSIONABLE MATERIALS - 2000 PROGRAM

METALLURGY

Nuclear Safety

a) UO_3 to UO_2 Reduction Problem

The safe design of a fluidized bed for the reduction of enriched UO_3 to UO_2 was reviewed and safe batch limits established. This study was required by the Ceramic Fuels Development Operation of the Fuels Development Operation (HLO) for the processing of 15% U-235 enriched uranium oxide powders.

b) Fuel Pickling Tank Problem for Enriched Washers

Meetings were held with members of FPD to discuss safety in the design and operation of their fuel pickling tank, as well as the handling of 1.47% and 1.61% enriched washers. Methods of handling nuclear safety in the unloading of enriched fuel element shipments from Fernald that do not meet FPD nuclear safety specifications were also discussed.

c) Fernald Visitors

Three days were spent with two members of the Fernald (National Lead of Ohio) nuclear safety committee to discuss theories and methods for handling nuclear safety problems in the processing and handling of enriched fuels.

REACTOR

STUDIES RELATED TO PRESENT PRODUCTION PILES

Temperature Coefficient with Synthetic Slugs

The vacuum oven has been inserted into the PCTR and criticality achieved. Flux traverses have been completed for three fuel configurations to look at longitudinal flux matching. The matching is satisfactory. The barometric pressure coefficient for the present PCTR configuration has been measured for correcting later reactivity data. Data are now being obtained showing changes in the mass of copper poison for a null reactivity coefficient of the lattice as a function of the fast-to-slow ratio. This data will serve as a criterion as to whether the flux ratio must be matched for every temperature condition to be measured.

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Lattice Neutron Temperature Study

The oven for the TTR temperature controlled thermal column has been installed. Flux traverses through the 4-foot cube of graphite are about half completed. No power has been applied to the oven as of this date.

The TTR fuel assemblies were recoated with paraffin and a fresh solution of sodium dichromate was placed in the fuel tubes. Gas bubbles resulting from corrosion of the aluminum have made difficulties in reproducing reactivity measurements.

Neutron Thermalization Problem

Work continued on the problem of the energy and spatial distribution of thermal neutron flux in a heavy-gas medium with a temperature discontinuity. The flux has been expressed formally in terms of an infinite series involving exponential functions and Laguerre polynomials. In order to compute this series for a number of temperatures and positions, an Omnicode program has been written for the IBM-650 and is now ready to go through the standard assembly procedure.

It has also been shown directly from the basic partial differential equation that the total flux approaches the same asymptotic value at large distances on either side of the discontinuity. This result is in accord with the Onsager theorem of irreversible thermodynamics and shows that the neutrons in such a system behave as a Knudsen gas.

STUDIES RELATED TO FUTURE PRODUCTION PILES

Lattice Measurements for 1.66" Fuel Elements

Measurements have continued for the 1.66-inch diameter, solid natural uranium fuel elements in the small exponential piles. Measurements have been made with air, light water, and MIPB as the coolants. The 5-3/16-inch lattice is now under construction. The 1.15-inch extrapolation length for the small piles is now considered to be in error. Assuming an extrapolation length of 1.66 inches, we find buckling values that are in agreement with the eight-foot pile results. The results of the measurements that have been completed are given in the table below. Included are the theoretical values calculated with an η of 1.3065 where the effective resonance integral was obtained from the expression

$$\left(\int \sigma_u \frac{dE}{E}\right)_{eff} = 5.95 \left[1 + 6.33 \frac{S}{M}\right] \times 10^{-24} \text{ cm}^2$$

Exponential Pile Results

Lattice (Inches)	H_2O	MIPB	Air	Calc. Bucklings x 10^6 cm^2 Air	Diff.
6-3/16	- 72.0	- 107.0	- 203.1	- 190.7	+12.4
7-3/16	32.4	*	0.9	- 13.1	-14.0
8-3/8	66.7	*	86.0	80.4	- 5.6
9-3/8	59.1	81.2	107.9	106.3	- 1.6
10-3/8	39.4		106.6	107.2	+ 0.6

* Measurements have been completed but these results have not been received from the 702 computer.

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Lattice Measurements - Cluster Fuel Elements

The graphite stack used in the temperature coefficient measurements was disassembled and pieces of graphite picked out for shipment to the University of Washington. In place of this stack, a 7-inch to 8-inch lattice will be erected to measure bucklings of clusters of 0.925-inch natural uranium rods.

Development of Methods of Calculating Reactor Parameters

In connection with a current study of the fast effect, an explanation is being sought of the discrepancy between the experimental and theoretical values of the ratio of U^{238} to U^{235} fissions. Theoretical values are about ten percent higher than experimental values. It is expected that a large part of the difference may be removed by use, in the theory, of improved first flight collision probabilities. Original Hanford data on activities and cadmium ratios are being studied in this connection.

Analog Computing

The computer has been inoperative since September 11 due to malfunction. Goodyear Aircraft Corporation sent a service representative on September 17 to install a new patch bay and a complete set of new resistor cards. This work was completed on September 23, at which time two additional service personnel arrived. After a reassembly of the computer a check was made on the new resistor cards. These were found to be far out of specifications. A phone call to Goodyear established that the cards had not been calibrated prior to shipment. The resistor cards were removed and hand-carried to Akron, Ohio, for calibration.

Most of the effort on the log simulator was directed toward the development of an antilog device to convert the log of the fuel temperature to delta K. At the present time it appears that the only practical method for accomplishing this is to use a function generator even though some accuracy is lost at low values of delta K.

STUDIES RELATED TO SEPARATIONS PLANTS

Criteria for Dissolver for .94% U^{235} Slugs

Experimental work on this program has been completed. Data is being analyzed.

Buckling for Enriched Homogeneous UO_3 - H_2O System

In connection with the k_∞ measurements on UO_3 - H_2O systems, buckling measurements were taken for a 1% enriched homogeneous system consisting of a UO_3 - H_2O mixture at an H/U ratio of 6. Vertical flux traverses were made with and without water reflector around the cylindrical tank. The horizontal neutron flux distribution was measured to evaluate the extrapolation length. Analysis of the data is in progress.

Planned Research in Support of the Program for Reprocessing Power Reactor Fuels

In view of the criticality problems associated with the program for reprocess-

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ing power reactor fuels, it is now planned to conduct experiments with 3% enriched uranium. The experimental work, which is to commence in February 1958, is designed to furnish information on the criticality of homogeneous and heterogeneous systems with 3% enriched uranium. Procurement of the enriched uranium fuel elements, needed for the heterogeneous experiments, is being taken care of by C. R. and D. The experimental work will involve buckling measurements on heterogeneous and homogeneous systems, with k_{oo} measurements on homogeneous systems in the PCTR.

Nuclear Safety Critical Mass Consultations

1. 234-5 Building Nuclear Safety

   a) Approval of the design of a new feed hopper to the continuous hydrofluorinator in Hoods 9A and 9B (Continuous Tasks I and II) has been given.

   b) The design of enlarged Hood No. 7 (Continuous Tasks I and II) to allow the addition of two vacuum traps was reviewed and approval given.

   c) Discussions on the design of continuous plutonium dissolvers were continued.

2. New Program Fuels Processing

   A method of using HW-48400, Effects of Pile Exposure on Reactivity of Slightly Enriched Fuel Elements, and HW-48873, Criticality Considerations in Final Cycle Processing of Enriched Uranium Fuels, to estimate criticality conditions for the processing of fuels from the 25-3 Program was presented to the Facilities Engineering Operation of C.P.D.

3. Redox Operation

   A review of Redox Processing specifications for plutonium critical mass control was begun. New specifications are required to allow a more complete coverage of flowsheet design factors which affect nuclear safety.

Plutonium Critical Mass Laboratory

The preliminary design of the Critical Mass Facility was completed by Facilities Engineering of C.P.D. and Document HW-52441, Preliminary Design of the Critical Mass Facility, was issued. The project proposal for the Critical Mass Facility was routed for comments and is now undergoing changes based on these comments. A design cost estimate and construction schedule is being prepared by C.E.O. for this proposal. The decision as to the final location of the laboratory is still pending due to uncertainties which exist in regards to the proposed 900 Area.

Further studies have been done in support of a detailed hazards evaluation of this facility, and an effort is being made to evaluate the effect of shock waves arising from nuclear bursts on the containing structure.

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Neutron Age Measurements

The first Na-Be neutron source was irradiated in DR reactor and used for a determination of the neutron age in water. The neutron intensity from the source was only 1/3 to 1/10 of the anticipated intensity. Handling techniques for this 75 curie source were satisfactory and the shielding better than anticipated. The analysis of the accumulated data is under way.

Mass Spectrometer for Plutonium Analyses

The construction of a mass spectrometer for plutonium analyses was initiated in the Technical Shops. This mass spectrometer is designed primarily for support of the Critical Mass and Plutonium Recycle Physics programs.

REACTOR DEVELOPMENT - 4000 PROGRAM

STUDIES RELATED TO THE PLUTONIUM RECYCLE PROGRAM

Measurement of p and ϵ for 19 Rod UO_2 Cluster

Measurements of p and ϵ were made in the 19 rod UO_2 cluster fuel assembly in the 8-inch PRPR lattice. The measurements gave

$$\epsilon = 1.017$$

$$p = 0.808$$

It is now known, however, that a repeat measurement of the cadmium ratio, using a newly fabricated cadmium cover which contains a thin slice of fuel, gives a rather different value from that first measured. This is in the direction to increase p which was felt to be too low. The new cover minimizes streaming of resonance neutrons through the cadmium directly to the counting foil.

Power Coefficients for 19-Rod UO_2 Cluster

Two sets of reactivity data have been obtained from the PCTR for getting the power coefficient of the PRPR lattice. The cell used had an 8-inch spacing with 19 UO_2 rods and air coolant. Data were obtained over the fuel temperature range of 21° C to 405° C.

Additional data were obtained showing changes in reactivity over long runs at 2 watts power to look for pile reactivity fluctuations at power. Fluctuations were observed and cannot yet be interpreted. If no explanation is found, these fluctuations will set an upper limit on the accuracy of the temperature coefficients.

Theoretical PCTR Studies

A solution is being sought to the two-dimensional problem of the effect of a cylindrical cavity on the thermal flux distribution due to a cylindrical fuel rod in an otherwise infinite moderator. This problem arises in connec-

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tion with an explanation of the observed change in Δ k/k with addition of buffers in the PCTR. The solution for the thermal flux can formally be written as

$$\phi(\bar{r}) = \frac{1}{2\pi D} K_0(\gamma|\bar{r} - \bar{b}|) - \frac{1}{2\pi D} \sum_0^\infty A_m \cos m\theta K_m(\gamma r)$$

where the first term is due to the fuel rod and the summation represents the effect of the cavity. The rod is at $\bar{b}$ relative to the center of the cavity, which is the origin of coordinates. The A_m in this equation are determined by the boundary conditions imposed at the surface of the cavity. Specification of the boundary conditions in appropriate form has been the first hurdle. This has now been done in terms of a transport theory formulation of the current at the surface of the cavity. The integrals encountered are now being evaluated. After the A_m are found, it will then be necessary to apply an inverse Laplace transform to $\phi(\bar{r})$ in order to obtain the slowing-down flux, which is also of interest.

Nuclear Safety

a) Estimates have been made of the minimum critical mass for plutonium solutions in an 18-inch diameter vessel in the Hot Semiworks. This study was made for the Engineering Development Planning Operation, Chemical Development Operation (HLO) to determine the suitability of processing highly irradiated plutonium fuels from the PRPR in the Hot Semiworks.

b) Nuclear safety in the manufacture of plutonium-aluminum alloy fuel elements from plutonium dioxide (PRPR) was reviewed for members of the Chemical Research Operation (HLO).

Resonance Escape Theory

Background material has been obtained and is being studied in preparation for completion of the work begun by H. Neumann and subsequent issuance of a report. The work is at present awaiting data on resonance capture which will be used to calculate the escape probability. These data are currently being processed by the IBM-702.

Analog Computing

An investigation has been initiated by Advance Engineering to determine neutron spectra during thermalization by application of the Wilkins equation. The equation is non-linear with neutron velocity as the independent variable. Solution on the differential analyzer appears promising on paper; however, since many non-linear components will be necessary, the stability of the system can only be determined when the problem goes on the computer.

Instrumentation

It is presently planned that a fuel examination cell will be included in the PRP reactor building for the purpose of studying any changes in the fuel element as a function of accumulated in reactor time. An optical profilometer will be provided for the measurement of fuel element diameters and for the measurement of warp. A 1X or 5X viewer will be provided to detect and note

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pinholes, loosened ribs and poor welds. To assist in handling and manipulating the fuel element, a wide field viewer will be provided. The wide field viewer will also allow complete inspection of the cell. After being measured and visually examined in this cell, the fuel element will either be returned to the reactor or shipped to another facility for sectioning. A decision as to which of these courses will be followed will be based upon the results of the examination. During the past month, more details concerning these viewers have been worked out. Two meetings were attended at which the general philosophy of the examination cell was developed and at which the requirements and details of the inspection equipment were presented for discussion.

PCTR OPERATIONS

There were two unscheduled shutdowns during the month, both caused by improper operation.

The core heater for the uranium graphite temperature coefficient tests was placed in the reactor. An additional 6.6 kg of U^{235} was required to drive the reactor critical with a 30-second period.

A revised control rod using an outer tube of aluminum instead of stainless steel was installed. Preliminary mechanical tests have all been satisfactory and reactivity tests indicate that replacement of all rods would gain about $2.00. This would amount to a fuel saving of about 700-1000 grams of U^{235} depending on the reactor loading. Additional mechanical testing is planned before more rods are changed.

CROSS SECTIONS PROGRAM

U^{235} Fission Cross Section

The liquid nitrogen cooled beryllium filter and a mica crystal monochromator were used to take U^{235} fission data in the neutron energy region 0.0027 to 0.0052 ev. The U^{235} fission cross section was found to be 1/v over this energy interval to a precision of about $\pm$ 0.5%. The data from about 0.0045 to 0.0052 ev were averaged and compared with the fission cross section at an energy of 0.10 ev. The normalization obtained was

$$\frac{(\sigma_f\sqrt{E})_{0.0045 \text{ to } 0.005 \text{ ev}}}{(\sigma_f\sqrt{E})_{0.10 \text{ ev}}} = 1.221 \pm 0.01$$

This result is in excellent agreement with the value previously obtained at the single energy of 0.0050 ev with the HLO spectrometer of 1.214 $\pm$ 0.008. This previous value was obtained with a LiF monochromator and a much less reliable room temperature beryllium filter.

Time-of-Flight Equipment

Modifications were made to the chronotron-256 channel analyzer system to restrict the chronotron to 256 channels of information and to match the dead time of the chronotron with the time necessary to register a count in the analyzer.

A five-step millimicrosecond delay line was calibrated for use in calibrating the absolute circuit time in the chronotron loops.

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The beam sweeping power supply for the Van de Graaff was modified to give a variable sweep frequency of 1.3 to 3.3 megacycles per second.

BIOLOGY AND MEDICINE - 6000 PROGRAM

BIOPHYSICS RESEARCH

Atmospheric Physics

Two field experiments designed to measure vertical diffusion coefficients for stable atmospheres were attempted. Both were only partially successful and, with the transition to unfavorable meteorological conditions, these studies of continuous elevated sources were discontinued. Equipment necessary for the measurement of vertical distributions of concentration near the ground was assembled and tested in preparation for field measurement of diffusion in stable atmospheres employing a ground source. (This program is directed specifically at the reactor hazards problem.) A mathematical model which permits the inference of the three-dimensional distribution of concentration from the measurement of the complete ground-level distribution of concentration and one measurement of the vertical distribution was developed, and is to be employed in the initial experiments in this problem area.

A comprehensive review of the problem of vertical exchange of materials near the ground and deposition of these materials was undertaken in connection with reactor hazards problems. These studies have not yet been completed, but a promising new approach, which appears to account for stability effects properly, has been developed, and is being pursued. If successful, this method should provide much more reliable estimates of deposition of airborne materials. Reactor hazards estimates are extremely sensitive to these deposition phenomena.

Movement of the Portable Mast and its auxiliary equipment from the Benson Ranch site to a position 3000 feet northeast of the Meteorology Tower was completed. Installation of instruments and air sampling equipment was in progress at month end.

DOSIMETRY

The 100-pound plastic scintillator and fourteen-inch photomultiplier tube obtained for Body Monitor studies were prepared so that they could be operated with portable equipment in a truck, boat, or airplane. The object is to test the usefulness of such a device for contamination surveys. It was tested in a truck and showed minimum effects from vibration and the earth's magnetic field.

Development was begun of an instrument for measuring very low doses with pencils by the pulse method. The device is not completed yet, but it was possible for Radiological Development Operation to carry out one leakage test. Pencils charged to a low voltage were stored in a lead cave for twenty days; practically the only radiation they received was from cosmic rays. The average dose rate measured was what one would expect from cosmic rays; this indicates that insulator leakage during the exposure was small. A relatively small number of pencils showed large leakage rates; presumably they had poor insulators.

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The Van de Graaff operated satisfactorily during the month.

Fabrication was completed of a new long counter to serve as a neutron flux standardizing instrument. Our old long counter had been considerably damaged by high summer temperatures in the accelerator laboratory. Careful comparison of the two counters showed that they have the same relative response for neutrons above 1 Mev. Below 1 Mev, there is a few percent difference.

The measurements of w for protons are in progress. The gas handling system was enlarged to permit more thorough cleaning of the gas from the ion chamber before recharging with some other gas. A preliminary value of w for argon was too high. This was interpreted as incomplete ion collection in the chamber; this is being corrected.

Increased insulation of the calorimeter for electron w measurements reduced, but did not eliminate, the discrepancy between the electrical and calorimetric measurements of the electron beam power. A bellows assembly is being prepared that will eliminate absorbing and scattering material that may be causing the difficulty.

INSTRUMENTATION

The redesign on the combination Alpha, Beta, Gamma Hand and Shoe Counter was completed and all amplifier and scaling circuits were fabricated. The remaining work consists of assembly and cabling. The redesigned instrument will be 18 inches shorter in height than the original experimental model making it approximately the same physical size as the present Beta-Gamma Five-Fold Hand and Shoe Counters.

The Transistorized Scintillation Alpha Hand Counter was assembled except for a commercial component not yet received. The instrument, with an alternate part substituted for the missing, has been used for one month with no malfunctions appearing. With merely a change of phosphors from ZnS (for alpha) to anthracene, the same instrument can be used for Beta-Gamma hand contaminant counting.

Work is continuing on instrumentation to be used for the detection of airborne alpha emitters, particularly Pu^{239}. Both the dual-filter method, with electronic background suppression, and a radon-thoron "boil-off" method are being investigated.

The analog-type Stack Effluent Monitor at Redox is being recalibrated.

The development work has been completed for the coding and sequence timing circuits for the radiotelemetering project. The data station specifications for this project were rewritten and submitted to C.E.O. for transmittal to the A.E.C. All data station wind generators and instrument enclosures have been installed.

Most of the electronic and detection portions of the Dog Counter for Biology have been assembled for laboratory testing. The cathode follower circuit boxes and cables are being fabricated. Good gamma pulse height analysis data has been obtained using the equipment for Pu^{239} and Fe^{55}. Approximately 0.3 μc or less of Pu^{239} will be detectable in vivo in the dogs. The stability with

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the equipment operating on the 17-Kev X-ray photopeak of Pu^{239} appeared excellent over 24-hour test periods.

The Zinc Sulfide Particle Detector for the Atmospheric Physics Operation has been completed in design form, and equipment has been ordered for the final instrument. The instrument uses a Pu^{239} alpha source to activate the zinc sulfide as collected on the 0.75-inch diameter filter. A phototube then views the filter and the resultant pulses are scaled to give a linear relationship between counts per minute and the number of ZnS particles on the filter. The system is linear over the range of interest.

A direct-impacting dust particle detector is being investigated. The experimental instrument incorporates a specially-coated phototube. The coating is ZnS (activated) with a heavy coating of coil dope to prevent ZnS erosion by the impacting dust. Operation for several running hours has been satisfactory with no signal degeneration. Pulse-height analysis looks feasible in determining the number of particles of the various size ranges impinging per unit time.

Development work was started on the feasibility of magnetic-tape recording of pulse information on an inexpensive tape recorder. If the pulse-height relationship information can be accurately recorded, it would eliminate the necessity of occupying the multichannel analyzer. The information could be recorded, even for very low counting rates, then played back at increased speeds through the multichannel analyzer at the operator's convenience.

Acceptance tests were completed on 52 HAPO G-M's, 26 Scintillation HAPO Alpha Poppies, 18 Scintillation (cart poppy) Probes, and 22 "Samson" Dose-Rate Meters; and were started on 5,000 pocket pencils. Evaluation of the Spear Single-Transistor High Voltage Supply was completed with good results. The cost of operation will be only about one-half cent per hour with zinc batteries. Evaluation and "de-bugging" was continued on the Scintillation Dose-Rate Meter.

The calibration was completed on the Experimental Radioisotope Analyzer and experimental results were obtained. Source components having gamma photopeaks at 360 Kev, 500 Kev and 660 Kev were prepared in various mixtures and used for calibration and testing. The output for most sources indicated, within approximately two percent, the quantity of each of the source components in the sample. Demonstrations were given to 100 and 200 Area radiation monitoring personnel.

Development continued on the experimental Cross-Correlation Detector. Data obtained with an Fe^{55} source at the X-ray energy of approximately 5.9 Kev indicated a noise reduction of about 70%. Further investigation is expected to result in greater noise reduction.

WASHINGTON DESIGNATED PROGRAMS

The construction of a mass spectrometer for use in the CAD program was initiated in the Technical Shops.

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CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
Production	90	86.1
24-Hour General	60	87.3
Special	111	86.5

In collaboration with personnel from the Industrial Hygiene Operation, a review of the acid mist and fume problem associated with operations in the 313 Building was made and plans for measurements of concentrations of these materials in the vicinity of that building were made.

The number of calls answered by the telephone giving recorded forecasts was 4,670 for the month. Weeks of rainy weather record increases of 25%-30% in the number of calls as compared to fair weather periods.

Summary of the Weather

In spite of temperatures which averaged much above normal for the month as a whole, there were two brief cool periods. The first of these was ushered in by dust and strong northerly winds on the evening of the 17th.

Total precipitation of 0.34 inch was near normal for September. Twenty-nine hundredths of an inch of this occurred on the 27th during the second cool wave of the month.

There was an unusual amount of auroral activity. The phenomenon was observed on 9 nights altogether. During the evenings of the 4th, 12th, and 22nd, the displays were particularly colorful and spectacular.

Optical Service

A study was made of a lighting problem at Redox Bldg. where the servicing of 80 300-watt lamps in a highly radioactive zone has become a problem. A new design of shield plug which will permit access to the lamp without exposure is being considered.

The routine optical shop work included the fabrication of sixteen glass bearings, two mirrors, and parts for a magnetic balance; the repair of a borescope, an underwater viewer, and two Redox crane periscopes; and the preparation of six platinum filaments and a special thermocouple junction. Fabrication was started on nine more glass bearings.

Paul F. Gast

Manager
Physics and Instrument Research
and Development
HANFORD LABORATORIES OPERATION

PF Gast:mcs

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VISITS TO HANFORD WORKS

Name	Dates of Visits	Company or Organization Represented & Address	Reason for Visit	H. W. Personnel Contacted	Access to Restricted Data	Areas and Buildings Visited
P McCreery H Zeitz	Sept. 9-11	National Lead Co. Cincinnati, Ohio	Discuss low enrichment criticality problems.	ED Clayton N Ketzlach	Yes	300: 303 305-B 326
EB Hackworth	Sept. 17-25	Goodyear Aircraft Corp. Akron, Ohio	Service Analog Computer	AE Tucker	No	300: 326
DD Porter	Sept. 24-27	" " "	" "	AE Tucker	No	300: 326
JG Simmons	Sept. 26-27	Goodyear Aircraft Corp. Long Beach, Calif.	" "	AE Tucker	No	300: 326

VISITS TO OTHER INSTALLATIONS

Name	Dates of Visits	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
BR Leonard, Jr. EJ Seppi	Sept. 9-13	Columbia University New York, N. Y.	Attend AEC-Sponsored International Conference on Interaction of Neutrons with Nuclei.	WW Haven	No
AE Tucker	Sept. 19	Sylvania Electronics Defense Lab. Mt. View, Calif.	Discuss Operation of Analog Computer.	Art Bridgman	No
JE Faulkner RE Heineman	Sept. 23-25	Phillips Petroleum Co. Idaho Falls, Idaho	Attend Conference on Theoretical Reactor Physics	WB Lewis	No

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HANFORD LABORATORIES OPERATION - PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION
QUARTERLY RESEARCH AND DEVELOPMENT REPORT - SUMMARY OF PRINCIPAL RESEARCH AND DEVELOPMENT STUDIES
JULY, AUGUST AND SEPTEMBER 1957

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				
Reactor Safety Provide data for prediction of reactivity changes in Hanford reactors under disaster conditions.	4	PCTR TTR	Oven installed in PCTR for temperature coefficient tests on 7½" graphite lattice with Pu containing fuel elements. Hot thermal column for TTR constructed. Theoretical study of neutron behavior at hot-cold boundary in reactor advanced.	Temperature coefficient experiment and neutron thermalization studies will be completed during 2nd Quarter FY-1958.
2. Future Production Piles				
Survey of lattices for IPR scoping studies.	5	Exponential Piles	Measurements have been made with 1.66" solid, natural uranium slugs in 6-3/16, 7-3/16, 8-3/8, 9-3/8, and 10-3/8 lattices with water, MIPB, and air cooling. Correlation of results with calculational recipes is in progress on 1.66" solid and I and E slugs.	Analysis of data in progress. Next series of measurements in small piles will be on 1.92" solid fuel elements. Large exponential planned for measurements on cluster elements.

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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
3. Separations Plants Provide critical mass information for safe operation and design of separations plants.	6	Exponential Tank PCTR	Critical mass specifications for dissolver to handle 0.9% enriched slugs obtained by exponential experiments. Design of critical mass lab scoped. Measurement of neutron age in hydrogenous liquids begun. Fabrication of plutonium mass spectrometer begun. Experiments to determine limiting safe homogeneous uranium enrichment run in PCTR.	Clean up experiments on dissolver will be completed during next quarter. Program for support of studies on processing power reactor fuels up to 3% enrichment will begin. Work on neutron age and mass spectrometer will continue. Final analysis of homogeneous experiments with uranium will be completed. Similar experiments with Pu may be started.
4. Cross Section Program (Jointly supported by 2000-4000 funds)	6	Neutron Spectrometers	U-235 fission cross-section measured in cold neutron range (.002 to .005 ev). Pu^{241} fission cross-section compared to Pu^{239} over range .02 to 2.0 ev.	This program will continue. New spectrometer available toward end of FY 1958.
5. 4000 Program - Plutonium Recycle	7	PCTR	k and f determined for 19-rod cluster elements in 7" and 8" lattices, also with 3 Pu elements per cluster. Temperature coefficient of fuel in 8-inch lattice measured to 400°C. Measurements of ϵ and p made in 8" lattice.	Physics parameters of plutonium-graphite and nested tubular elements will be measured during next quarter. Theoretical study of resonance escape probability will begin.

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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
6. CAD Program	1	PCTR	Fabrication of mass spectrometer begun.	Mass spectrometer to be completed in about 1 yr.

7. 6000 Account

Separately reported in Quarterly Biology and Medicine Report.

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Chemical Research and Development

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ORGANIZATION AND PERSONNEL

V. R. Cooper, Manager, Chemical Research & Development, transferred to Chemical Processing Department as Manager, Research and Engineering.

T. R. McKenzie, Engineer I-L, transferred to Chemical Research from Chemical Processing Department.

G. L. Richardson, Engineer I, transferred to Chemical Research from Chemical Processing Department.

B. W. Mercer, Jr., Chemist I, transferred to Analytical Laboratories from Chemical Processing Department.

R. E. Hamm, Engineer (Temporary), terminated.

J. L. Hepworth, Chemist II-L, transferred from Chemical Research to Chemical Processing Department.

P. E. Brown, Senior Engineer, terminated to accept employment at Argonne National Laboratory.

J. L. Carroll, Engineer II, terminated to return to school.

RELATIONS

The Summer Institute of Nuclear Energy - Chemical Processing

A report covering the Hanford "Summer Institute of Nuclear Energy - Chemical Processing" was completed and issued, along with the detailed questionnaire. The report described the program as presented, evaluated it on the basis of the results of the questionnaire, and proposed minor changes and additions to increase the quality and effectiveness of any future program.

RESEARCH AND DEVELOPMENT

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Analytical Services

Flame photometry was utilized to measure total silver in KER cooling water. Data are to be used for tracing the origin of Ag-110.

Bureau of Mines methods were used to measure tin, chromium, nickel, iron, carbon, and nitrogen in Zircaloy-3.

Early results show that M-388 cans do not significantly change the radioisotope spectrum of reactor effluent cooling water.

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Activation of water treatment chemicals, alum and sulfuric acid, produced relatively large P^{32} quantities. Mode of formation seems to be mainly S^{32} (n,p) P^{32}.

Automatic Analyzing Monitor

The monitor was disassembled early in the month for installation at 100-F. Because of need for space for priority biology research the laboratory previously allotted for this installation was not available. An extensive search for a suitable location with access to reactor effluent water was unsuccessful. It became necessary to modify a small room in 146-FR to permit installation.

Assistance was given in placing the 107-K beta monitors in operation. Pumps for delivering the sample to the monitor were found to need repair. Performance of these beta monitors will be followed to insure proper functioning.

Uranium Oxidation-Melting Experiments

Procedure and equipment design for the initial stages of the fission product release experiments were outlined in detail. General acceptance of the program was obtained from representatives of Irradiation Processing Department and Radiation Protection Operation. The necessary laboratory equipment for the initial experiments was ordered.

Process Assistance

An extensive sampling program was planned, coordinated and carried out in order to support a plant scale test on decontaminating the rear crossheaders at 100-H Area with Turco 4306-B. Samples were taken at 107-H inlet, outlet, and 181-F intake. The program was designed to yield data so that the following can be evaluated:

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flowsheet as in earlier runs and utilized the shielded 21-stage Mini unit as a dual-purpose HA column, an unshielded 16-stage Mini unit as the HS column, and an exhaustive batch stripping operation to simulate the stripping column. Both Mini units were operated at 35 C, as before. The solvent for this run was vacuum-distilled TBP blended with n-dodecane which had been treated with 20 per cent oleum and then passed through a silica gel column.

Cumulative arithmetic decontamination factors through the HA unit, the HS unit, and the batch stripping operation were as follows. For comparison, data are included for an earlier run (Run 7-30) which employed vacuum-distilled TBP blended with Soltrol 170 which had been further purified by treatment with oleum followed by washing with five per cent sodium carbonate solution.

Arithmetic Decontamination Factors

Run	Zr-Nb			Ru-Rh			Gross Gamma		
	HAP	HSP	ICU	HAP	HSP	ICU	HAP	HSP	ICU
7-30	3.8×10^3	2.0×10^4	2.5×10^4	1.1×10^4	2.8×10^4	$>6\times10^4$	8.5×10^3	3.1×10^4	4.3×10^4
8-21	3.5×10^3	2.0×10^4	2.0×10^4	1.5×10^4	4.5×10^4	$>6\times10^4$	6.6×10^3	1.9×10^4	2.7×10^4

It is apparent that at these conditions decontamination was not significantly different with these two diluents. Organic activity profiles were also substantially identical in the two runs. When the organic product (HSP) from Run 8-21 was contacted batchwise with fresh scrub solution (HSS) distribution ratios (E_a^o) for Zr-Nb and Ru-Rh were, respectively 0.26 and 1.0. These values are sufficiently large that continued exhaustive scrubbing at the L/V ratio of 0.16 would have accomplished little additional decontamination.

As a preliminary test of the two-cycle decontamination potential of the Purex Phase II flowsheet, products from several first-cycle Mini runs were combined, subjected to a batch boil-down simulating the intercycle concentration operation and processed through a second Mini cycle. The flowsheet used was as follows:

2DF:	1.5 M U, 0.6 M HNO_3,	Flow 100
2DS:	H_2O	Flow 33
2DIS:	2.8 M HNO_3	Flow 33
2DX:	Purex plant II00	Flow 385

The gross gamma decontamination factor in this run was about 400. The final uranium product had a gamma activity only about 50 per cent of that of aged natural uranium.

However, it should be noted that the feed which had been used in the first-cycle runs which preceded this second-cycle run was only 20 per cent activity level. Thus, the demonstrated two-cycle decontamination is of the order of two to three-fold less than would be required in the plant. The Mini runs, however, did not

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include a uranium plutonium partition step and were made at a lower temperature than is likely to be employed in the plant. It is considered that the Mini result provides considerable basis for optimism that a two-cycle flowsheet will be capable of adequate uranium decontamination in the plant.

Metal Dissolution

I&E Slug Dissolution Rate. Dissolution studies, made under present Purex plant dejacketing and dissolution procedures, were initiated to: (1) compare the dissolution rate of I&E slugs with that of conventional solid slugs, and (2) to compare the efficiency of the present jacket removal procedure when processing I&E slugs.

The studies were carried out in the 321 Building pilot plant downdraft dissolver, which consists of a 2.5-foot-diameter by 4-foot-tall stainless steel pot, surmounted by a 6-inch-diameter by 18-foot-tall condensing tower.

The fuel elements used were unirradiated, reject 8-inch solid and I&E slugs having the following specifications:

Type	O.D., In.	I.D., In.	Length, In.	Surface Area, Sq.In./Slug	Weight, Lb. U/Slug
Solid	1.34	--	8.33	37.7	7.94
I&E	1.37	0.50	8.33	52.3	7.33

The program was divided into two separate dissolution studies using: (1) regular solid slugs and (2) I&E slugs. Each study comprised: (a) two preliminary runs to prepare a near-equilibrium heel and (b) a third run for dissolution rate data. The two preliminary runs each consisted of a 300-pound unjacketed slug charge followed by one dissolution cut. The third run was made with jacketed slugs and consisted of a coating removal step and two successive dissolution cuts.

Highlights of the studies include:

(1) Dissolution times 6.1 and 7.0 hours were required for the first and second cut on solid slugs to reach 2.1 M uranium in solution. In comparison, I&E slugs dissolved to the same uranium concentration in 5.3 hours for each cut.

(2) Although the observed dissolution rate of I&E slugs was greater than that of solid slugs, it was not as great as predicted on the basis of relative surface area.

(3) The effect of lower bulk density of I&E slugs is not expected to limit the total heel plus charge tonnage of the plant dissolvers.

(4) Present dejacketing procedures were adequate to completely remove the outer jacket on all slugs. However, approximately 30 per cent of the I&E slugs contained an amount of undissolved aluminum in the core which was estimated to be approximately two per cent of the original jacket.

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(5) The efficiency of the water rinses following coating removal was not noticeably different for the two types of slugs.

Slug Distribution in an Annular Dissolver. A mild steel, full-scale mock-up of the proposed Redox annular dissolver and slug chute (SK-2-17688 and SK-2-17687) was fabricated. The proposed dissolver, designed to be critically safe for the dissolution of slugs enriched to 0.94 per cent U-235, has an annular slug crib 10-1/2-inches wide, 7-1/2-feet outer diameter and 10-1/2-feet high. The charging chute has a slug bucket tripping mechanism above the center of the tank which dumps the slugs down either one of two 32-inch wide, 50-degree inclines into openings on opposite sides of the dissolver. The mock-up used for testing slug distribution consisted of a semicircular annulus and one incline of the charging chute. The dummy slugs were steel bars 1-1/2-inches in diameter and 8.9-inches long.

Three test chargings were made during the month. The chute as described above was used for the initial charging. For the second charging, the chute was modified to include a triangular deflector centered on the incline. The deflector was one foot high at the lower end of the incline (at the inner diameter of the slug crib) and was tapered to meet the incline three feet from the lower end. The angle of the apex was approximately 60 degrees. For the third charging, the triangular deflector was extended across the annulus (to the outer diameter of the slug crib).

Standard slug buckets were used for charging the dummy slugs to the dissolver mock-up. A full slug bucket contained 236 stacked slugs. In all three charging runs, the first bucket was dumped slowly. All subsequent buckets were dumped by dropping the bucket after it was engaged in the tripping mechanism.

Data from the chargings are:

Charge No.	Approx. No. of Slugs Charged	Maximum Slug Depth, In.	Avg. Slug Depth, In.	Percent Void Volume
1	1430	68	41.8	55
2	1430	60	43.2	56.5
3	944*	42	25	50.4

* Run was discontinued after slugs from three out of four buckets charged jammed in the lower end of the chute.

The void volume for slugs charged to a conventional slug crib has been estimated at 65 per cent. The lower per cent void volume experienced with the annular slug crib may be attributed to the slugs orienting themselves tangentially to the curvature of the annulus.

A recent revision to the proposed charging chute specifies raising the tripping mechanism by about ten feet. Additional runs are planned after incorporating this revision into the chute mock-up.

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Solvent Extraction

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

Four additional cartridges were tested in a 9-foot-high, 3-inch-diameter glass pulse column. Phase II Flowsheet conditions with the aqueous phase continuous and a 0.5-inch pulse amplitude were used throughout.

Cartridge configurations tested were:

Cartridge No. 7. One linear polyethylene sieve plate (0.1875-inch hole diameter, 23 per cent free area) alternated with four stainless steel sieve plates (0.1875-inch hole diameter, 23 per cent free area) all on 2-inch spacing.

Cartridge No. 8. One linear polyethylene sieve plate (0.1875-inch hole diameter, 23 per cent free area) alternated with three stainless steel sieve plates (0.1875-inch hole diameter, 23 per cent free area). Plate spacing 4 inches except between a plastic plate and the steel plate immediately above it, where spacing has two inches.

Cartridge No. 9. One linear polyethylene sieve plate (0.1875-inch hole diameter, 33 per cent free area) alternated with four stainless steel plates of same description on 2-inch spacing.

Cartridge No. 10. One linear polyethylene sieve plate (0.1875-inch hole diameter, 33 per cent free area) at bottom, followed by two stainless steel sieve plates, (0.125-inch hole diameter, 23 per cent free area); remainder of cartridge composed of one polyethylene plate alternated with four stainless steel plates, all on 2-inch plate spacing.

The data obtained in studying these cartridges, as well as that observed with the cartridges studied last month are summarized in the following table:

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Cartridge(2)	Continuous Phase	Flooding VV(1) at 60 cyc/min	Flooding Frequency VV=670(1)	Flooding Frequency VV=1173(1)	Instability Threshold VV=670(1)	Instability Threshold VV=1173(1)
1	Aqueous	1500	>105	90 ± 5	90 ± 5	<30
1	Organic	1300	110 ± 5	100 ± 5	110 ± 5	90 ± 5
2	Aqueous	1100	130 ± 5	110 ± 5	110 ± 5	<80
2	Organic	1400	130 ± 5	120 ± 5	110 ± 5	90 ± 5
3	Aqueous	1300	130 ± 5	80 ± 5	120 ± 5	---
6	Aqueous	1600	110 ± 5	95 ± 5	Flooding	
7	Aqueous	1400	110 ± 5	90 ± 5	105 ± 5	---
8	Aqueous	1500	115 ± 5	105 ± 5	110 ± 5	90 ± 5
9	Aqueous	1700	130 ± 5	115 ± 5	Flooding	
10	Aqueous	1500	95 ± 5	90 ± 5	Flooding	

Notes: (1) VV = Volume velocity gal/hr/sq.ft. sum of phases. A volume velocity of 335 is equivalent to a Purex plant capacity factor of 1.

(2) Cartridges 1 through 6 are defined in HW-52303 C, p C-5.

Although Cartridge No. 9 gave the highest capacity of any of the ten cartridges tested, the dispersion characteristics were generally poor. Cartridge No. 10 appears to provide a good compromise between relatively high capacity, good dispersion characteristics, flooding pulse frequencies within the range of the Plant pulse generators at low capacities and instability thresholds. Efficiency studies on Cartridge No. 10 are planned.

Wetting Characteristics of Plastic and Plastic Coated Sieve Plates. A program to evaluate the wetting characteristics of plastic and plastic coated sieve plates was initiated. Studies were carried out in a 3-foot-high, 3-inch-diameter glass pulse column through which an aqueous phase containing 10 g./l. uranium and 146 g./l. nitric acid and an organic phase containing 73 g./l uranium and 11 g./l. nitric acid were recirculated. Column velocities of 420 and 840 gal/hr/sq.ft. and aqueous phase and organic phase continuous operation were studied with an aqueous to organic flow ratio of 0.14 and a pulse amplitude of 0.6 inch. The column cartridge consisted of alternate groups of four stainless steel sieve plates and two linear polytehylene (Super Dylan) sieve plates. Comparisons were made by replacing one pair of plastic plates with two test plates.

All three types of linear polyethylene tested (Super Dylan, Hi-Fax, and Marlex 50) gave good coalescence as evidenced by large globules of organic leaving the plates during aqueous continuous operation and alternate zones of continuous phase during organic continuous operation. Hi-Fax appeared to be even slightly better than Super Dylan or Marlex 50 which were indistinguishable from each other.

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Stainless steel sieve plates coated as follows were tested:

(1) Super Dylan applied by the Whirlclad process

(2) Super Dylan applied as a dispersion coating

(3) Regular polyethylene applied by the Whirlclad process

(4) Polypenco K-51 applied by the Whirlclad process.

Although Super Dylan applied by the Whirlclad process gave the best performance of the coated plates, all of the coated plates, as received, were markedly inferior to the solid plastic plates. Drilling out the holes in the Super Dylan coated plates from 0.170-inch-diameter to 0.1875-inch-diameter (diameter of steel plate holes) improved performance. However, the performance was not as good as that obtained with solid linear polyethylene plates.

WASTE TREATMENT, FISSION PRODUCT RECOVERY

Silver Iodide-Iodine Exchange Reactor Development

Development work on the silver iodide-iodine exchange reactor as described by E. D. McClanahan (HW-47676) has been started. Initial work involved checking the actuality of exchange between silver iodide and iodine since a report from Vitro Laboratories (KLX-10060) stated that no exchange occurs. Silver iodide containing inert iodine and I-131 was formed on the inner surface of a glass tube by passing the iodine at 200 C over previously deposited metallic silver. Inert iodine was then vaporized and passed back and forth through the tube (at 200 C). At the end of each pass, the iodine was collected on a cold finger and monitored for radioactivity. Essentially complete equilibrium ($\frac{\text{atoms I-131}}{\text{total atoms iodine}}$ in iodine and silver iodide the same) was reached in a single pass. These results confirm the exchange between silver iodide and iodine, and, although not a quantitative measure of the rate of approach to equilibrium, do indicate that the reaction is relatively rapid. Current work is aimed at comparing rates of approach to equilibrium of the exchange reaction and of the reaction of iodine with metallic silver.

Observation Wells

Detectable concentrations of Sr^{90} were again found in samples from a well adjacent to the abandoned 216-S-1 and 2 cribs, but no other wells sampled contained detectable concentrations of radiostrontium or radiocesium. Other wells southeast of the 216-S-1 and 2 cribs continued to show gradually increasing concentrations of radioactive material, tending to confirm the ground water movement in that direction.

In the 200 East Area, well monitoring data indicated an additional 1000-foot spread of the ground water contamination from the A-8 crib. No significant change in the concentration of radioactive material was found in monitoring wells adjacent to the crib. Ground water in the vicinity of the abandoned BY cribs continues to show Co^{60} concentrations ranging up to 6×10^{-4} ucc/cc, but the concentrations are gradually decreasing. A well 3000 feet west of these cribs contained trace concentrations of radioactive material that may be indicative of a westerly or northwesterly path for the pool of ground water contamination beneath the BY cribs. Although such

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a path could result in this material reaching the permeable aquifer immediately south of Gable Mountain, the trend will be reversed upon establishment of the Gable Mountain swamp for Purex cooling water.

Ground water levels beneath the 200 West Area responded significantly to changes in cooling water disposal procedure near the Redox plant. About 800,000 gallons of cooling water per day were diverted to a recently established swamp southwest of the 216-S-5 and 6 caverns. As a result, the elevation of the water table beneath the caverns decreased as much as one foot during the month, while the water levels in wells adjacent to the new swamp increased nearly two feet.

The southeasterly path of ground water movement from the 200 East Area represents the most probable direction of movement of ground water contamination from the separations plants. The rate of movement along this path is being further evaluated by means of a tracer test. A solution of 100 pounds of soluble fluorescein dye in 100 gallons of water was injected into a well at plant coordinates N 24,000, W 33,000 over a 12-hour period. The movement of this material will be detected by sampling wells further to the southeast over a period of one to three months.

Disposal to Ground

The three batches of in-farm supernatant liquid that were scavenged this month contained Co^{60} in concentrations exceeding the recommended cribbable limit of 4×10^{-4} uc/cc. This material was discharged to the 216-BC specific retention trenches.

The problem of predicting the useful life of Hanford cribs is frequently complicated by the wide range of waste compositions discharged to a single crib. This is particularly true with regard to cribs receiving batches of scavenged waste. Samples of each batch of waste are routinely tested by standard soil column techniques to evaluate the influence of soil in adsorbing critical radioisotopes from the solutions. To study the behavior of waste-soil systems resulting from the batch-wise addition of wastes of different compositions to a crib, soil columns were treated in accordance with the past history of several of the B-C cribs. These columns were treated with samples of actual or synthetic waste solutions of the proper composition and volume to simulate actual conditions. It is felt that this technique will permit more realistic evaluation of these cribs for further disposal and will permit optimum utilization of their capacities.

These laboratory soil column experiments are in progress using A-8 crib waste. Two of these columns received thin layers of crushed limestone on top of the standard 80 cm of soil. These tests are designed to evaluate the possibility of increasing the capacity of the column for removing Sr^{90} from the waste by the addition of calcite to the system. One of these columns received a preliminary flush with a phosphate solution and the other is receiving waste made 0.02 M with phosphate ion. Each of these columns is flowing at 30-50 ml/hr, but no analytical data are yet available to report.

Redox process condensate since mid-June has contained radio-cobalt, cesium and strontium at concentrations well above normal; the continued high activity in this waste stream may appreciably shorten the life of the 216-S-7 crib. Predictions of the effect on crib life are under study.

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A study was made of the influence of "Permacol" (a commercial anti-corrosion compound) on the adsorption of radioisotopes from wastes. This compound is being used in process steam in the Purex plant. No detectable influence on soil adsorption was found with 15 ppm Permacol solutions.

A method for detecting moisture by means of x-ray film treated with mercuric chloride and potassium iodide was investigated. The treated film undergoes a pronounced color change in the presence of small amounts of moisture. The technique shows promise for application to hydrologic model studies.

Gelling of Wastes - Field Work

The feasibility of continuously gelling coating waste was demonstrated in a "cold" field test. The coating waste and sodium silicate solution were metered by rotameters at a 5:2 volume ratio into a mixing nozzle. Good mixing, achieved at both high and low flow rates, resulted in the formation of a firm product having a gelation time of about 1-1/2 minutes after being discharged into the pit. The average flow rate of the coating waste was 7 gpm which is equivalent to an instantaneous plant rate of 40 tons per day. Periodically, over the next two months, samples will be taken and measurements will be made in order to evaluate moisture loss to the soil and the degree of shrinkage of the gel.

300 Area Waste Disposal

An analysis of samples of the Columbia River, the 300 Area Pond, and the associated wells was made. It was found that soil adsorption of uranium below the 300 Area Pond was ineffectual in reducing the amount of uranium reaching the ground water. However, river dilution reduced the uranium concentration to approximately background levels a short distance below 300 Area.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Analytical Services

U-235 mass spectrometer assays were made for numerous customers. Three assays provided accountability information for Chemical Engineering Development and FPD Quality Control. Six assays were made to support a Reactor Lattice Physics study involving enriched, hydrated UO_3. CPD received several assays covering plant UO_3 and a receipt from Chalk River.

Emission spectrographic determinations included those of Fe, Na, U, Al, Ni, and Cr in Purex 1WW. Use of the shielded source permitted safe handling of associated radiation.

The five-channel gamma energy analyzer was calibrated for individually counting mixed Zr-Nb-95, Cs-Ba-137, Ru-Rh-106, and Ce-Pr-144 occurring in streams of separations interest. Tedious chemical separations will thus be eliminated to a greater extent than has been possible with a scanning spectrometer.

Plutonium (uranium also) was measured as it occurred in several Pu-U alloys and one PuO_2-UO_2 alloy. Alpha radioassay was applicable after specific activity had been established by coulometric plutonium titration.

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ANALYTICAL DEVELOPMENT AND INSTRUMENTATION

Mass Spectrometry

Conversion of the General Electric Analytical Mass Spectrometer to use a thermal emission ion source was completed. Tests showed that this modified instrument is satisfactory for the isotopic analysis of both plutonium and uranium. An instruction manual for the instrument is being assembled.

Gamma Monitor Cells

Two molded fluorothene gamma cells of the latest design were received this month. The design constitutes two molding operations. First a 3/16-inch thick shell of fluorothene is molded around the usual pattern. Second, polyethylene is molded over the fluorothene to make a finished rectangular block 1-1/2-inches thick by 4-inches high by 8-inches long. The pattern is then dissolved out and the fluorothene threaded for fittings. The cell appears to have all the characteristics desired and is planned to be tested in the Redox plant in November.

Absorptometers

The design of the IAFS absorptometer - pH meter sensing unit has been completed and the detailed prints are now being prepared. Since the combination sensing unit will fit into the existing pH monitor flow-cell housing, no design change to the existing box is necessary.

A 300 mg. source of Americium-241 was purified, encapsulated and installed in a spare Purex-type source holder. This source will replace the presently used thulium-170 source in the Recuplex absorptometer.

Ion Exchange Unit Controls

Instrumentation for the plutonium resin column is now complete. The gamma photon sources and ion chambers for the column feed point and XCP absorptometers will not be installed until construction forces have completed their work on the unit. Chemical Development personnel will assist plant forces in start-up of the ion exchange unit. Preliminary checking of the instrumentation is now underway.

Neutron Counting

Chemical Development is working jointly with Facilities Engineering in the installation of a neutron monitor on the Task I supernate. A review of the design of the primary sensing element by Experimental Physics and Chemical Research revealed the need for more shielding and a modification of the preamplifier. A preamplifier design suggested by Chemical Research personnel is currently being tested by Facilities Engineering.

EQUIPMENT AND MATERIALS

Pumps

Pogo Stick Pump No. 3 - Transfer Pump. This unit has now operated 2400 hours and continues to transfer 5-6 gpm since increasing the internal bleed port from 1/8- to 1/4-inch.

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The end of the stainless steel plunger has indented about two mils where it is impacted against the stainless steel seat. An Armco 17-4 PH plunger will be used to replace the 300 series stainless steel originally used.

Glass Bearing Retention. Pyrex #7740 glass bearings have been successfully fitted into stainless steel housings using an interference fit of about one mil per inch of diameter. Conventional shrink fit techniques were used. Annealing the glass prior to installation in the bearing housing reduces the possibility of fracture.

Bearings installed in stainless steel housings did not fracture when dropped seven feet to the floor (asphalt tile on concrete) repeatedly. A ten foot drop to bare concrete and a fifteen foot drop to an asphalt tile covered concrete surface caused bearing fracture but not fragmentation.

Seal Ring Tests. Dry run wear tests on seal rings for a mechanical shaft seal have shown little promise. A tungsten-carbide flame plated (Linde Air Products) stainless steel ring versus 440 C stainless steel was tested. The tungsten carbide surface exhibited flaking after about 30 hours operation at a ring face pressure of 15 lb./sq.in.and a speed of 200 ft./min.

Continuous Calciner Paddle Arms [redacted]

Stress analysis of the paddle arms to provide a basis for a new design was completed. This analysis considered the impact load encountered as the paddle enters the powder. These calculations showed that the fatigue strength of the existing arm may be exceeded during normal operations. Previous analysis has apparently neglected the impact forces, thereby leading to the conclusion that during normal operation the stresses are low. Based on the new analysis a design strengthening the arms by a factor of four has been prepared. There is a shear pin feature incorporated in the design to protect the calciner shell from gross damage.

Titanium Welding

An "open-air" technique was used successfully to weld commercially pure titanium. A fusion weld was used to join titanium flanges to 5/8-inch diameter titanium tube extensions on a "Dean Thermo-Panel" heat exchanger. A diffuser cone was used to blanket the work with argon while an inert-gas arc-welding torch was used to melt the metal. The diffuser cone was previously developed for use in a glove-box titanium welding process. To further reduce possible air contamination by cross-drafts, a V-shaped sheet metal screen was erected around the work. The resultant welds were bright and shiny, indicative of good ductile weld metal.

Corrosion Studies

Darex Process. Liquid and vapor phase corrosion of 304-L stainless steel in boiling solutions simulating feeds prepared via the Darex process was studied. Liquid phase corrosion rates of about three mils per month were obtained for a chloride-free boiling solution containing 1 M UNH, 0.15 M HNO_3, and dissolved 304-L stainless steel corresponding to 40 g of the steel per liter. Decreasing the HNO_3 concentration to zero reduced the rate by a factor of two while tripling the chromium content more than doubled the rate. The presence of chloride up to 0.01 M had no significant effect on the corrosion rate. Vapor phase rates were all very low

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(<0.2 mil/mo). All liquid phase samples were attacked intergranularly. Corrosion rates for titanium under the same conditions were below the limits of detection.

Zirflex Process. Stainless steel (304-L) coupons were both anodically and cathodically activated while in contact with boiling 1 M NH_4F. Negligible corrosion of the coupons was obtained in subsequent 48-hour exposures to boiling 1 M NH_4F.

Corrosion of sensitized 304-L stainless steel and of titanium in nitric acid solutions containing low concentrations of fluoride was studied as a function of nitric acid and fluoride concentrations. Data obtained at the lower fluoride concentrations studied are tabulated below.

CORROSION OF 304-L STAINLESS STEEL AND TITANIUM IN BOILING HNO_3 - HF SOLUTIONS

HNO_3, M	NaF, M	Exposure time, Hour	Corrosion Rates, Mil/Mo. 304-L	Titanium
1.0	0.001	19	0.17	0.57
1.0	0.005	19	1.72	2.19
1.0	0.01	7	3.40	17.8
4.0	0.001	5	0.70	5.17
4.0	0.005	5	0.97	9.48
4.0	0.01	7	2.06	56.8
10.0	0.001	7	1.73	5.88
10.0	0.005	7	4.61	17.9
10.0	0.01	7	13.7	106

In all cases, 304-L was more resistant to corrosion than titanium. Rates observed for both 304-L and titanium increased rapidly for fluoride concentrations above 0.01 M (data not shown). These data also point to the necessity for relatively complete removal of fluoride following an ammonium fluoride jacket removal to avoid excessive corrosion of stainless steel in subsequent uranium dissolution in nitric acid. Experiments are in progress comparing corrosion of 304-L and 316, 312, 309 SCb, and Carpenter 20 steels under these conditions.

In a study of the corrosion of 304-L stainless steel during dissolution of zirconium jackets by ammonium fluoride, coupons of 304-L were exposed to boiling solutions containing varying concentrations of $(NH_4)_2ZrF_6$ and NH_4F to simulate expected solution composition at different times in the decanning process. Rates obtained were very low (<0.05 mil/mo) for all solution compositions used.

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Sulfuric Acid - Nitric Acid Corrosion. Coupons of 304-L and 347 stainless steels showed undetectable corrosion during 48 hour static immersion exposure to a solution containing 57 per cent HNO_3 and 4.5 per cent H_2SO_4. On exposure to 42 per cent HNO_3-32 per cent H_2SO_4 solutions at 100 C, similar coupons exhibited corrosion rates of 1-2 mils/mo. when sensitized and 0.5-1 mil/mo. when annealed. These tests are pertinent to the problem of preparing HNO_3-H_2SO_4 stripping solutions in the Purex plant.

Materials of Construction

Paraflint RG. A high melting point (200 F) synthetic (Fischer-Tropsch) marketed by Moore and Munger, was tested by static immersion at room temperature. The material showed definite signs of softening and dissolution in carbon tetrachloride after 1 day and in Recuplex CAX after 13 days. After 171 days in Purex HAX the wax had increased in weight 4 per cent. Less than 1 per cent weight increase was noted after 171 days in 60 per cent nitric acid, 10 per cent nitric acid, 50 per cent caustic soda, hexone, and distilled water.

Amerplate 93Y and 94Y. Vinyl chloride tank lining materials manufactured by the Amercoat Corporation were tested by static immersion to determine the effects of irradiation.

	Dimensional Increase						
Material	HNO_3 60%	NaOH 50%	CCl_4	Recuplex CAX	Purex HAX	Hexone	Distilled Water
93Y	1%	0	0	0	12%	80%	0
93Y 10^8r	3%	0	2%	10%	10%	50%	2%
94Y	1%	0	4%	7%	3%	88%	0
94Y 10^8r	2%	0	7%	12%	12%	87%	0

Either of these materials appears comparable to Vyflex L-10 for chemical compatibility or radiation tolerance.

Blue Goop. A pipe thread compound, marketed by the Crawford Fitting Company, was tested in a pipe joint by static immersion at room temperature for 29 days. Test solutions were 60 per cent nitric acid, 50 per cent caustic soda, carbon tetrachloride, Recuplex CAX, Purex HAX, and hexone. The joints broke easily. The material was unaffected by all solutions except hexone, which dissolved it.

Trantex Tape. A product of Johns-Mansville was applied to short lengths of stainless steel pipe and tested by static immersion at room temperature and in the vapor above the solutions. The immersion samples withstood 10 per cent nitric acid, 50 per cent caustic soda and distilled water for 42 days. The immersed tape started separating from the pipe after 1 hour in carbon tetrachloride and Recuplex CAX, 1 day in 60 per cent nitric acid and 30 minutes in hexone. The sample in Purex HAX separated from the pipe after seven days immersion. Hexone dissolved the tape as well as the adhesive. After 1 day in the vapor above 60 per cent nitric acid, carbon tetrachloride, or hexone, the sample in each vapor loosened. Vapors

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above 10 per cent nitric acid, 50 per cent caustic soda, or Purex HAX did not affect the adhesion of the tape to the pipe.

Protective Coatings

Plastite. Several Plastite coatings were tested by static immersion at room temperature. Plastite coatings are manufactured by the Wisconsin Protective Coating Company. All coupons tested were factory prepared.

The results of the tests are tabulated below:

Coating	Solution	Results	Duration of test
Plastite 5122	60% nitric acid	Dissolved	1 hour
Plastite 7100	60% nitric acid	Swelled severely	2 days
Plastite 7111	Carbon tetrachloride	No effect	39 days
Plastite 7122	60% nitric acid	Swelled severely	2 days
Plastite 7122	Carbon tetrachloride	No effect	39 days
Plastite 7133	Hexone	No effect	39 days

The prime coating under the three samples tested in nitric acid was completely resistant to the acid for 39 days. Subsequent tests indicated a primer coating thickness of 0.2 to 0.5 mils.

Plastite 7100, 7111 and 7122 are epoxy-phenolic coatings, 7133 is a modified epoxy and 5122 is a phenolic-epoxy-furane combination. All are suitable for field application and will cure at room temperature.

Carboline 2710. A hypalon rubber based coating manufactured by the Carboline Company was tested by static immersion at room temperature in the usual solutions. The samples were prepared locally in the Technical Shop. The primer and first coat of the system went on quite easily but did not cover well. After a 48 hour drying period a second coat was attempted. The second coat "lifted" the first. None of the coupons was pin hole free. Results of the immersion test are tabulated below:

Solution	Results	Test Duration
60% nitric acid	Blisters, general	1 day
10% nitric acid	No effect	20 days
50% caustic soda	No effect	20 days
Carbon tetrachloride	Coating separated	1 day
Recuplex CAX	Coating separated	1 hour
Purex HAX	Coating separated	1 day
Hexone	Primer Dissolved	1 hour
Distilled water	No effect	20 days

A sample in the vapor above 60 per cent nitric acid failed by blistering in 7 days.

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NEW PROCESSES

Dissolution of Zircaloy-2 By Ammonium Fluoride

Decladding of uranium metallurgically bonded to Zircaloy-2 was studied. The fuel element used for this study consisted of a 0.57-inch diameter by 1.5-inch long uranium cylinder clad in a 30 mil Zircaloy-2 jacket. The ends were closed by means of 0.5-inch thick Zircaloy-2 plugs welded to the Zircaloy-2 jacket, which overlapped the end plugs by 0.25-inch at each end. The jacket had been fabricated of graphite-melted Zircaloy-2 (vintage 1951) and the end caps of arc-melted, reactor grade Zircaloy-2. The element was beta heat treated (1.5 minutes in 710 C salt bath), quenched, and then autoclaved for 100 hours in 350 C water. The surface after autoclaving was not at all uniform in appearance, different areas being different shades of gray or black.

On exposure of the element to boiling 6 M NH_4F, much more attack was observed on the jacket surrounding the uranium than on the end caps. The most probable explanation for this at the present time is the fact that an inferior grade of Zircaloy-2 was used for the jacket. Further experiments are planned employing arc-melted Zircaloy-2 throughout. After 45 minutes in the ammonium fluoride, the walls were completely dissolved, leaving the cylinder of uranium and the two end caps. The reaction was continued for a total of 6.9 hours, at the end of which time 99.3 per cent of the Zircaloy-2 had dissolved and about two per cent of the uranium had reacted. The hot jacket solution had a (calculated) fluoride to zirconium ratio of 7.4 and contained about 0.5 per cent of the total uranium. The cooled jacket solution, however, contained only 0.04 per cent of the total uranium and 57 per cent of the total zirconium. Excessive evaporative loss occurred during the experiment, thus perhaps decreasing the value of the results, but it is felt that they are still of interest. This experiment did serve to emphasize the problem of end caps, which had not previously been considered. Thus, the relatively large amount of Zircaloy-2 in the end caps necessitates the use of larger volumes of decladding solution thereby increasing the uranium loss; also the low surface to mass ratio of the end caps (as compared to jacket walls) necessitates longer times for the dissolution of a given weight of Zircaloy-2.

An interesting observation made during the decladding of this metallurgically bonded fuel element was that when the uranium cylinder became coated with the green fluoride salt, the Zircaloy-2 end caps became encrusted with a dark-colored coating. Thus, the formation of a mixed Sn-U(IV)-F^- coat was inferred. Analysis of the dark coating on the Zircaloy-2 showed it to contain 59 per cent uranium (NH_4UF_5 = 68 per cent uranium). To better study this effect, a rectangular coupon of Zircaloy-2 (wt = 17 g, area = 13 cm^2) was exposed to boiling 6 M NH_4F saturated with uranium (IV) and the rate of weight loss was determined. The weighings were performed on the coated piece, care being taken to remove as little of the coat as possible in the rinsing and drying steps.

The data indicate identical dissolution behavior as in earlier experiments not involving uranium (IV) during the first 50 minutes exposure to boiling 6 M NH_4F, during which time about eight grams of Zircaloy-2 was dissolved. As the digestion continued, however, the sample in contact with the solution saturated with uranium (IV) lost weight at a lower rate than had been observed in earlier experiments in which uranium (IV) was not present.

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After 110 minutes exposure to the solution saturated with uranium (IV), the sample had lost 9.5 grams and only 9.6 grams after 150 minutes. Thus, the protective coating effectively stopped the dissolution at a fluoride to zirconium mole ratio of about nine as compared with about six in earlier runs in which uranium (IV) was not present.

Krypton-85 Recovery Process

In view of the potential for widespread application of krypton-85, a fission product, for use in certain types of signal lamps, study of practical processes for the recovery of this active gas from Hanford separations plants' dissolver off-gases was initiated. Application of variations of the process involving low temperature scrubbing, absorption and fractionation from liquid nitrogen, and recovery on silica gel was given attention. Although such processing is considered technically feasible, it is expected to be costly from an installation standpoint. The intentional dilution of dissolver off-gases with large quantities of air which enters around the existing loose-fitting dissolver charging hole covers contributes significantly to the need for relatively large size and thus costly processing equipment. Possible advantageous modifications to the new dissolvers required for "E"-metal and power reactor fuel elements to control and minimize air in-leakage are being factored into this study. Although the thought of manufacturing substantial quantities of liquid nitrogen may be disconcerting, it is recognized that potentials exist for advantageous use of oxygen in the nitric acid recovery system and for excess nitrogen in the inert gas system at Redox.

Anion Exchange Process for Plutonium Recovery

Further studies were carried out on the anion exchange absorption of plutonium (IV) from metal nitrate media. Loading of a 45 cm column of Dowex-1, X-4 (50 to 100 mesh) at 60 C from 3.75 M $Ca(NO_3)_2$ - 0.5 M HNO_3 - 0.6 g/l Pu at a flow of 14 ml/min cm^2 gave a capacity of 98 mg/ml resin at 50 per cent breakthrough. No resin shrinkage occurred on loading, but shrinkage did occur during the following 7.2 M HNO_3 wash. This resin loading indicates that anion exchange at elevated temperature can be successfully used to process metal nitrate solutions such as Recuplex type material. A resin loading at 60 C was made using a Recuplex feed solution without additions or adjustments. Insufficient feed was available for complete column loading, but it appears that the resin capacity is quite satisfactory. No waste loss due to non-absorbable plutonium was observed. The Recuplex feed used in this run contained a considerable amount of gelatinous precipitate which interferes with column operation.

The stability of Dowex-1, X-4 (50 to 100 mesh) in 7.2 M HNO_3 at 60 C is being studied by holding samples of the resin at 60 C in 7.2 M HNO_3 for prolonged periods. It is expected that the experiments will show more damage than will be observed in column operation because of the buildup of nitrite in the batch type experiments. The alpha radiation dosage to resin loaded to 100 mg Pu/ml was calculated to be equivalent to about 7×10^7 roentgens/month so this is expected to cause as much or more resin damage as the chemical attack. Resin loaded to 100 mg Pu/ml for six months was found to have its physical properties damaged beyond usefulness. This amounts to 4.2×10^8 roentgens of alpha radiation.

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A batch of a new Dow resin (Dowex 21 K, 50 to 100 mesh) was received. Its chemical and physical behavior were found to be nearly identical to Dowex 1, X-4, (50 to 100 mesh).

Experimental studies have been initiated to evaluate the effect of degraded or solubilized anion exchange resin on Purex solvent extraction performance. In the projected Purex phase II flowsheet, wastes from the anion exchange plutonium concentration step will be blended with second-cycle solvent extraction wastes, concentrated, and backcycled to the HA column as the 3WB stream. Thus, resin degradation products which survive the concentration step will enter the HA column.

Preliminary data indicate that recycled waste from the plutonium anion exchange column (XAW) is capable of exerting an adverse effect on decontamination and column operation. The vibrational disengaging time of 7.2 M HNO_3 versus 30 per cent TBP was increased about two to three fold when the acid had been digested with Dowex-1, X-4 for 70 hours at about 60 C. The effect of the digestion on fission product decontamination was studied by blending equal volumes of the 7.2 M HNO_3 and HAF made from 0.1 per cent dissolver solution, contacting this mixture with an equal volume of 30 per cent TBP in purified Soltrol, and scrubbing the resulting organic phase three times with equal volumes of synthetic HSR (0.07 M U, 2.4 M HNO_3). The resulting gamma decontamination factors were as follows:

	Fresh Acid	Acid Digested with Resin
DF on initial content	410	270
DF after three scrubs	30,000	3,000

It should be recognized that these tests represent a much more severe condition than should ever be encountered in the plant. The concentration of resin degradation products should be much lower in the streams that will be recycled in the plant since the exposure to the resin will be much shorter and the recycled XAW will be diluted by a factor of 20 or more in the HA column. Experiments are planned to study this effect under conditions more nearly approximating steady-state operation in the plant.

Flurex Development

Experiments reported last month indicated some transference of nitrate ion from the feed compartment, through the cation permeable membrane, into the catholyte compartment. Since high concentrations of nitrate in the catholyte are objectionable, further experiments were conducted to determine more accurately the magnitude of nitrate transfer. In long term (26 hour) runs under conditions simulating Flurex feed chamber and cathode compartment conditions average transfer of nitrate through a Permutit 3142 cation membrane was 2.3×10^{-4} g/amp min. The rate was constant (within experimental error) over the run period. Under the same conditions the transfer of nitrate through a Nalfilm 1 cation was nearly identical to that for Permutit 3142. Since the hydraulic permeability of the Permutit membrane is very much higher than for Nalfilm 1, these data indicate that migration of nitrate into the cathode compartment is not due to seepage but rather by transfer with uranyl ion.

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Although the transfer of nitrate relative to uranium is low (ca. 0.013 eq. NO_3^-/mol U transferred), the concentration of nitrate in the catholyte may become, if not somehow removed, appreciable in an operating cell due to recirculation of the catholyte. Calculations show that, because of the very low catholyte bleed required to keep uranium losses low, if no back-transference of nitrate from the catholyte to the feed chamber were to occur, nitrate transferred into the catholyte with uranium could accumulate to produce concentrations as high as 3-4 molar at equilibrium.

Mechanisms by which nitrate may be removed from the catholyte include back-transference to the feed compartment because of less-than-perfect permselectivity of the cation membrane and reduction to hydroxylamine at the cathode. Preliminary data from determinations of nitrate backtransference vs. catholyte nitrate concentration indicate that the rate at which nitrate leaves the catholyte by back-transfer will equal the rate at which it enters with uranium when the catholyte nitrate concentration is about 0.1 M, assuming no other processes contribute to the transfers. Possible reduction of nitrate at the cathode has not been investigated.

In support of a proposal to use an ammonium nitrate solution as anolyte in a Flurex cell, a study of back-transference of ammonium ion through three commercially available anion permeable membranes (Permutit 3148, Nalfilm 2, and Nepton AR-111) was made. Variables studied were anolyte NH_4NO_3 concentration (0.05 to 0.25 M), temperature (30-60 C), and membrane current density (0.5 and 1.0 amp/in^2). Back-transfer of ammonium ion was about the same for the three membranes when under equivalent conditions. This confirms other work showing little difference in back-transfer of hydrogen ion among these three membranes. Increasing current density increased ammonium ion back-transfer relative to nitrate while increasing cell temperature decreased it. Back-transference rates observed ranged generally from 2 to 5 x 10^{-5} g/amp. min. On the basis that, at equilibrium, any ammonium ion entering the feed chamber from the anolyte must ultimately go on through the cation membrane to the catholyte, back-transfer of ammonium ion of the magnitude observed would account for an overall loss of current efficiency for uranium transfer ranging from three to eight per cent.

In an attempt to determine the contribution of hydrogen ion, introduced with the feed and transported through the cation permeable membrane, to the overall loss of current efficiency for uranium transport, a series of runs involving calcium nitrate solution as anolyte is in progress. Under these conditions, transport of cations from the anolyte to the feed chamber is insignificant. The first run was made with a feed solution 1.93 M in UNH and 0.02 M acid deficient. Current efficiency for uranium transport was about 90 per cent. Thus it appears that, to achieve greater than 90 per cent current efficiency for uranium transport (even with no loss due to cations coming from the anolyte), significantly acid deficient feeds are required.

Neptunium Recovery

Gassing continues to be the major problem in the application of ion exchange to the isolation of neptunium from Purex plant wastes. Good results were obtained when the Savannah River "heat kill" technique was applied to synthetic solutions. However, when a boiled down plant 2DW solution was similarly treated, gassing

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occurred in the column and resulted in plugging after about an hour. It is thought that this may be due to organic degradation products formed during boil-down or to corrosion products (or other trace impurities) which were not present in the synthetic solutions.

UO_3 Studies

Pressurized Feed System - Continuous Calciner

Development and demonstration of a pressurized, high temperature feed system for the continuous UNH calciners has been continued. Potential advantages of this approach are:

1. Increased throughput because 25 to 30 per cent of the heat necessary for calcination is added with the feed.

2. Improved reactivity characteristics of the oxide because of more rapid calcination.

The 222-S laboratory scale continuous calciner has been modified so that either UNH (m.p. 60 to 72 C) or UNT (m.p. 113 to 140 C) can be fed to the system at a pressure of 700 psig.

To date two successful runs have been made, one of 3-1/4 hours duration in which a feed corresponding to $UO_2(NO_3)_2 \cdot 5.2H_2O$ at a temperature of 225 C and pressure of 450 psig was fed to a bed having temperatures of 270 C at the feed point and 350 C at the discharge point. The second run was under similar conditions except it was of 4-1/2 hours duration, the feed corresponded to $UO_2(NO_3)_2 \cdot 5.5H_2O$, and a feed line temperature of 240 C was maintained.

The final product of the first run had a high temperature reactivity ratio ten per cent greater than a sample of plant product; however, comparison with base line runs in the same equipment will be necessary for accurate evaluation. The production rate under similar bed temperatures was 45 to 50 per cent greater than with the conventional equipment. The fact that this is a greater improvement than expected is explained by less heat loss associated with the pressurized feed system.

REACTOR DEVELOPMENT - 4000 PROGRAM

Processing of PRP Fuels by Anion Exchange

Two runs were made at elevated temperature to evaluate the decontamination potential of the anion exchange process for PRP fuels. The resin used in these runs was Dowex-1, X-4 (50 to 100 mesh) in a bed of 4 mm diameter, 1.9 cm deep. The feed in Run 4 was 7.3 M HNO_3, 6 g/l Pu(IV) spiked to 1.4×10^9 γ/m, ml Zr-Nb activity with a radio-zirconium solution prepared by extracting Purex dissolver solution with TTA. The spike had aged sufficiently that about ten per cent of the total gamma activity was due to the niobium-95 daughter.

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The feed in Run 5 was 7.2 M HNO_3, 100 g/l U, 0.44 g/l Pu(IV) spiked to 1.2×10^9 γ/m, ml Zr-Nb and 1.5×10^8 γ/m, ml Ru-Rh with Purex dissolver solution and was thus about eight per cent of Purex feed activity level.

Decontamination results obtained on loading the column to essentially complete breakthrough, washing the loaded resin with 7.5 M HNO_3 and eluting the plutonium product in 0.35 M HNO_3 were as follows. All operations were conducted at 55 C.

Run	Total Wash Volume (col. vols.)	Pu Concentration Factor (Feed to Product)	Arithmetic Decontamination Factors		
			Gross γ	Zr-Nb	Ru-Rh
4	40	4.2	7500	8400	---
5	60	37	5550	4400	1.1×10^4(a)

(a) Ru not detected in gamma scan. Minimum df reported based on detection limit of gamma spectrometer, five per cent of total gamma.

Plotting the logarithym of the gamma activity in grab samples of effluent wash solution versus the total volume of wash solution passed through prior to collecting the sample yielded a straight line in Run 4, the gamma activity in the effluent wash dropping from 8×10^7 GSC c/m, ml initially to 2.4×10^4 after 40 column volumes. This indicates that a higher decontamination factor could have been obtained in this run with more prolonged washing.

In Run 5, however, the activity in the effluent wash decreased from 10^8 GSC c/m, ml initially to 10^6 GSC c/m, ml at ten column volumes but then leveled off and decreased to only 3×10^5 GSC c/m, ml after an additional 50 column volumes.

There is evidence that solid material of high specific activity was filtered out on top of the resin in Run 5. It is felt that slow dissolution of this material in the 7.5 M HNO_3 wash solution may be responsible for the observed leveling off of the wash curve in this run.

Impregnated Graphite Studies

Plutonium impregnated in graphite was successfully converted to an aqueous solution by burning the graphite in air at 900 C, dissolving the PuO_2 in fused potassium pyrosulfate at 600 C, and dissolving the melt with nitric acid. The reactions proceed smoothly and rapidly and may have application in a processing cycle.

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The homogeneity of each pour was excellent; however, variation of heavy metal content between batches was evident. This is believed due to the method of addition of the reactants which could permit the oxide to escape the cryolite layer and sink to the bottom of the aluminum where its reaction rate would be much inhibited. The effect on batch uniformity of pre-mixing and pressing the cryolite and oxide, and of more vigorous stirring will be studied.

The use of a valve for bottom pouring the melt proved unsuccessful, and this technique will be abandoned in favor of top pouring or ladling.

A topical report, HW-52461, covering cryolite studies to date has been written.

Preparation of Uranium Nitride

A 50 gram batch of UN has been prepared for bismuth slurry studies and for evaluation (by Ceramic Fuel Development) as a possible fuel material. Uranium metal was nitrided to U_2N_3 at 900 C and converted to UN by heating to 1200 C in vacuo.

Plutonium Oxide Fuel Materials

Scouting experiments were performed on the preparation of PuO_2-MgO type fuel material by both mechanical and chemical means. In experiments in the former category, uranium dioxide was used as a stand-in for plutonium dioxide. Uniform mixing in a twin shell dry blender was obtained in thirty minutes of blending, and the mixture was free flowing. This type of mixing is recommended since ball milling did not produce a free flowing powder nor was the mixing uniform.

A satisfactory product was also prepared chemically. A slight excess of oxalic acid was added to a solution of 1 M $Mg(NO_3)_2$, 1 M HNO_3 containing ca. 10 g/l plutonium nitrate, and the solution was then neutralized with ammonia to precipitate the oxalates of magnesium and plutonium. The light green colored precipitate was filtered, air dried, and calcined at 700 C for thirty minutes. The product was a light free flowing powder, except for a few lumps which were easily powdered in a mortar.

Isotopic Composition of Recycled PRP Fuel

Calculations made earlier on the isotopic composition of the recycled plutonium PRP fuel were reviewed and rechecked by others, as well as the originator. These calculations were substantiated and are considered to be highly useful in physics as well as chemical processing studies of the reactor and the cycle. The results showed that, with processing losses as little as one per cent, fuel could be recycled indefinitely since the "high isotope" fuel continues to have adequate reactivity. The objectionable Pu-240 and Pu-242 contents reach equilibrium values at which the reactivity of the composition is still adequate for power production. A report covering these calculations was issued.

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PRP Fuel Processing - Hot Semiworks Flowsheets

In continuation of the study of the processing of PRP fuel elements in the Hot Semiworks, flowsheets for the Pu-Al elements and the UO_2 elements were developed. Major equipment changes necessary for such processing were determined. A rough draft document was prepared to present the flowsheets, along with suggested items for research and development. For the plutonium fuel elements, uranium is proposed as the necessary diluent in the flowsheet utilizing 30 per cent TBP as the solvent.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Environmental and Radiation Chemistry

Gamma ray spectrometric measurements on vegetation, milk and an employee show radioisotope concentration resulting from use of Franklin County Irrigation District water which comes from the Columbia River below Hanford. Grass contained 82.9 x 10^{-6} μc/g Zn^{65}, 111 x 10^{-6} μc/g Cr^{51}, and 2.5 x 10^{-6} μc/g Sc^{46}. Milk from a cow pastured at the grass sampling site contained 4.88 x 10^{-6} μc/ml Zn^{65}, 0.042 x 10^{-6} μc/ml Mn^{54}, and an indication of Cs^{137}. An employee who has drunk about 700 ml of this milk per day for about one and one-half years contained an estimated 0.037 μc of Zn^{65}. Measurements of radioisotopes in fruits and vegetables from this area are in progress, and the values obtained to date are included in the following table.

	Radioisotope (μc/ml x 10^6)				
Sample	K^{40}	Cr^{51}	Zn^{65}	Zr^{95}-Nb^{95}	Ce^{141}-^{144}
Grapes	2.79	--	*	0.050	0.016
String Beans	4.01	0.19	0.067	0.10	0.066
Okra	2.81	--	0.29	--	---
Tomatoes	2.18	--	*	--	---

* Present, but quantity not yet determined.

Some radioruthenium were detected but are not reported since they may not be representative because of probable loss on sample ashing. While the values observed for these isotopes are low they provide information relative to uptake and retention of radioisotopes introduced into the river as a result of reactor operations.

A study was made of the increased sensitivity of the I^{131} in vegetation procedure which would result from doubling the sample size and increasing the crystal size from 3" x 3" to 5" diameter 3" high. The counting efficiency for I^{131} is increased by a factor of 1.7 by increasing the sample size from 150 to 300 grams. An increased sensitivity of a factor of four for I^{131} is obtained using both the 300 gram sample and the 5" x 3" crystal. Since background and Compton counting rates from other isotopes present in the samples also increase when larger crystals are used, the increase in sensitivity for I^{131} using the 300 gram sample and the large

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crystal is only a factor of two to three rather than four. Special shielding and instrumental techniques to reduce backgrounds and Compton contributions will be necessary to bring about a further increase in sensitivity.

Four π counting determinations of Np^{239} have shown that all calibration values for Np^{239} made by mica window counting are in error due to lack of correction for the internal conversion electrons. The high per cent of internal conversion requires that all values based on mica window counting be divided by a factor of 1.92 in converting from the calculated mica window disintegration rates to true disintegration rates. Other radioisotopes will be studied to determine if similar connection factors are needed.

Values for the fraction of the energy emitted by a homogeneously distributed spherical source of P^{32} which is absorbed in the sphere itself were determined for three sizes of spheres. The values obtained with 95 per cent confidence limits are 0.951 ± 0.009 for a 2.22 cm diameter sphere, 0.905 ± 0.035 for a 1.91 cm sphere and one value of 0.792 for a 1.59 cm diameter sphere. These values were used to test the validity of the two theoretical equations for absorbed dose proposed by Rossi and Ellis and Loevinger. The results indicate that the theoretical equations underestimate the integral dose absorbed by as much as 12 per cent.

Studies of the relative abilities of chemical compounds to protect the dye, erioglaucine, from chemical change due to irradiation of dilute dye solutions show evidence that this ability is related to the electron density that can be made available to carbon atoms with bound hydrogen atoms in the molecule. This is consistent with the idea of protective ability as competition for the HO_2 radical formed in water by the irradiation and may allow more efficient protective agents to be selected through the use of the theories of charge densities within organic molecules.

Special Geological Studies

Good progress was made on the CA-700 drilling project by the Geological Survey and the drilling contractor, with about 1400 feet drilled. Reduction to one Geological Survey crew is planned for the immediate future; the remaining crew will be retained as long as work is available. Future drilling on Chemical Effluents Technology wells will be by fixed-price contractors.

The procurement of logs of recently drilled wells in the Columbia Basin Irrigation Project east of the Hanford Works, together with previously available data, permitted the construction of an improved contour map of the surface of the basalt, as well as providing useful data on the attitude of the Ringold formation. These data permitted a better evaluation of the potential effect on the Hanford Works of the proposed Richland Dam than previous data by better defining the types and depths of the various geologic units at the dam site and at the affected reactor areas. Ground water problems at all sites of concern are accordingly now better appreciated.

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Geology and Hydrology

Data from recently drilled wells in the Columbia Basin Irrigation Project, east of the Hanford Works, provided data on the configuration of the basalt surface, confirming the previously conceived structural concepts of the Pasco Basin area, and permitting the construction of a revised map showing the surface of the basalt in that Basin. Stratigraphic data from wells deep in the basalt also clarified the attitude and sequence of the basalt flows such that the possible disposal of liquid radioactive wastes within or beneath the basalt flows may be better appraised.

Further study of the variables associated with unsaturated flow phenomena were designed to evaluate the applicability of the data obtained to date to field conditions. Specifically the application of the modified Darcy's equation to vertical unsaturated flow and to unsaturated flow through very fine-grained material was studied. Previously the moisture content exponent in the equation was determined to be 3.93 ± 0.5 on the 95 per cent confidence level. This value was obtained for horizontal flow in uniform-sized, washed sand. Similar tests in which vertical flow was measured resulted in the average values of 3.91. A single test utilizing a very fine-grained soil resulted in the c value of 3.96. It is felt that these data substantiate the constancy of the exponent over a wide variety of conditions and justify the application of the equation to actual field situations.

Gelling of Wastes

Further tests were performed to evaluate the necessary conditions for disposal of aluminum coating waste by gelling with sodium silicate. The optimum ratio of sodium silicate to aluminate in the waste solution to yield a firm gel was confirmed to be about 2:5. A large excess of free caustic is needed in the solution to assure the formation of a non-granular gel. The granular gel formed when this excess caustic is not present does not incorporate all of the liquid of the waste; this would tend to defeat the purpose of the gel method of disposal. Suitable gels may be formed from aluminum solutions ranging from 0.3 to 0.6 molar. Experiments were conducted in which the aluminum solution was added to the silicate solution rather than the reverse. It was found that satisfactory gels could be formed either way but that the necessary compositions and gelling times were different.

A gel formed from 40 ml of coating waste stood above a soil column for four months during which time liquid "bled" from the gel into the soil. The amount of moisture entering the soil was sufficient to wet 30 inches of the column. Upon sectioning the soil column it was found that 2.8 per cent of the Sr^{90}, 2.2 per cent of the Co^{60}, and 3.2 per cent of the Cs^{137} in the gel had entered the soil column. All of these isotopes were found throughout the soil column indicating very little adsorption of the material draining from the gel.

Soil Chemistry and Geochemistry

A laboratory study is in progress to determine the mechanism involved in Sr^{90} uptake on calcite and other minerals in the presence of phosphate ion. The most probable reaction mechanism indicated is the growth of a strontium hydroxy apatite structure on suitable nuclei on calcite crystal surfaces. Since other carbonate minerals also permit the removal of strontium in the presence of phosphate ion, it is probable

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that the nuclei are associated with carbonate positions in the crystal lattice. The reaction is of a non-equilibrium type and appears to proceed with strontium concentrations below that limited by the solubility of the hydroxy apatite. The reaction is not reversible, since very little of the strontium thus attached is removed by leaching with distilled water or alkaline solutions. Thus, the reaction seems to be other than a simple adsorption process. It is possible that the mechanism is actually simple precipitation, the hydroxy apatite solubility being exceeded by the effect of dissolved calcium. The size of the calcite crystals in the system affects the rate of strontium removal during the early stages of contact, but the degree of removal after a long contact time appears to be independent of calcite grain size.

The calcite-strontium-phosphate reaction was studied in an effort to identify the compound formed. Calcite in the form of limestone was contacted with a 0.01 M phosphate solution traced with P^{32}. Phosphate ion was removed from solution by the calcite at a rate of about 3 per cent per day. Limestone treated in a similar way with untraced phosphate solution for two weeks was examined by x-ray diffraction in an attempt to identify phosphate minerals produced, but none were identified. This latter experiment will be repeated with calcite in the form of iceland spar to avoid the impurities associated with limestone.

A laboratory soil column test of the effectiveness of calcite for removing strontium from synthetic wastes was performed. A 3 M sodium nitrate solution containing 0.1 M tri-sodium phosphate and 2 ppm of strontium traced with Sr^{90} was passed through a crushed limestone bed. It was possible to pass as much as 70 column volumes of the synthetic waste through the bed without a detectable breakthrough of radiostrontium.

Field Apparatus Development

Equipment and material for shaped charge well perforating is expected early in October. Arrangements were made for storage of charges, primacord, and detonators in an isolated building in the old Hanford townsite. Suitable isolation of detonators will be provided.

Assistance was provided for fluorescein dye tracer tests. A constant flow tracer feed rate was provided by means of a vacuum flow control system.

Components were received for the deaeration system for treatment of water to be used in permeability measurements. Assembly will begin shortly.

A low-rate pump for soil column feed was constructed from a design made earlier, and tested. The pump features a continuously variable range of flows of 20 to 1 through speed changing and can be extended by changing syringes. A minimum flow of 0.038 ml. per minute and a maximum of 3.8 is thus possible. In 24-hour tests the flow was constant to within ± 1 per cent at the 95 per cent confidence level. Improvements will be incorporated in future models needed for multi-column studies.

Evaluation of Slug Rupture Detectors

Discussions were held with instrument personnel responsible for training instrument mechanics in the maintenance of rupture monitors. Problems relating to

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stability and setting up the instruments were reviewed. A need was expressed for a high energy gamma source with long life for checking the gamma spectrometer used in the signal channel. The use of thorium as a source was suggested which yields a 2.6 Mev gamma from the Th"C" daughter. A small cylinder of thorium metal was obtained and a gamma scan made. Although the 2.6 Mev gamma was clearly recorded in the spectrum, the level was too low to be practical for the crystal used in the rupture detectors. Other possible sources will be investigated. Any improvement in reproducibility and dependability achieved in this equipment will aid in establishing its usefulness as a radiological hazard monitor for fission debris.

Radioisotopes in Reactor Effluent

An in-pile experiment involving the addition of sodium arsenate to a process tube in the KE reactor was completed. Enough arsenic was added to the process water for this tube to increase the As concentration by 9×10^{-5} ppm. From the resulting increase of As^{76} in the effluent the As^{75} content of the process water was determined to be 8×10^{-5} ppm, in reasonable agreement with the previously determined value of 1.4×10^{-4} ppm.

Samples of process water chemicals were analyzed for phosphorus and arsenic by a radioactivation process in an attempt to discover the source of the P^{32} and As^{76} in reactor effluent. Radiochemical analyses of the irradiated samples for P^{32} and As^{76} were used to calculate the respective stable isotopes in the sample, assuming all of the radioactive species to be formed by an $(n-\gamma)$ reaction. The following results were obtained.

	p.p.m	
Sample	Arsenic	Phosphorus
Sulfuric acid	<1.3	1700
Alum	4.6	910
Sodium dichromate	not determined	12
Process water solids	0.003	0.037
River water solids	0.0048	0.035

It is felt that the phosphorus determinations by this procedure were badly distorted by a $S^{32}(n,p)\ P^{32}$ reaction, especially in the sulfuric acid and alum analyses. The apparent discrepancy between the arsenic content of the process water determined by this method and that resulting from the addition tests cannot yet be explained.

Environmental Analytical Services

A 9.7×10^{-7} μc/gm positive bias was eliminated from Ba-La-140 measurements on vegetation. The bias resulted in more than 10 per cent error for current low Ba-La-140 levels. Cause was natural K-40 Compton radiation contributing to gamma

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energy channels that had been assigned to counting Ba-La-140. Analytical Chemistry obtained a new Ba-La-140 calibration factor using 5 instead of 8 channels. K-40 interference disappeared. A 15 per cent loss in Ba-La-140 sensitivity is being sustained.

The new gas flow "beta" proportional counters may be useful for counting alpha activity. A first-shelf counting efficiency of 43 per cent was observed. Alpha particles may be stopped with 4.5 mg/cm^2 aluminum absorber for selective beta measurements.

L P Bupp

Acting Manager
Chemical Research & Development

LP Bupp:bp

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VISITS TO HANFORD WORKS

Name	Dates of Visits	Company or Organization Represented and Address	Reason for Visit	HW Personnel Contacted	Access to Restricted Data
WI Patnode DF Root AS Gregory	9/4/57	Weyerhauser Timber Co. Tacoma, Washington	Solvent extraction laboratory equipment.	VR Cooper WH Reas MT Walling LL Burger RG Geier	Yes
LR Setter	9/5/	Robert A. Taft Sanitation Engineering Center Cincinnati, Ohio	To obtain information about Radiological Chemical Analysis methods.	WY Matsumoto LC Schwendiman DW Pearce	No
J Figenshau W Haines	9/5/	General Mills Minneapolis, Minn.	Discuss remote manipulators.	AE Smith	Yes
RD Rowe	9/11/	General Machinery Spokane, Washington	Pumps and Agitators	AE Smith	Yes
O. Roth JA Lieberman	9/6/ 9/11/	Fission Reactor Dev. Washington AEC Washington, D.C.	Waste treatment and isotopic recovery and waste disposal research.	HH VanTuyl JL Swanson LC Schwendiman HG Rieck DW Pearce CE Linderoth WN Koop JF Honstead JR McHenry	Yes
JS Butts	9/9/	Oregon State College Corvallis, Oregon	Discuss biophysics research in earth sciences.	LC Schwendiman	No
P McCreery H Zeitz	9/9/	National Lead of Ohio Cincinnati, Ohio	Solvent Extraction Discussions.	RJ Sloat RG Geier	Yes

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VISITS TO HANFORD WORKS

Name	Dates of Visits	Company or Organization Represented and Address	Reason for Visit	HW Personnel Contacted	Access to Restricted Data
AE Reuhle	9/12/	Mallinckrodt Chemical St. Louis, Missouri	Uranium Oxide	RG Geier	Yes
E Zebrowski	9/23/	APED San Jose, California	Discussions concerning the plutonium recycle program.	WH Reas RL Moore EE Voiland MT Walling	YES
FP Baranowski R Moore	9/26/	AEC Washington, D.C.	Storage of wastes, recovery of by-products.	LC Schwendiman LP Bupp	Yes
AF O'Donnell	9/30/	Stanford Research Inst. Palo Alto, California	Discuss radioactive waste disposal.	DW Pearce LP Bupp	Yes
HE Goeller RE Blanco JJ Perona	9/30/57	Oak Ridge National Lab. Oak Ridge, Tennessee	Discussion of power fuel reactor processing.	WH Reas JL Swanson RJ Sloat LP Bupp	Yes

VISITS TO OTHER INSTALLATIONS

Name	Dates of Visits	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
LL Burger	9/5-6/	Crown Zellerbach Corp. Camas, Washington	Discuss solvent extraction problems.		No
WL Lyon EE Voiland	9/11/	Kaiser Aluminum & Chem. Corporation Spokane, Washington	Discuss technical problems associated with aluminum processing.		No

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VISITS TO OTHER INSTALLATIONS

Name	Dates of Visits	Company Visited and Address	Reason for Visit	Personnel Contacted	Access to Restricted Data
OF Hill	9/9-12/	American Chemical Society Fall Symposium New York, New York	Present paper and working at the Employment Clearing House		No.
	9/13/	Argonne National Laboratory Lemont, Illinois	Discuss engineering development programs.	S Lawroski	Yes
GL Nicholson	9/16-18/	AIChE Meeting Baltimore, Maryland			No
	9/19-20/	ORNL Union Carbide Nuclear Co. Oak Ridge, Tennessee	Discuss ion exchange and power reactor fuel reprocessing processes.	WK Eister	Yes
GJ Alkire	9/30/	GEL Schenectady, New York	Automatic process control instruments.	JL Michelson	No
KH Hammill	9/30/	Argonne National Lab. Lemont, Illinois	Design and operating techniques in high level chemistry facilities.	WB Doe	Yes

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Special Facilities (Office and laboratory space is assumed all cases)	Status and Progress	Future Status and Comments
ies.	1. Dissolution rates for I&E slugs shown to be as fast as or faster than solid slugs. Loading problem of annular dissolver under study. Understanding on role of plastic plates in pulse column cartridges being expanded. Cartridges for high capacity "C" Columns examined. Studies initiated on annular 2A Column with 1-in. Raschig rings. Initial design of a "step-tray" contactor for organic treatment of low capacity. Work initiated with new bearing test machine to measure wear. Techniques developed for shrink fitting glass bearings on stainless steel housing. Second design of spline shaft deepwell turbine pump received and under test with 60% HNO_3. "Pogo stick" sample circulating pump operating at 5-6 gpm. Marlex-50 equivalent to Super-Dylan on irradiation up to 10^9R. At 5 x 10^9R Super-Dylan becomes tacky. Diffuser cone technique allowed successful welding of titanium without glove box enclosure. Manganese(II) induces nitrate decomposition in alkaline wastes. Formaldehyde destruction of HNO_3 at pH < 2 demonstrated in lab under continuous conditions. Exchange of iodine with AgI in AgI reactor confirmed to be fast. Future costs of waste storage indicate justification for alternate methods.	1. Small scale annular dissolver to be fabricated and operated to study engineering parameters. Same for 5-in. continuous dissolver tower about first of year. Plastic and stainless steel geometries for pulse column cartridges to be extended to increase understanding, including definition, of 1BS cartridge. "Step-tray" contactor to be modified. Annular pulse column studies to be extended to other packing and/or cartridges. Titanium thermopanel is being installed for determining heat transfer characteristics to provide technology for sub-critical slab geometries. New concepts for packless, sealess pumps under study. AgI reactor to be further explored. Alternate waste storage techniques are to be investigated. Increase level of effort on simplified Purex flowsheets, including single-cycle.

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eve	No. of Eng.	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
Prof		2. Laboratory-scale facility.	2. Installation of pulse column components in multicurie cell in Room 1E, 222-S Bldg., initiated. Anomalous and nonreproducible temperature effects in solvent studies disclosed, and origin of these under investigation.	2. Continue profile pulse column studies at reduced level of effort (0-2 people). Establish origin of anomalous temperature effects. Extend study to fission products when uranium transfer mechanism is clarified. Continue at same level of effort. Further work on organophosphorus compounds will be deferred until desired compounds can be procured or synthesized off-site.
	ıle.		3. Solubilities of unirradiated core materials studied. Effects of oxide coatings on Zircaloy-2 evaluated. Studies with unirradiated PRPR cores initiated.	3. Continue at same level of effort. Extend studies to irradiated core materials. Establish methods for handling tin residues resulting from dissolving Zircaloy-2 in ammonium fluoride.
	ırie		4a. "Acid side" flowsheets for cesium recovery from Purex waste were successfully tested on a laboratory scale. A study of the effects of precipitation conditions on density and handling characteristics of ferric hydroxide was completed. Development of a flowsheet for cerium recovery and for recovery of other fission products in conjunction with cesium was continued and substantial progress made. The role of Fe_2O_3 in the calcination of $Cs_2ZnFe(CN)_6$ somewhat better defined. No pressure rise observed on exposure of three gram samples of $Cs_2ZnFe(CN)_6$ to 5×10^8R of 1.25 mev (avg.) gamma. Tooling up of 222-S cell continued. Several reports were issued during the quarter or are ready for issuance.	4a. Tooling up of 222-S cell for liter scale demonstration runs should be complete about mid-November and large-scale testing of the several cesium recovery flowsheets will commence. Principal uncertainty to be resolved by these tests concerns extent of radiation damage to reagents. Other work will continue at present level. Specific engineering flowsheet development to proceed on choice of specific isolation procedures. Complete issuance of reports.

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·el of No. of Eng.	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
	b. ---	b. A process was developed for the recovery of americium from Purex 1WW. A terminal report is being prepared.	b. Issue report.
	·ture mixer- Laboratory e.	c. Work has been continued aimed at recovery of neptunium as a byproduct from the Hanford Purex process. Both anion exchange and tri-n-octyl amine extraction have been investigated as a means of neptunium isolation. Several progress reports and invention reports have been written.	c. Will continue at present level. Emphasis will be put on determination of effect of Purex Phase II changes on neptunium routing, elimination of gassing in ion exchange isolation, further elucidation of effect of organic degradation products, and firming up of oxidation flowsheets for forcing neptunium past the HA cycle.
		d. Low-temperature liquid nitrogen extraction process regarded as feasible. Economics depend on plant location and capacity.	d. Economics will be developed further. Involvements with "E"-metal and power reactor fuel processing will be considered.
	:al labora- :lities; it prototypes lalized in- s including :trometer, :aphs, radia- ıting equip- mma and alpha alyzers, aphy equip- x-ray spectro-	5. Instrumental development programs for square wave polarography and for thermal emission mass spectrometry completed. Polarography and controlled potential coulometry studies of plutonium solutions and alpha energy analyzer equipment have progressed significantly. Applications of x-ray fluorescence to HAPO problems evaluated. Studies of Purex Phase II Flowsheet indicate satisfactory DF attainable in two-cycle process. Studies begun on flowsheet alternates, including potential one-cycle flowsheets. Support provided as required to in-line instrument projects. Redox 1AFS absorptometer-pH meter design	5. Emphasis on completion of alpha energy analysis studies and on controlled potential coulometry. Square wave polarography to be applied to plutonium and uranium analysis studies. X-ray fluorescence studies to continue. Major emphasis over next quarter to be in support of start-up of new instruments. New preparation methods for phosphors for contact alpha monitor under study. New flow control devices to be studied. To explore the application of the analog computer to column control.

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Project	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
			transmitted to CPD. Instrumentation for Purex prototype ion exchange system provided. In-cell canyon jumper pH development begun.	
			Development progressed on stable circuits for gamma energy analysis and proportional beta counters used in the monitor. Laboratory instruments and equipment were designed to assist earth science research. A special low-rate feed pump was constructed and thermoregulator assembled. Modification and testing of scintillation well probe accomplished. The isotope analyzing monitor for recording concentrations in reactor effluent was given shakedown tests prior to installation. The monitor is being installed for in-line testing.	Optimum data handling will be established. Down-river monitor configurations to be developed. Fission product detectors for evaluating rupture material are being studied and the required sensitivity estimated. Development will continue of equipment to support research in other CET or laboratory operations. Assistance to be given in ground water movement and direction measurements, permeability studies, and improved well perforation studies. Demonstration of the monitor in actual use. Its incorporation in the effluent stream should provide a good index to prominent isotopes in the reactor effluent and signal the need for better control of radioactive material going to the Columbia River; the interpretation of data and optimum methods for data presentation.
		y-scale alciner, ction urface nt, pilot ype cal-	6. Laboratory demonstration of high-temperature feed system for continuous calciner made. Stress analysis of plant paddles in continuous calciners indicated underdesigned. Solubility of NH_3 in 100% UNH determined.	6. At least 25% increased production rate was shown in laboratory demonstrations. Powder quality will be evaluated as function of process variables. Explore new paddle designs in prototype. Dependent on lab results, pilot NH_3 addition. Provide support to calcination plant as required.

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of	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
. of	Laboratory and plant proto-	7a. Studies of a pulsed ion exchange column with screen separators and overflow downcomers initiated. Radiation stability of resins studied. Plutonium-uranium partition evaluated. Application to recovery of plutonium from Purex wastes studied. Studies on PRP processing by anion exchange initiated.	7a. Continue evaluation of pulsed ion exchange column. Obtain efficiency studies. Examine other continuous contactors. Continue at slightly increased level. Construct laboratory-scale shielded anion exchange column to evaluate decontamination with full-level feeds. Evaluate anion exchange as reprocessing method for recovery and recycle of plutonium. Evaluate anion exchange as reprocessing method for slag and crucible wastes. Basic study of exchange kinetics of plutonium with anion exchange resins.
		b. Further information obtained to classify operating conditions over and above that presented in preliminary flowsheets. These flowsheets and alternates have been evaluated for pilot plant studies. Complete destruction of nitrate in UNH solution by formic acid at pH <2 shown possible. Project proposal for semiworks modification essentially ready for approval.	b. Approval to be sought on project proposal for semiworks modifications. Specific program for pilot plant development to be established and evaluated.
	nduc- acuum h ilities.	c. Program for investigating pyrochemical processing of irradiated uranium underway. Setting up equipment and establishing methods.	c. Program to continue with operation of equipment.

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Level of rt - No. of or Eng. nnel	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
Proj. 8. Sepr a.	a. Cobalt-60 source.	a. Additional data obtained on radiolysis of alkaline nitrate-nitrite mixtures. Predictions from these results check closely the compositions of stored Purex wastes.	a. No additional work on radiolysis of wastes planned at this time.
		b. A study has been made of chemical problems associated with ultimate disposal of wastes from fission product recovery processes. A study report has been prepared.	b. It is planned to initiate limited laboratory work, personnel permitting, on ultimate waste disposal.
		9. Details of necessary research and development program in support of the interim fuels reprocessing program are being worked out. Preliminary engineering studies on titanium requirements for Darex feed preparation carried out. Titanium continues to look good as material of construction for Darex. Gold gaskets appear applicable for titanium service. Tie-in with Redox process investigated and appears feasible. Flowsheets studied.	9. Laboratory studies on corrosion of materials of construction for feed preparation will continue. Engineering development of Darex process and alternates will be initiated upon program authorization. Likewise, choice of mechanical processing methods and development program to be begun upon authorization. Study of Redox flowsheets will be continued.
		10. Preparation of materials and solutions for present phase of program has been completed and 321 Building experiments completed. Data being evaluated by Physics R&D personnel.	10. Program to be extended as required in support of processing materials of higher enrichment. Support of CR&D in solution preparation will be required.

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evel of - No. of Eng. l	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
	11. Radiochemical laboratory facilities.	11. Initial activation analysis suggests there is enough As and P in the additives to account for As-76 and P-32 in the effluent. Rough draft of bibliography of oxidation, melting and burning of uranium completed. Equipment ordered for preliminary experiments. Calculations of the Inland Lake effects on the basis of previous research were completed and a report is being prepared. The influence of the proposed Richland dam on the regional water table was studied and technical assistance rendered in the interpretation of the results. Continued evaluation of changes in reactor processes which may change kind and quantity of waste disposed to the Columbia River. Effects are under study on fuel element cladding corrosion inhibitors, decontamination of piping.	11. Continue study of statistical analysis, possibly initiate a new analysis. Impact of Project CG-558 on river contamination to be closely watched during coming low water season. Continue studies to determine the source of most significant isotopes. Continue literature research. Trip planned to ANL and ORNL for consultation. Assemble equipment and initiate experiments by January 1, 1958. Technical assistance will be rendered, on the basis of experience gleaned from previous research, to the current study of 100-K outfall line failure. Evaluate the merits of the retention basins and lend support to the group investigating the Inland Lake. The effort is expected to continue at about the same level.
ield well quip- hem- tory, apping		12. Data from areas east of the Columbia River in the Columbia Basin Irrigation Project resulted in a revised contour map of the basalt surface of the Pasco Basin. Two additional pumping tests were performed to evaluate hydrologic parameters. A fluorescence tracer test was initiated. The evaluation of soil capacity for waste disposal was continued. A three-month study culminated in an experimental design for systematically developing a technique for routine evaluation of crib life.	12. Extend geologic studies into environs as necessary and to greater depths by well drilling and geologic work of others and by field mapping to evaluate the potential of waste containment at intermediate or greater depths. Evaluate the usage rate of real estate for waste disposal activities to assure the most efficient utilization of the ground. The tracer test currently in progress will be completed. Additional

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Project	Level of Effort - No. of Sci. or Eng. Personnel	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and Comments
				pumping tests will be performed as equipment becomes available. The special waste disposal test will be initiated as test structures become available. Application of the Hiester-Vermeulen method will continue at about the same level. Development and testing of special apparatus for conducting these tests will be necessary in the early stages. About the same level of manpower application is anticipated.
		try lities. oring	13. A preliminary study of Recuplex waste disposal to the ground was performed. General techniques for evaluating these and other wastes were being developed. Recommended Purex A-8 crib to be replaced by January 1. Scale-up test on gelling of coating waste started. Co-60 use test in progress. Monthly interpretation of ground water monitoring data and hydrologic conditions was continued. The completion of several new wells permitted clarification of the ground water contours in the same portions of the area. Calculations were performed concerning the probable influence of the proposed Richland dam on ground disposal of wastes in the 200 Area. Assistance was rendered in the design and location of replacement crib for 216-A-8. Document on "Thermal Considerations on Gelled High Level Radioactive Wastes" issued.	13. Development of basic techniques will continue at the same level. Continue to advise on high Co-60 use test. Complete first scale-up test on gelling of coating waste. Continue close surveillance of wastes discharged to the cribs and provide consultation on waste disposal practices. The work is expected to continue at the same level. Current ground water contamination patterns will be routinely studied and interpreted in a search for significant trends. Technical assistance will be rendered in the scheduling and design of future waste disposal structures. Continue theoretical work, emphasis on the process that may be necessary for gelling high level wastes.

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Level of - No. of r Eng. el	Special Facilities (Office and laboratory space is assumed in all cases)	Status and Progress	Future Status and comments
. High temperature oment, induction e; x-ray dif- facilities; equipment.		14. Rough draft flowsheets for processing PRPR fuels in the Hot Semiworks were completed. Stainless steel found satisfactory for dissolvers for Zirflex process (ammonium fluoride dissolution of zirconium). Equipment changes needed in Hot Semiworks defined. Study of isotopic composition of recycled fuel completed and showed that fuel has sufficient reactivity to justify continuous recycling with no need to discard. "Inert" isotopes reach equilibrium values. PCTR loading of Pu-graphite completed. Processing methods for Pu-graphite under investigation. Several potential methods for pyroprocessing of Pu-Al under evaluation. Semicontinuous method for production of Pu-Al alloy has been demonstrated. Preparation of UO_2-bismuth slurries has been demonstrated and method for non-destructive study of oxide bismuth slurries has been developed. Methods of preparing PuO_2-UO_2 and PuO_2-MgO materials have been investigated, as have the problems attending the dissolution of PuO_2 prior to chemical reprocessing.	14. Required laboratory and pilot plant development will be defined from flowsheets. Engineering studies of Zirflex process will be initiated prior to first of year. Budget study for Hot Semiworks modifications to be carried out prior to end of FY. Flowsheet and equipment changes will be studied further. Cost estimation of recycling process will be refined. Continue Pu-graphite studies; prepare pieces for irradiation effects on dimensional stability. Examine electrolytic production of Pu-Al alloys. Continue all fuel reprocessing studies. Stability of oxide bismuth slurries will be continued. New materials applicable to slurry system will be prepared and studied. The trialkyl amines will be studied for the reprocessing of irradiated plutonium from PRP fuel elements.

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A. Organization and Personnel

Dr. L. A. George joined the Experimental Animal Farm Operation on September 3, 1957.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Samples of terrestrial and aquatic organisms were routinely collected and assayed for radioactive contamination released to the atmosphere, pond impoundments, and the Columbia River.

Atmospheric Contamination

Concentrations of I^{131} in thyroid glands of jack rabbits are tabulated below in decreasing order:

Collection Site	μc I^{131}/g thyroid Average	Maximum	Trend Factor
West of 200 West Area	2×10^{-3}	5×10^{-3}	-
One mile SE of Redox	2×10^{-3}	4×10^{-3}	+ 2
100-B Area	2×10^{-3}	4×10^{-3}	+ 2
East of 200 East Area	2×10^{-3}	3×10^{-3}	- 10
Meteorology Tower	9×10^{-4}	2×10^{-3}	-
Four miles SW of Redox	6×10^{-4}	1×10^{-3}	+ 2
Prosser Barricade	3×10^{-4}	7×10^{-4}	- 2
Three miles S of White Bluffs	2×10^{-3}	2×10^{-3}	- *
Route 4S, mile 14	3×10^{-4}	4×10^{-4}	- 7*
Wahluke Slope, E	2×10^{-4}	2×10^{-4}	- 5*
Wahluke Slope, NE	1×10^{-4}	2×10^{-4}	- 20*

* The last four trend factors compare values with samples obtained in July rather than August, because collections are made at these locations bi-monthly.

Current values are approximately twenty-five per cent above those observed one year ago.

Fission products were present in rabbits in the following concentrations:

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

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These values for bone and liver exceed those for the same period of last year by factors of five and two, respectively. The increase presumably results from fallout from recent nuclear weapons tests.

Swamp Contamination

Waterfowl collected at the 221-U swamp contained the following concentrations of mixed fission products:

Sample Type	μc FP's/g sample Average	Maximum	Trend Factor
Coots			
Bone	7×10^{-4}	2×10^{-3}	- *
Soft tissues	2×10^{-4}	3×10^{-4}	+ 2*
River ducks			
Bone	1×10^{-4}	3×10^{-4}	+ 2*
Soft tissues	2×10^{-4}	8×10^{-4}	- 3*
Shorebirds			
Bone	6×10^{-4}	1×10^{-3}	- *
Soft tissues	7×10^{-4}	5×10^{-3}	+ 3*

* Trend factors compare values with samples obtained in July, because no samples were obtained during August.

Columbia River Contamination

The contamination levels during September for beta emitters in representative organisms from the Columbia River were as follow:

Sample Type	Collection Site	μc beta emitters/g wet wt. tissue Average	Maximum	Trend Factor
Minnows (entire)	Hanford	2×10^{-2}	3×10^{-2}	-
Caddis fly larvae	"	4×10^{-2}	4×10^{-2}	*
Whitefish flesh	Ringold	1×10^{-3}	2×10^{-3}	*
Whitefish flesh	Priest Rapids	5×10^{-5}	9×10^{-5}	+ 2
Shorebirds flesh	Hanford Res.	7×10^{-3}	3×10^{-2}	+ 3
River ducks flesh	"	5×10^{-3}	2×10^{-2}	+ 3
Mergansers flesh	"	4×10^{-3}	9×10^{-3}	+ 8
Gulls flesh	"	3×10^{-3}	1×10^{-2}	+ 8
Grebes flesh	"	3×10^{-3}	9×10^{-3}	*
Terns flesh	"	1×10^{-3}	2×10^{-3}	- 2
Coots flesh	"	6×10^{-4}	3×10^{-3}	*
Herons flesh	"	5×10^{-4}	8×10^{-4}	+10

* No samples collected during previous month.

The concentrations of beta emitters in most species were about three times those for the same period last year.

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Aquatic plants and animals and waterfowl were sampled from the mouth of the Columbia and the adjacent coastal area. The samples are being analyzed for radiochemical composition.

Effect of Reactor Effluent on Aquatic Organisms

Young whitefish continue to be subjected to four per cent strength reactor effluent and to an equal quantity of the effluent which is varied in concentration to simulate conditions which may exist when the flow of the Columbia River fluctuates widely during each 24-hour period as a result of power production at Priest Rapids Dam. At the end of four months there is no indication of any adverse effect due to effluent concentration being tested.

Further results on the temperature sensitivity of young whitefish have shown an increased mortality during this season of warmest water. A 2 C temperature increase resulted in about 10 per cent increased mortality.

Biological Chains

Study of the accumulation of Ru^{106} by aquatic organisms, which was initiated August 5, was terminated September 23 and awaits analysis for final results.

Effects of Radioactive Elements on Aquatic Life

An experiment to determine the effects of chronic feeding of radiophosphorus on yearling rainbow trout was started during the second week of the month and is to continue for six months. Three lots of 75, 150, and 75 fish are being fed P^{32} at the daily rate of 0.006 µc, 0.06 µc, and 0.6 µc per gram of body weight, respectively. The isotope is given to the animals incorporated in a gelatine pellet. Fish are being sampled from each group at regular intervals to determine rate of uptake, histological damage, and changes in the components of the blood.

No results are apparent other than the gross symptom of inflamed livers in the high level group.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM AND TOXICITY OF RADIOACTIVE MATERIALS

Ecological Transfer of Radioisotopes

Water in a pond which was spiked with Cs^{137} during June continued to decrease in radioactivity at a more rapid rate than the organisms. The concentration of cesium in the mud decreased slightly from that of last month. There were no marked differences in the amounts of radioactivity in plankton organisms of different sizes.

Zinc

The concentration of Zn^{65} in hair 140 days after injection is about 100 times that in the skin and twice that of the bone. Male and female rats were started

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on a long-term chronic exposure experiment in which the drinking water will contain .05 μc Zn^{65}/ml.

Phosphorus

Twenty female rats were injected with P^{32} to study localization and retention in the ovary.

Strontium

Statistical analysis of the data from an experiment designed to test the applicability of calcium gluconate as an isotopic diluent of strontium in lambs showed that the bond samples were not always representative aliquots. Although the entire skeleton was ground up and well-mixed, as great a difference still existed between aliquots from the bone of one lamb as between the bones of different lambs in the same group. As a result of this observation, a method was developed in cooperation with Biological Analyses whereby large bone samples could be satisfactorily dry-ashed.

Plutonium

Vitamin A administered by stomach tube to rats had no significant effect on the therapeutic action of zirconium citrate, EDTA, or potassium acid saccharate. There was a tendency for the vitamin A to increase tissue retention and decrease excretion of plutonium. This does not preclude the possibility of vitamin A being beneficial in cases of chronic plutonism where bone mobilization might help in plutonium removal. The administration of four amino acids, D-counterparts of non-essential amino acids for rats, showed no beneficial effect in decreasing tissue deposition or increasing urine output of plutonium.

Radioactive Particles

A malignant lung tumor has been confirmed by microscopic examination of histological sections from a mouse killed 500 days after a single intratracheal injection of 0.003 μc of plutonium oxide. This is the third malignant tumor found in plutonium treated mice. Autoradiographs of tissues from this and other mice show "alpha stars" in pulmonary tissue, walls of blood vessels, in lymph, and in submaxillary tissue. The "stars" always appear with large bizarre shaped macrophages. Examination of histological sections from other mice is continuing.

Seventeen days after intratracheal administration of 20 μc plutonium oxide to four dogs, three dogs have excreted about 70 per cent in the feces and the other only 5 per cent. The amounts of plutonium excreted in the urine by all four dogs during this period was only 0.5 per cent of the administered dose. Periodic collection of feces and urine from these dogs is being continued.

Over 300 mice have been allowed to inhale plutonium oxide aerosols. The amount deposited in each mouse ranged from 0.2 to 0.9 μc depending upon the particular exposure. Whole-body monitoring of the mice with the mouse monitor modified to detect the 17 KEV X rays from plutonium was satisfactory. Turnover and metabolism of plutonium oxide and the pathological changes caused by the plutonium will be studied.

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The turnover and metabolism of inhaled $Ru^{106}O_2$ in mice has been studied for 19 weeks. Preliminary results indicate that the turnover can be represented by a power function type equation. This is in agreement with the results previously reported for intratracheal injection of $Ru^{106}O_2$ in mice. After 19 weeks the lungs contain 3 per cent of the amount initially deposited in the mice. This is about 10 per cent of the quantity present in the lungs 2 days after the exposure.

Gastrointestinal Radiation Injury

Rats made anemic by blood withdrawal were exposed to lethal doses (1900 r) of X ray following which absorption of radioiron injected into the stomach was studied. Absorption in the irradiated animals was slower than in surgical controls, due, no doubt, to gastric retention. There was no evidence of a significant defect in absorption due to radiation damage to the mucosa. There was an indication that the anemic animals were more resistant to lethal effects of gastrointestinal tract irradiation than are normal animals. This may be due to the stimulation of the hematopoietic system which is called upon to replace the considerable blood losses due to hemorrhaging following irradiation of the gastrointestinal tract.

Preliminary studies on the alkaline phosphatase content of the serum of rats whose intestines were irradiated suggest that the level of this enzyme is reduced by the third day following irradiation.

Skin Changes Due to Radiation, Aging, or Hypothyroidism

A pilot study designed to detect quantitatively the changes in the skin due to mild pathologic conditions such as hypothyroidism and low levels of beta irradiation, or due to aging was performed. Intradermal injections of Evans' Blue and hyaluronidase were made, and the area of spreading at various times after injection was determined with a polar planimeter. There appeared to be a far more rapid spread of the dye in the young animals.

HA Kornberg
Manager
BIOLOGY OPERATION

HA Kornberg:es

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C. Offsite 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						
Wash. State Newspaper Men	9/13/57	-	Tour facilities.	R.F. Foster L.K. Bustad	No	100-F, 146 FR & 141-M
Dr. Charles C. Congdon	9/30/57	Oak Ridge National Lab, Oak Ridge, Tennessee	Discuss current studies at Animal Farm and present a seminar.	W.J. Clarke L.K. Bustad	No	100-F, 108-F 146 FR, 141-M
VISITS TO OTHER INSTALLATIONS						
R.F. Foster	9/15-28/57	Naples, Italy Symposium on Use of Radioisotopes in Marine Biology	Present a paper	F. Ghiretti	No	
R. Borasky	9/16-20/57	Rome, Italy International Congress of Leather Chemists	Present a paper	-	No	
B. Kawin	9/2-9/7/57	Iowa City, Iowa Ames, Iowa	Attend Am. Physiol. Soc. and present paper. Visit Ames Lab.	-	No	
D.E. Warner	9/8-9/17/57	New York, N.Y. Brookhaven Nat'l. Lab. Oak Ridge Nat'l. Lab.	Attend ACS meeting. Discuss counting methods.	Dr. Carsten K.Z.Morgan J.H.Gillette	No	
R.C. Thompson	9/21-25/57	New York City	Attend NAS Pathological Effects Mtg.	S. Warren	No	
H.A. Kornberg	9/21-29/57	New York City Washington, D.C.	" " " Discuss budget and research problems.	S. Warren P. Pearson	No No	
WJ Clarke RT O'Brien	9/26/57	Portland, Ore.	Participate in TV program.	Dr. Arthur Scott	No	
WJ Clarke, LA George, LK Bustad	9/28/57	Seattle, Wash. Univ. of Washington	Attend Radiation Biology lectures .	-	No	

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D. Lectures

a. Papers presented at meetings

B. Kawin, "Effects of Stable Calcium and Strontium on Distribution of Ca^{45} and Sr^{89}", American Physiological Society, State University of Iowa, Iowa City, Iowa (September 4, 1957).

W. J. Clarke and R.T. O'Brien, "Biological Effects of Radiation", participated in TV program sponsored by the Oregon Museum of Science and Industry (September 26, 1957).

R. Borasky, "Collagen Reactivity with Metals," International Congress of Leather Chemists, Rome, Italy (September 18, 1957).

R. F. Foster, "Radioactive Tracing of the Movement of an Essential Element through an Aquatic Community with Specific Reference to Radiophosphorus," Symposium on Marine Biological Applications of Radioisotopes, Naples, Italy (September 15, 1957).

*

E. Publications

Borasky, R. and B. Mastel, "Electron Microscopy of Magnesium Oxide Particles Collected on Membrane Filters," Document HW-46722 (UNCLASSIFIED) January 1956 (issued in September 1957).

* b. Seminars

Dr. Charles C. Congdon, "The Foreign Bone Marrow Reaction" - September 30, 1957.

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OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT

September, 1957

ORGANIZATION AND PERSONNEL

There were no significant changes during September.

OPERATIONS RESEARCH ACTIVITIES

Economic Studies

Following the completion of Operation Pool, work has been resumed on the study of the relationship of product value to historical operating and capital costs. Studies of the economic evaluation of capital expenditures were continued, with emphasis on the relationship between such expenditures and the operating costs and production plans for the time period involved.

Matrix Methods of Cost Allocation

A draft of a report on matrix cost allocation has been completed. This report describes the basic characteristics of the matrix method of cost allocation and its potential for improving the effectiveness of HLO cost data. The method is adapted for use with current accounting practices.

Attitude Survey

Tabulation of results in the plant-wide attitude survey conducted early in September was completed by Data Processing, and a report describing the results for HAPO and each department or operation as a whole will be issued early in October. Results for components within departments have been forwarded to the respective department task force members for further distribution and analysis.

Inventory Control

At the request of the Stores Operation, the formula used to determine economic order quantity in the present inventory control system for general supplies is being reviewed. The applicability of the general method to spare parts inventories is also being studied.

Paperwork

Liaison with Office Procedures on the paperwork problem continued. Possible types of questionnaires were submitted to small groups of selected personnel to determine their practicality.

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STATISTICAL AND MATHEMATICAL ACTIVITIES IN SUPPORT OF RESEARCH PROGRAMS

2000 Program - Metallurgy

Assistance was given in designing an experimental procedure for determining the density of radioactive materials by the hydrostatic method. Data from one experiment have been analyzed and the density estimates plus uncertainty limits were reported to interested persons. A statistical evaluation of each individual measurement involved in the method was also made. (Unclassified letter to T. K. Bierlein, "Statistical Analysis - Density Determinations by the Hydrostatic Method," September 23, 1957.)

Further discussions were held with personnel of Coating and Corrosion Operation concerning the design of a long term experimental program to minimize uniform corrosion as a function of aluminum alloy.

Assistance was given in analyzing data relating fracture angles of metallic specimens to notch depths. Data were collected at several levels of temperature, and the individual fits for given temperatures were utilized to estimate the average fracture angle at a given notch depth.

2000 Program - Reactor

An interpretation of the formal mathematical theory related to the reflection of x-rays by small irradiation-distorted graphite crystals was provided to the Nonmetallic Materials Development Operation. A method has been proposed for employing this theory to experimentally obtained data.

2000 Program - Separations

The derivation and solution of the partial differential equation pair which describes the time and spacial behavior of the materials in a gas absorbent column were provided to a member of the Engineering Development Planning Operation. Since the exact solutions were obtained in terms of untabulated transcendental functions, a method of satisfactory approximation was devised.

Consultation was provided a member of the Heavy Element Chemistry Operation with respect to the probable rate of reaction in an ion-exchange reactor.

6000 Program - Biological Research

Analysis of sheep bone and liver deposition data from a recent Experimental Animal Farm Operation investigation of the effectiveness of Ca as a preventor of Sr-90 deposition has been completed. Results of the statistical analysis plus comments on the efficiency of the experimental procedure for estimating skeletal deposition were sent to interested persons. (Unclassified letter to L. K. Bustad, "Calcium as a Preventor of Strontium Deposition," 9-3-57.)

Radioecology Operation requested assistance in devising a statistically acceptable method of reporting Cs-137 uptake as a function of time for the various organisms of a test aquatic community. Curve fitting techniques are being used to determine an appropriate form for the uptake function. Programs will be written so that the actual parameter estimates for the numerous organisms can be computed on IBM equipment.

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STATISTICAL AND MATHEMATICAL ACTIVITIES FOR THE PRODUCT DEPARTMENTS

FUELS PREPARATION DEPARTMENT

Process Control

An analysis of operational data from all canning lines was completed. In this analysis, the canning variables for the different lines were investigated for a period in which a significantly large number of ruptured slugs has been canned in one line. The use of control charts to perform this type of analysis on a continuing basis was recommended.

A review of certain current analytical sampling methods has begun. The aim is to reduce the sampling frequency if feasible. Such a move would result in a lighter work load for the analytical laboratory.

The effect of the amounts of lead and iron in the canning bath on the magnitude of the poor bond reject rate is being evaluated.

Consideration was given to changing the specifications on can wall thickness for as-received cans. The effect of such a change on the resulting distribution of wall thicknesses for the canned slugs was investigated. The proposed change would permit thinner can walls, but would compensate in part for this by specifying a smaller population variance.

Process Experimentation

Assistance was give in designing a production test to evaluate low hydrogen dingot material with respect to rupture resistance. Several discussions were held in which the pros and cons of different proposed tests were considered.

Sonic orientation values (a measure of grain orientation) for slugs from several different populations were analyzed as requested.

IRRADIATION PROCESSING DEPARTMENT

Possible relationships between slug reject rates (primarily the void category) and slug rupture rates are being investigated, using data for the past two and one-half years. Using data supplied by IPD personnel for April, 1956 through February, 1957, a rank correlation between number of ruptures per month and the average of certain reject rates was computed and found to be significantly different from zero.

A discriminatory analysis performed on data for slugs canned during a period of six months in 1956 indicated that a more complete study would be feasible. For these relatively meager data, the discriminant function developed, using five reject categories as independent variables, showed that a fair amount of separation between the two types of lots (ruptured lots and non-ruptured lots) could be effected. A more complete analysis, using seven independent variables and data for several more months, will be undertaken.

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More recent rupture data pertinent to the comparison of Hunter-Douglas and

[redacted]

Selective Service

Military status of HLO employees is as follows:

STATUS		Non-Technical	Technical	Non-Technical 1-A	*Critical	TOTAL
Reservists	Standby	11	31	0	1	43
	Ready	21	21	6	2	50
	Total	32	52	6	3	93
Non-Veterans		30	38	21	40	129
TOTAL		62	90	27	43	222

Deferments requests pending	3
Deferments granted	5
Deferments denied, appealed and pending	0
Deferments pending at Presidential appeal level	0

*Critical refers to those employees for whom deferments are currently being requested.

Two HLO employees on military leave were reactivated during September, one joining Relations & Utilities and the other joining HLO Radiation Monitoring Operation.

Benefit Plans

Hanford Laboratories participation in the Employee Benefit Plans as of the end of September is listed below:

	August	September
Insurance Plan	99.7%	99.6%
Pension Plan	98.2%	98.6%
Stock Bonus & Savings	60.2%	59.4%

UNION RELATIONS

A hearing was held on September 25, 1957, in the Prosser Superior Court regarding the Wonacott case. Judge Hamilton decided that the case is arbitrable, but no written decision has been received.

There are no new developments in the negotiations with the Regional Monitors.

Notification was received from the HAMTC that the Stewards and Chief Stewards representing the Chemical Workers and the Operating Engineers would not be recognized as representatives until further notice. They have informed us that, in the meantime, the HAMTC Grievance Committee will serve such groups as stewards.

One grievance was received during the month of September. This grievance was submitted by a Radiation Monitor who alleged that union dues had been deducted from his weekly check without his consent or authorization. The Step I answer was not satisfactory, but due to expiration of time limit, the grievance is considered settled at Step I.

The grievances processed by this Operation since January 1, 1957, now total 17. This number includes one non-unit grievance. The following is a breakdown as to the status of these grievances.

Step I

Answered satisfactorily*	9
Pending time limit	1

Step II

Pending Step II discussion	0
Pending Step II answer	0
Answered	
Satisfactorily**	7
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.

The grievance shown last month at "Pending Step II discussion" is now shown under "Answered satisfactorily - Step I".

The two grievances shown last month at "Pending time limit - Step II" are now listed under "Answered satisfactorily - Step II".

TECHNICAL PERSONNEL PLACEMENT

PhD Recruiting

During the month, ten candidates visited HLO for interviews; four offers were extended, one accepted. Two accepted offers from 1956-57.

PhD - HLO - 9/1/57 to 9/30/57

Cases Considered	Visited	Offers Extended	Offers Accepted	Offers Open	Offers Rejected	On the Roll
11	10	18	3	11	0	2

Offer totals include 14 offers extended during the last recruiting season which were open on September 1, 1957.

Offers accepted do not include 7 acceptances received during the last recruiting season from people who were not on our payroll on September 1. Two of the 7 carry over acceptances reported on the roll during the month.

A statistical summary of complete recruiting activity appears in Table III.

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BS/MS Recruiting

During September, HLO interviewed three candidates, extended offers to two. There were no acceptances or rejections.

BS/MS - HLO - 9/1/57 to 9/30/57

Cases Considered	Visited	To Visit	Offers Extended	Offers Accepted	Offers Open	Offers Rejected	On the Roll
26	3	3	2	-	2	0	2

Exempt Transfers

There were no new transfer requests this month. There were 21 exempt transfer cases carried over from the preceding month. One case was closed this month by termination. A statistical summary of exempt transfers appears in Table IV.

SALARY & WAGE ADMINISTRATION

Salary Administration

Individual graphs prepared for all exempt personnel were forwarded to each level 3 manager during the month. The graphs portrayed the individual's salary and appraisal history as well as showing the upward salary structure trends which have already occurred and those which are anticipated. The main aim was of course to provide the level 3 managers with additional and up-to-date tools in administering the salaries of their employees.

The rough draft copy of the performance appraisal has been revised incorporating changes which were recommended by appropriate managers. It will be sent to printing in the near future so that sufficient forms will be available for the annual appraisals which will be processed around the first of the year.

In view of the continuing increase of hiring rates for new Technical Graduates, graphs plotting annual salary versus degree dates were prepared for all personnel in the four Research and Development components who had first degree dates during the period 1950 - 1957. After completion, the graphs were forwarded to the specific level 3 managers for their review which would enable them to initiate any action they deemed appropriate.

Salary Administration personnel participated with the Manager, Laboratory Auxiliaries and the Manager, Technical Information in completing a minor reorganization within the Technical Information component during the month.

The following position audits were completed during the month.

Financial	2
Laboratory Auxiliaries	4
Reactor & Fuels R & D	2
Physics & Instruments	2
Chemical R & D	1
Radiation Protection	4
Operations Res. & Syn.	2
	17

The following position changes were effective during the month.

Positions deleted	7
Position titles changed	4
Position levels changed	2

Wage Administration

Twenty-seven meetings were held with level 4 and 5 supervision during the month for purposes of discussing the evaluation plan for semi-technical jobs. After all supervisors and managers have been contacted the plan will be modified to incorporate all pertinent comments. On the whole, the plan is being favorably accepted by supervision.

The analysis of the data obtained from the attitude survey conducted during the month is being completed by the Specialist, Wage Administration. The final report should be ready for distribution by the end of October.

HEALTH, SAFETY, AND SECURITY

During September, Laboratories personnel worked a total of 178,277 hours with no disabling injuries. Since September 1, 1956, a total of 2,437,078 hours have been completed with no disabling injuries.

There were 30 medical treatment injuries with a frequency of 1.68 as compared to 1.35 last month. For the year to date, the frequency is 1.76.

Six security violations in September made the 1957 total 79 to date.

Arrangements were made to integrate Health, Safety, and Security orientations for new employees with Radiation Protection Orientations that are presented monthly.

A one-year analysis of injuries was completed for submittal to Atmospheric Physics Operation for an investigation of possible effects of weather on incidence of injuries.

A study on silica fume hazards and illumination problems was completed for the Glass Blowing Shop by Industrial Hygiene Operation.

Assistance was given three Operations on preparation of safety meeting material:

Technical Shops
Radiation Monitoring - 200-East
Process Demonstration & Analysis

A talk on injury experience in HLO and goals for injury prevention was presented to Radiochemical Analysis group.

A summary of HLO fire experience for the past year was published in HL News to introduce "Fire Prevention" month.

Inspections were made at Radiological Chemical Analysis and General Chemical Analysis Laboratories in 100-KE Area. In the latter lab, Safety procedures were outlined for new equipment being planned.

Scheduled medical exams were 102% completed this month.

T G Marshall

Manager
Employee Relations

TG Marshall:tr

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VISITORS TO HAPO

Name	Dates of Visit	Company or Organization Represented	Reason for Visit	Personnel Contacted	Access to Restricted Data	Areas and Buildings Visited
Ralph M. Baltzo	9/20	Univ. of Washington School of Medicine Dept. of Radiology	Discussions re AEC Radiological Physics Fellowship Program	DC Fleckenstein WJ Bair LK Bustad WC Roesch JW Healy AR Keene	None	300 - 3702, 329, 3746 100F - 141-M

VISITS TO OTHER SITES

T. W. Galbraith	9/17-9/20	GE - Schenectady	Attend GE PhD Centralizer Meeting	Jack Wolfe George Hazzard Glen Giddings David Cline Richard Neal		
M. W. Hall	9/4-9/6	APED, San Jose	Recruiting	MW Hall RW Trevithick		

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TABLE III. EMPLOYMENT - TECHNICAL PERSONNEL STATUS

I. Employment

Non-Exempt Employment Status	Aug.	Sept.
Requisitions		
At end of month	26	13
Cancelled	1	2
Received during month	17	11
Filled during month	7	22
Candidates Considered		
Total applications	3	23
Total Transfer Request from other at HAPO	9	3
Total Interviewed	0	0

Non-Exempt Transfer Requests	Aug.	Sept.
Transfer Cases		
Active cases at end of month	46	51
Cancelled	1	3
New during month	4	9
Transfers effected	4	1
Planned Transfers		
Effective during month	1	2

II. Technical Personnel Placement

Ph.D. Recruiting - HLO

	Cases Considered	VISITS TO RICHLAND: Extended	Visited	To Visit	Open Invite.	OFFERS: Extended*	Accepted	Open	On The Roll
Engineering:									
Chemical	16	7	-	2	5	3	-	3	-
Electrical	5	2	-	2	-	2	-	1	-
Mechanical	5	3	2	2	-	2	-	-	-
Metallurgy & Ceramics	20	11	2	4	4	2	-	2	1
Other	2	-	-	-	-	-	-	-	-
Science:									
Chemistry	34	12	2	7	3	5	3	2	-
Physics	77	34	4	18	12	4	-	3	-
Math-Stat.	7	1	-	-	1	-	-	-	-
Other	5	1	-	1	-	-	-	-	1
TOTALS	171	71	10	36	25	18	3	11	2

*Offer totals include 14 Ph.D. open offers as of Sept. 1, 1957

BS/MS Experienced Recruiting - HLO

	Cases Considered	VISITS TO RICHLAND: Extended	Visited	To Visit	Open Invite.	OFFERS: Extended	Accepted	Open	On The Roll
Engineering:									
Chemical	2	1	-	1	-	-	-	-	-
Electrical	4	1	-	1	-	-	-	-	-
Mechanical	8	4	2	1	-	2	-	2	-
Metallurgy & Ceramics	1	-	-	-	-	-	-	-	-
Civil	1	-	-	-	-	-	-	-	-
Science:									
Chemistry	3	-	-	-	-	-	-	-	2
Math-Stat.	1	1	1	-	-	-	-	-	-
Other	6	-	-	-	-	-	-	-	-
Totals:	26	7	3	3	-	2	-	2	2

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TABLE IV. Exempt Transfer Cases

			Sept.	Aug.	Total
Active cases at beginning of month			21	17	
New cases:	Initiated by employee			3	
	Initiated by management*			2	
Cases reactivated					
			21	22	
Cases closed:	Transfers:	Within HLO			3
		Within HAPO			2
		Other GE			7
	Withdrawn				7
	Terminated		1	1	9
			20	21	28
Active cases at end of month			20		20

Total cases - January 1, 1957 to date 48
Initiated by employee 25
Initiated by management* 23

*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 17 (includes 1 non-unit grievance)

Step I

Answered satisfactorily	9
Pending time limit	1

Step II

Pending Step II discussion	0
Pending Step II answer	0
Answered	
Satisfactorily**	7
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.

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FINANCIAL OPERATION MONTHLY REPORT
September 1957

Compiled by Members of the
FINANCIAL OPERATION
HANFORD LABORATORIES OPERATION

Personnel

One exempt person was added to the payroll during September to fill the position of Specialist - Cost Analysis in Cost Accounting.

Activities

General Accounting Operation

All field work in connection with the physical inventory of uninstalled cataloged equipment in the custody of Physics and Instruments Research and Development Operation is complete and the reconciliation is in progress. 914 items, valued at $734,812 were inventoried with 125 items ($35,634) physically located for which no record could be found. These items were added to record and lists of unlocated equipment, 33 items valued at $11,516, were sent to applicable custodians.

Preparations were made and a procedure distributed for the physical inventory of uninstalled cataloged equipment in the custody of Reactor and Fuels Research and Development Operation which began September 30, 1957.

A procedure was distributed for the physical inventory of uninstalled cataloged equipment in the custody of Chemical Research and Development Operation. This inventory will begin October 28, 1957, and continue through November 8, 1957.

A report of findings in connection with the physical inventory of Hot Semi-works was issued in September 1957. The Hot Semi-works valued at $4,356,674 was transferred from operational status to "Plant and Equipment Held for Future Use".

All field work in connection with the physical inventory of reactor and other special materials is complete and the reconciliation is in progress. Twelve financial personnel particpated in the counting and listing of the physical inventory which extended over a two-day period. Financial personnel were borrowed from CPD, Contract Administration and HLO Cost to assist in taking the physical inventory.

Two Property Disposal Requests were processed in September to write off portions of P-11 Facilities. PDR HL-57-44 removed from record contaminated equipment and Building #120 valued at $60,610. HLO will retain control over these contaminated facilities and initiate appropriate measures to insure radiation safety. PDR HL-57-42 removed from record $48,773, representing buildings #121,122,123 and wire fence, released for public sale. It is expected that the balance of P-11 Facilities will be removed from HLO records in October.

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HEW numbered tags on RDX equipment will be painted red to clearly distinguish RDX equipment from capitalized movable equipment. This will enable field personnel to readily identify an item as either RDX or capital. As soon as the current inventory of uninstalled cataloged equipment is completed, all RDX tags previously issued will be painted.

Estimates of funds required for attendance at off-site courses and seminars during FY 1958 have been received from level 3 managers and tabulated for submission to the Manager - Hanford Laboratories Operation. Total Hanford Laboratories Operation estimated requirements equal approximately 175% of available funds.

At the direction of Contract Administration, per diem reimbursement was obtained from the Commission for eight days that the Crotonville course on Advanced Management was not in session while being attended by the Manager - Hanford Laboratories Operation.

During the month, an AEC Auditor worked on an audit of travel and living expenses.

Letters seeking AEC approval or agreement were prepared covering the membership of Dr. R. B. Leonard in a national committee being established by the AEC and covering a proposal that Hanford Laboratories Operation fabricate approximately 135 extruded uranium dioxide pieces for APED.

A forecast covering the requirments of Hanford Laboratories Operation for beryllium was prepared and submitted to Contract Administration.

Cost Accounting Operation

A study was made to determine the effect upon Hanford Laboratories of possible reductions in FY 1958 amounts requested for HAPO operating costs. Two hypothetical plans were developed varying in the extent of reductions for HAPO programs. The resulting action to be required of HLO ranged from 1% to 15%. The study could serve as the starting point should, in reality, such a situation develop.

Effective September 1, 1957 the Technical Information Operation of Laboratory Auxiliaries was reorganized. The FY 1958 Revised Budget and FY 1958 actual costs through August 31 were recast to conform to the new level five organizations.

Due to the establishment of a new level four component, Radioecology Operation, on September 1, 1957 in Biology Operation, the FY 1958 Revised Budget was reallocated during the month to the current level four components.

Effective October 1, 1957, Calibrations Operation will assume plant-wide responsibility of coordinating the fabrication and issuance of sources used to check portable health instruments. The cost of fabrication will be from two sources: Radiochemical Analysis Operation will make the sources while the holders will be fabricated by FPD Maintenance. Calibration Operation will assemble and issue the completed sources to requesting components. Rates are currently being established which, based on number and type of sources issued, will distribute the related costs.

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A regular schedule of monthly meetings has been agreed upon by the various cost accumulation groups throughout HAPO with a different person conducting the meeting each month. The prime purpose of these meetings is to discuss current problems and for exchange of ideas.

Personnel Accounting Operation

One non-exempt employee was employed on 9-11-57 as a General Clerk B, in the Laboratory Auxiliaries Operation, Technical Information Operation, on a part time basis of 2 hours per day Monday through Thursday, a total of 8 hours per week. The employee will work from 6:00 p.m. to 8:00 p.m. in W-10 Technical Library.

Average cost of Safety Awards of $2.93 are to be included in exempt and non-exempt year to date earnings in September and applicable taxes deducted.

Salary Administration data and College Graduate Index information were combined and transmitted to L. L. Weiss by October 15, 1957. As a result of this request we found that at HLO we have 415 exempt college graduates, 95 with doctor's degrees, 103 with master's degrees, 215 with bachelor's degrees; also 37 non-exempt employees with bachelor's degrees.

As a result of the Better Living Program the base rates and isolation pay of non-exempt employees were increased 3% on October 1. Area Differential pay to exempt employees was also adjusted by 3%. Shift differential to non-exempt employees was increased one cent per hour. Based on the hourly base rate of non-exempt employees week ending 9-9-57 this increase of 3% would amount to an approximate annual increase of $78,000. Isolation pay increase to non-exempt employees would amount to approximately $2,600, shift differential $1,500 and area differential to exempt employees $1,800. This would mean a total increase on an annual basis of $84,000.

Two death claims were paid in the month of September totaling $30,341.

Auditing

Audit activities during September have been:

1. Completion of the Suggestion Plan audit. The report, which is now ready for issue, contains no significant findings.

2. Start the Cost Accounting audit. This is scheduled to be completed in November 1957.

3. Review and test Payroll Operation procedures for deducting and reporting Good Neighbor Fund contributions.

Measurements

An outline incorporating objectives, programs, and goals was submitted for Financial. Assistance was given in the initiation of revised unit cost reporting for Exposure Evaluation and Records.

Office Procedures

During the period, efforts continued concerning the problem of paperwork in HLO. A questionnaire was designed for submission to all first-line organizations in the Operation; it is intended that this survey provide factual information concerning all aspects of this problem. Coordination of efforts in this regard were continued with Operations Research and Synthesis. An alternate questionnaire was developed by that group and samples of both surveys were submitted to several offices on a test basis. Following the evaluation of the sample results now being completed, the main survey of the entire Operation will be made.

Assistance was given to Radiation Protection Operation concerning their current study of the management of all records originated by that component. The study includes a review of appropriate chapters of the AEC manual on records control. Further records management criteria and schedules are being developed.

Payroll Statistics

Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1,159	498	661
Additions and Transfers in	25	8	17
Removals and Transfers out	(22)	(12)	(10)
Transfers from Non-Exempt to Exempt	-	-	-
Employees on Payroll at End of Month	1,162	494	668

Overtime Payments During Month	September	August
Exempt	$1,114	$2,880
Non-Exempt (Five weekly periods in August)	7,958	6,548
	$9,072	$9,428

Gross Payroll Paid During Month		
Exempt	$367,955	$369,918
Non-Exempt (Five weekly periods in August)	259,400	332,421
	$627,355	$702,339

Participation in Employee Benefit Plans at Month End	No. Participating		% Participating	
	September	August	September	August
Pension Plan	1,090	1,072	98.6	98.2
Insurance Plan				
Personal Coverage	1,184	1,179	99.6	99.7
Dependent Coverage	719	716		
U.S. Savings Bonds				
Stock Bonus Plan	689	698	59.4	60.2
Savings Plan	96	96	8.3	8.3

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Insurance Claims Paid	September Number	September Amount	August Number	August Amount
Employee				
Life Insurance	2	$30,341	-	-
Weekly Sickness & Accident	17	1,073	12	$ 1,113
Comprehensive Medical	33	4,881	26	2,836
Dependent				
Comprehensive Medical	49	5,924	56	6,442
Total	101	$42,219	94	$10,391

Good Neighbor Fund	September	August
Number Participating	755	754
Percent Participating	64.9%	65.0%

Other Statistics

Cash Advances and Travel Expense	No.	September	No.	August
Accounts Outstanding at Beginning		$14,540		$10,721
Charges:				
Cash issued - by checks	35	3,476	29	5,854
- by currency	51	5,390	44	4,521
Transportation		11,633		6,145
Other - (Billings from other GE Components, Moving Expense, etc.)		1,319		3 064
		36,358		30,305
Less:				
Expense vouchers processed				
Travel expense accounts	75	14,097	37	7 777
Other (Moving Expense, Conference Expense, etc.)	29	1,505	14	2,726
Refund of advances	59	5,526	35	2,628
Billings to and from HAPO components-Net		(8)		2,634
Accounts Outstanding at Close	47	$15 238	51	$14 540

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INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

INVENTOR	TITLE OF INVENTION OR DISCOVERY
W. A. Kline F. G. Moore	Latching Switch
M. O. Rankin	A Light-Activated Zinc Sulphide Particle Counter
M. O. Rankin H. Kudish	An Alpha-Activated Zinc Sulphide Particle Counter

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