# HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

## AUGUST, 1961

SEPTEMBER 15, 1961



HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

GENERAL ELECTRIC

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# HANFORD LABORATORIES OPERATION
# MONTHLY ACTIVITIES REPORT
# AUGUST, 1961



Compiled by
Operation Managers

September 15, 1961



HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

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# TABLE OF CONTENTS

TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE August 31, 1961

| | At close of month | | | At beginning of month | | | Additions | | Separations | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Exempt | NonExempt | Total | Exempt | NonExempt | Total | Exempt | NonExempt | Exempt | NonExempt |
| Chemical Research and Development | 128 | 123 | 251 | 128 | 118 | 246 | 1 | 6 | 1 | 1 |
| Reactor & Fuels Research & Development | 205 | 200 | 405 | 205 | 193 | 398 | 2 | 7 | 2 | 0 |
| Physics & Instrument Research & Development | 100 | 63 | 163 | 99 | 60 | 159 | 2 | 4 | 1 | 1 |
| Biology Operation | 36 | 49 | 85 | 38 | 48 | 86 | 1 | 1 | 3 | 0 |
| Operation Res. & Syn. | 19 | 4 | 23 | 19 | 4 | 23 | 1 | 0 | 1 | 0 |
| Radiation Protection | 39 | 95 | 134 | 41 | 97 | 138 | 0 | 3 | 2 | 5 |
| Laboratory Auxiliaries | 47 | 184 | 231 | 47 | 183 | 230 | 1 | 4 | 1 | 3 |
| Financial | 19 | 16 | 35 | 20 | 15 | 35 | 0 | 2 | 1 | 1 |
| Prof. Placement & R. P. | 98 | 11 | 109 | 98 | 11 | 109 | 4 | 0 | 4 | 0 |
| Programming | 18 | 4 | 22 | 18 | 4 | 22 | 0 | 0 | 0 | 0 |
| General | 2 | 4 | 6 | 2 | 4 | 6 | 0 | 0 | 0 | 0 |
| Totals | 711 | 753 | 1464 | 715 | 737 | 1452 | 12 | 27 | 16 | 11 |
| Totals excluding internal transfers. | 711 | 753 | 1464 | 715 | 737 | 1452 | 12 | 25 | 16 | 9 |

## BUDGETS AND COSTS

August operating costs totaled $2,397,000; fiscal year-to-date costs are $4,464,000, or 17% of the $26,165,000 control budget. The budget conforms with the departmental allocation of funds authorized by the General Manager - HAPO in August.

Hanford Laboratories' research and development costs for August, compared with last month and the control budget, are as follows:

| (Dollars in Thousands) | Cost: Current Month | Cost: Last Month | Cost: FY To Date | Budget | % Spent |
|---|---|---|---|---|---|
| HLO Programs | | | | | |
| 02 Program | $ 36 | $ 37 | $ 73 | $ 605 | 12% |
| 04 Program | 1 134 | 755 | 1 889 | 9 930 | 19 |
| 05 Program | 60 | 61 | 121 | 993 | 12 |
| 06 Program | 194 | 197 | 391 | 2 665 | 15 |
| | 1 424 | 1 050 | 2 474 | 14 193 | 17 |
| FPD Sponsored | 126 | 105 | 231 | 1 400 | 17 |
| IPD Sponsored | 113 | 100 | 213 | 1 325 | 16 |
| CPD Sponsored | 131 | 108 | 239 | 1 525 | 16 |
| Total | $1 794 | $1 363 | $3 157 | $18 443 | 17% |

## RESEARCH AND DEVELOPMENT

### 1. Reactor and Fuels

A project proposal revision for the Critical Facility requests a new completion date of December 31, 1961, and additional funds of $40,000. The revised completion date of June 30, 1962, for the Rupture Loop has been approved.

PRTR process tube plugging resulted in an eight-day reactor shutdown. The cause of the plugging was determined to be fragments of a coffee can believed to have been introduced into the system during process pump seal repair.

$D_2O$ and helium losses from PRTR were high during the month. Detection and repair of leaks and improvement of the $D_2O$ recovery system and of $D_2O$ inventory methods are of high priority.

No evidence of wire wrap loosening, corrosion, crud, or surface damage was found in two PRTR $UO_2$-bearing fuel elements examined after operating at maximum heat generation conditions and a total exposure of ca. 250 MWD/T. Pu-Al spike elements show evidence of wire wrap loosening although not in the wires contacting the process tubes. It is possible that the effect disappears at operating temperature.

A section of PRTR process tube No. 1154 (removed from the reactor in July) which contained two 4 to 5-mil deep and 5/8-inch long wear or fretting marks was burst-tested at room temperature at an internal pressure of 7450 psi. The fracture did not pass through the fretted areas.

Radiochemical analyses have confirmed the extensive relocation of fission products in highly exposed $UO_2$ fuel as first detected by autoradiographic techniques.

Hot swaging of $UO_2$ fuel rods at 700 C consistently produces densities of 92%.

Ten $UO_2$-$PuO_2$ capsules are being irradiated in the MTR; six are low-density (65% TD) specimens and four are high-density (90% TD) specimens. One high-density sample was discharged at 10,000 MWD/T exposure after having operated for part of that exposure at a surface heat flux of 780,000 Btu/hr-sq ft.

Zircaloy-clad capsules containing fuel mixtures of $PuO_2$-$ZrO_2$ and $PuO_2$-MgO are being prepared for irradiation testing in the MTR.

The thermal electromotive force of four Pu-O compositions in the range $PuO_{2.00}$ to $PuO_{1.85}$ has been measured. Electrical resistivity measurements have been made on 50 $UO_2$-50 $PuO_2$ and $PuO_2$.

Insertion of the Phoenix capsules in MTR has been delayed until September 5 by the requirement of a hot-spot hot-channel analysis.

Sixteen of a total of 21 Euratom test fuel rods containing high exposure plutonium oxide (17%-240) have been fabricated and shipped to the customer.

Data from the basic swelling studies combined with other capsule irradiations lead to the provisional and somewhat surprising conclusion that Zircaloy-2 cladding provides little resistance to swelling of metallic uranium fuel.

Buckling of the inner clad surface of single tube metallic uranium fuel has resulted from exposure to 3600 MWD/T.

Three metallic uranium fuel elements with fluted outer surfaces are being prepared for irradiation to test the hypothesis that the extended surface should eliminate direct tensile strain in the clad, reducing failure due to clad thinning mechanisms.

Ex-reactor rupture tests of irradiated NPR-type fuel continue to show much superior rupture behavior for 2 w/o Zr-uranium cores compared with unalloyed uranium core elements. In other fuel rupture tests the rupture appearance of irradiated coextruded fuel has apparently been duplicated in unirradiated rods by preheating the rods to 850 C to weaken the cladding bond.

Modifications of the ETR 6x9 loop for the irradiation of structural materials were completed in time for the reactor startup on cycle 39. An assembly containing 504 Zircaloy-2 tensile specimens constitutes the first loading of this facility.

For graphite at 800 C and Zircaloy at 400 C, a water partial pressure of 0.3 to 0.5 mm in simulated NPR stack gas was required for sufficient water-vapor diffusion through the graphite to maintain a protective film on the Zircaloy.

Maximum fuel temperatures to be expected at C Reactor following a sudden flow reduction to an "overbore" process tube were determined in the heat transfer laboratory. It was found that for initial tube powers of 1000 and 1800 KW, flow reductions to 10 and 30% of original flows could be sustained without encountering excessive temperatures.

Analysis was completed of laboratory experiments determining fuel temperatures following an inlet piping rupture on a BDF reactor process tube. The results indicated that the majority of central zone tubes in these reactors would not be subjected to fuel jacket melting for such a piping rupture.

2. Chemical Research and Development

Prototypical NPR fuels subjected to a temperature of 1200 C in an air atmosphere were observed to fail in about one hour's time through air oxidation and subsequent penetration of the Zircaloy-2 clad; at 1300 C, the Zircaloy-2 clads failed through an uranium diffusion mechanism.

Preliminary interpretation of ground water temperature data indicates that some thermally warm water from the separations areas is moving southward and may have reached the Columbia River just north of the 300 Area. Although a tongue of warm water extends southward from the 200 Areas to within two miles of the Yakima River, the buried Yakima Ridge anticline is shown to be an effective barrier to further southward movement.

Approximately 300 kilocuries of strontium-90 were recovered in the third Hot Semiworks campaign. The total inventory of purified strontium-90 now in storage at the Hot Semiworks is about 500 kilocuries.

Pressure build-up problems associated with the shipment of Decalso laden with strontium or cesium in sealed casks can virtually be eliminated by removing the interstitial liquid from the ion exchange media. Near quantitative removal of the cesium or strontium from Decalso can be realized providing the bed temperature remains below 100 C.

A Hot Semiworks solvent extraction slowsheet has been devised which shows promise of effecting the sequential recovery of three separate fission

product packages; namely, strontium-90, cerium-144, and a gross rare earth fraction.

The extraction of cesium from alkaline Purex waste supernate with nickel ferrocyanide was shown to effect substantial cesium concentration and separation from sodium ion, thus permitting markedly increased quantities of cesium to be loaded onto Decalso prior to off-site shipment.

Studies on the selective precipitation of cerium(IV) peroxyacetate from full level Purex waste have led to identification and correction of previously defined process conditions which negated successful demonstration of the cerium recovery process at the Purex plant.

What appears to be single crystals of $UO_2$, weighing up to about four grams, were produced by electrolytic deposition from the molten $KCl-PbCl_2$ system.

3. Physics and Instrument Research and Development

Improved understanding of operating limitations of NPR fuel will result from measurements recently completed of the higher heat generation adjacent to the end caps in both inner and outer tubes of fuel.

In the program supporting existing reactors a more sophisticated model simulating the reactor during safety rod drops and partial insertions is giving substantially different results than were obtained before with more simple models. Implications of the results for reactor operation are being assessed by the customer, IPD. In the instrument area an invention disclosure was filed on a device for measuring structural displacements of reactor process channels out of the line of sight. The present concept which has been embodied in a device for testing in the reactors uses an optical method, but electrical readouts are being developed to increase the rapidity of use.

In the nuclear safety program, critical mass experiments on plutonium solutions continued in a 14-inch sphere and have revealed an enhanced poisoning effect of Pu-240 in high concentration soltuions arising from a shift in the neutron energy spectrum.

In Air Force supported programs in Atmospheric Physics, the first series of diffusion experiments at Vandenberg Air Force Base, California, was completed. It comprised a total of 52 field trials embracing a wide range of wind speeds and atmospheric stabilities over rough terrain. Data collected during the earlier test series at Cape Canaveral, Florida, were forwarded to the Air Force for further analysis.

Efforts to improve our capabilities in reactor physics calculations continued with the completion of the coding of three new computer codes during the month. Two of these represent advances in physical sophistication over

previous methods available here while the third allows a more accurate analysis of the results of exponential pile measurements. In addition, one new program and two nuclear data tapes were obtained from the former GE-ANP laboratory.

Analysis of the PRTR core using the RBU code made progress when several test cases of the Monte Carlo portion of the code gave excellent results.

A detailed investigation of the use of "Phoenix Fuel" in compact, water-moderated, power reactors has begun.

In the area of basic nuclear data, calibration data were successfully obtained which will allow a quantitative interpretation of measurements previously made on neutron scattering by water molecules. Other cross section work included the first successful trail run using the Van de Graaff positive ion accelerator as a neutron source in which results obtained for a total cross section of aluminum from 3.5 to 10 mev agreed with known data.

Significant progress was made in the radiation instrument program through completion of an experimental pocket-size dosimeter with register readout; completion of another type miniature dosimeter with an aural alarm; completion and delivery to the reactor areas for demonstration of an improved beta-gamma personnel and area monitor; completion of system modifications for the Radiation Protection Operation Automatic Film Badge Densitometer; and development of new techniques for making solid state detectors which have alpha energy resolutions of about one percent.

4. Biology

Some very interesting data on the in vivo and in vitro ultrafiltrability of added $Ca^{45}$ as compared with the normally present $Ca^{40}$ suggests that the formation of calcium-phosphate complexes in the blood of living animals may serve, in addition to protein complexing, in the regulation of the levels of ionic calcium and phosphate.

Thirty days after inhalation of plutonium nitrate, the lungs of three dogs contained from 64 to 72 percent of the total body burden, the liver from 9 to 17 percent, and the skeleton from 15 to 20 percent. Less than 1 percent of the total deposited had been excreted in the urine.

Solutions thought to contain predominantly Np(IV), Np(V), and Np(VI) were absorbed from the intestine of rats to the extent of 0.3, 1.1, and 2.3 percent, respectively. These studies were made with $Np^{237}$, and citrate was present in all cases in order to enhance solubility. Further studies in the absence of citrate and at much lower mass levels will be conducted employing $Np^{239}$.

It has been found possible to prepare a plutonium solution in such a form that approximately 90 percent of an intravenous dose to a rat is deposited in



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the liver. This plutonium, presumably of a colloidal nature, is not appreciably affected by subsequent DTPA treatment (less than 5 percent removed).

5. Programming

An important result of the "crash" program during July and August on computation of plutonium values was the clear recognition that not only is Pu-239 a fissile substitute for U-235, but Pu-240 is a fertile substitute for substantial quantities of U-238. In order to obtain minimum fuel costs (and maximum plutonium values) when recycling reactor grade plutonium, it will sometimes be necessary to decrease substantially the uranium oxide density in order to reduce the amount of U-238 present. Computed plutonium values ranged from $8 to $14 per fissile gram for five prototype reactors studied; it is anticipated that values based on optimum density of mixed oxide fuel for each reactor type not only will be higher but also may show a smaller spread.

## TECHNICAL AND OTHER SERVICES

The updating and further development of "learning" curves describing the irradiation process and over-all HAPO production and cost were completed.

Increased attention is being given to statistical studies in connection with process tube leaks caused by internal corrosion.

Void fraction and void density estimates were calculated for all fission gas pore size distributions currently available from the Swelling Studies Program. Analysis is continuing using BIMD routines.

Data were analyzed to determine the existence of an association between rainfall and cesium content in milk.

A review was initiated of the methods of statistical analysis used in the atmospheric diffusion experiments to obtain down-wind cross section profiles and meteorological parameters from the experimental data.

There were four new cases of plutonium deposition confirmed through analyses of biological samples. The total number of plutonium deposition cases that have occurred at Hanford is 271, of which 197 are currently employed.

Two CPD engineers received whole body exposures in excess of the Hanford operational control when they were exposed to dose rates up to 500 r/hour. The exposure occurred when the men entered a trench to inspect welds on two lines leading to a newly constructed waste crib for the Purex facility. Premature and unauthorized usage of the lines led to the uncontrolled exposure. Evaluation of the film badge dosimeters and analysis of the dosimetry involved indicated that the whole body dose was between 1.7 r and 2.1 r for one employee and between 2.1 r and 2.8 r for the second individual. Previous exposure for this calendar year was negligible for both men.

Routine processing and analysis of the film badge dosimeter for a CPD lab technician at the 234-5 Building indicated a dose of 2.1 r for the four-week period. Although a thorough investigation failed to reveal a satisfactory explanation for the exposure, examination of the film indicated that the film density resulted from exposure to penetrating gamma radiation.

There are 20 currently active projects having combined authorized funds in the amount of $5,415,000. The total estimated cost of these projects is $10,781,000. Total expenditures on them through June 30, 1961 were $1,982,000. In addition, project proposals have been submitted requesting authorization of $562,000 total project funds on 4 new projects.

SUPPORTING FUNCTIONS

Advanced Degree - Eight Ph.D. applicants visited HAPO for professional employment interviews. Seven offers were extended (all HL); six acceptances and six rejections were received (all HL). Current open offers total six. Twenty-two Ph.D. acceptances were obtained during the recruiting year ending August 31. Of these twenty-two, seven were Company transfers, five were open market and ten were campus candidates.

BS/MS - Plans were made for fall campus recruiting trips. A new record-keeping system was devised and is being installed for the 1961-62 recruiting year along with other routines designed to streamline the administrative efforts involved.

Technical Graduate Program - One Technical Graduate was placed on permanent assignment. Seven new members were added to the program rolls and three terminated. Current program members total 89.

The document HW-69476, "Guide to Procurement and Use of Pressure Equipment," was issued to all HAPO personnel concerned with such equipment in furtherance of operational safeguards.

During August, three security violations and 32 medical treatment injuries occurred.

Twenty-six requisitions for non-professional personnel were filled during the month with a total of twenty active requisitions remaining to be filled.

Standard rates were established to bill salaries of section and sub-section managers and specialists for special off-site work. Section level personnel will be billed at $100 per day. Sub-section managers and specialists will be billed at $75/day.

It is presently planned to visit Arco during September to physically inventory the equipment purchased on Project CA-681, Hanford Equipment in the ETR.

W. H. Rees
for Manager
Hanford Laboratories

HM Parker:WHR:mlk

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# REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

## TECHNICAL ACTIVITIES

## A. FISSIONABLE MATERIALS - 2000 PROGRAM

### 1. METALLURGY PROGRAM

#### Corrosion Studies

Erosion Corrosion of Aluminum Alloys. Small areas of aluminum alloys X-8001 and 1245 were exposed to 300 Area tap water at 105 C and a flow velocity of 88 ft/sec for six hours. The water was adjusted to various pH levels between six and eight by adding nitric acid or sodium hydroxide. Results showed no measurable corrosion on X-8001 at pH 6, 6.3, and 6.7, but at pH 7 the penetration was 1.6 mils and at pH 8 was 6.0 mils. Alloy 1245 showed a penetration of 3.2 mils at pH 8, but no measurable corrosion at pH values of seven and below.

Two other tests on water quality were performed using deionized water at pH 8 and pH 10. At pH 8, X-8001 showed no measurable corrosion and at pH 10, the penetration was only 0.5 mil. Tests are being continued to investigate further effects of water quality on erosion-corrosion rates.

Corrosion Resistant Coatings for X-8001 Aluminum. Determinations have been made of the comparative corrosion resistance imparted to X-8001 aluminum by three different autoclave treatments, viz; (a) dual-cycle steam-chromic acid, (b) dual-cycle water-chromic acid, and (c) single-cycle chromic acid autoclave treatment. The single-cycle chromic acid process was used as a reference treatment because its in-reactor corrosion behavior has previously been characterized.

The corrosion resistance of each coating was determined by using boiling 1% HCl 5% NaCl, and boiling 5% $Na_2CO_3$. The results of these accelerated tests indicate that the water-chromic acid autoclave treatment reduces "worm tracking" and provides the most corrosion resistant coating, approximately three times as resistant as a single-cycle, chromic acid treatment.

A test designed with the assistance of Operations Research is being run to determine the optimum time and temperature for the individual water and chromic acid cycles.

#### Radiometallurgy Laboratory Studies

Six zirconium specimens from capsule GEH-14-230 were mounted and prepared for x-ray diffraction studies (RM-512). The reaction between the coolant and fuel was confined to the area around the defect in an irradiated tubular, 2% Zr-U alloy element which was purposely defected

and ruptured in an ex-reactor loop (RM-566). Examination of two end-cap sections from two KER single-tube elements irradiated to 2000 MWD/T showed that the weld closures were in good condition, but cracking of the uranium had occurred (RM-578). An NIE suspect failure was loaded into a special cask and shipped to the IRP Facility for testing (RM-580). An NPR inner tube element, which was irradiated to 1000 MWD/T at simulated NPR conditions, PT-IP-277A, was warped 60 mils, double throw, and both the internal and external surfaces were slightly bumped (RM-583).

Examination of longitudinal end-cap sections from an Fe-Be-Zr brazed element, GEH-4-58, revealed porosity in the braze under both end caps. Also, considerable porosity was observed in the uranium adjacent to the internal cladding (RM-707). Metallography of one end of a KER size tube-tube element, GEH-10-39 and 40, showed the Fe-Be-Zr braze was cracked adjacent to the uranium in both inner and outer components (RM-709).

Further details and interpretations of the above findings will be reported in connection with the development programs served.

Basic Metallurgy Studies

Electron and Optical Microscopy. High purity aluminum foils in the annealed and cold worked states have been irradiated in a Hanford Snout facility to doses as high as $2 \times 10^{20}$ nvt (Thermal). Small loops, approximately 200 A in diameter, are formed during low exposures and these increase in size with continued dose to eventually give very large irregularly shaped loops. These loops are due to vacancy or interstitial clustering. In order to compare the behavior of these loops with known vacancy loops, high purity aluminum foils have been quenched from 620 C to -10 C, and have been examined. The collapsed vacancy clusters are small, $<$ 200 A diameter, are numerous, and are absent in regions close to dislocation lines and grain boundaries. Foils of quenched aluminum have been encapsulated for irradiation, and changes as a function of neutron dose will be correlated with results obtained on annealed and on cold-worked specimens which originally contained no vacancy loops. Foils of aluminum separated by a distance of approximately 0.002" from a carbon coated-$UO_2$ fission source have been prepared for irradiation. After irradiation, the foils will be directly examined for evidence of fission fragment damage.

Notch Sensitivity of Zircaloy-2. Unpredicted failure of several test fuel elements has prompted an investigation of mechanical properties of Zircaloy-2 cladding. The failures are a result of severe local straining without uniform deformation. In order to examine the effects of tube wall irregularities on strength and ductility, tensile tests at elevated temperatures (280 C) are being conducted. Data previously reported from V notch specimens with a 0.005" base radius showed an increase in nominal strength values with increasing notch depth. A strain rate effect was also observed with an increased rate causing an increase in strength. Uniform strain in the unnotched section of the specimens decreased with increasing notch depth, but the decrease was not proportiona

to the reduction of cross section area at the notch. The influence of notch shape on strength values was investigated using square notched specimens. Notches were of various depths and 0.065" wide. Nominal strength values increased with depth of notch for this shape, but the strengthening was less than that caused by a V notch. Uniform elongation decreased with depth of the square notch and corresponds more closely than the V notch to deformation predicted under uniaxial stress. Various investigators have reported a substantial loss of ductility in irradiated Zircaloy. A capsule containing Zircaloy-2 specimens defected by V notches with varying base radii is being prepared for a one-cycle irradiation in the ETR. Post-irradiation testing will determine the combined effects of a notch and radiation damage on deformation and strength.

## Metallic Fuel Development

Fuel Irradiations. Radiometallurgical examination of KSE-3 single tube fuel elements exposed to 3600 MWD/T has started. The elements have been given a visual examination and bumping of the inner bore has been observed. The bumping is presumably the result of buckling of the inner clad caused by fuel swelling. Attempts are being made to prepare a replica of the surface.

An NPR inner tube, which had been suspected as the cause of a KER rupture indication and subsequent loop discharge has been tested in the IRP facility for 20 hours at 300 C without activity release or failure indications. It is concluded that the KER loop discharge was not the result of in-reactor failure of this element.

The irradiation testing of an NPR inner tube resumed in the ETR 3x3 loop. The tube, 24 inches long, had received only a nominal irradiation in cold water. It is now operating at 38 kw/ft and maximum central temperature of 425 C. It will be measured after each of the four ETR cycles.

Electron micrographs of uranium and U-2 w/o zirconium irradiated to approximately 3200 MWD/T were studied. The porosity seen in the micrographs correlates qualitatively with the observed density decreases. Irradiation appears to have caused dissolution of the U-Zr intermetallic compound. One U-2 w/o Zr specimen contained an extremely low degree of porosity and had less density decrease than a uranium specimen with similar irradiation history.

Radiometallurgical examination has begun on the KER tube-tube assembly irradiated in the ETR 6x9 loop. This test ran at 320 kw/ft to an outer tube exposure of 1200 MWD/T (0.14 a/o burnup). The closure was made with the 12 Fe + 4 Be + 84 Zry-2 brazing alloy. Detailed examination of the closure revealed the following:

(1) The outer tube operated in the extreme alpha temperature range, probably 620 to 650 C. The uranium structure was recrystallized with virtually no cracking.

(2) The inner tube operated in the low beta temperature range, probably 670 to 700 C. The resulting structure was beta transformed with columnar grains oriented in a "chevron" pattern, parallel to the direction of heat flow. There was no evidence of cracking in the uranium.

(3) The braze layer was cracked between the cap and core in both the inner and outer tubes. However, there was no evidence of the same failure mechanism observed in GEH-4-57,58.

Irradiation has continued on GEH-4-63, 64 in the MTR. This irradiation is subjecting production brazed material to the same conditions as GEH-4-57, 58 which failed in the MTR. The test is in its second cycle operating at a calculated power generation of 64 kw/ft.

Failures of Zircaloy-2 clad uranium rods and tubes, as a result of localized clad thinning have occurred in NaK capsule and high temperature water irradiations. From the results of measurements made on the cladding thickness of seven rods irradiated in NaK capsules, it appears that both thickness and thickness variability are factors influencing the susceptibility of Zircaloy-2 cladding to localized clad instability. To further study the effects of cladding thickness variations on the susceptibility to failure, a new series of NaK capsule irradiations of Zircaloy-2 clad fuel rods is planned in the Hanford reactors. Eighteen capsules with three test samples in each capsule and three instrumental capsules with thermocouples in the uranium are completed and ready for irradiation.

Twenty-two Zircaloy-2 clad coextruded uranium rods have been irradiated in the MTR in NaK-filled capsules to burnups ranging from 600 to 5000 MWD/T and maximum uranium temperatures from 250 to 700 C. Of the fourteen rods examined to date, seven have cladding failures.

Support and Clip Development. A buggy spring inner fuel tube support design for the first fuel charge of the N Reactor was accepted for production in quantity by a vendor. It is expected that the vendor will be required to make slight developmental modifications to the design because of the difference between supports made in the laboratory and those made by production methods. Various designs of the locking clip, which is to hold the inner and outer NPR fuel tubes together, were subjected to simulated discharge tests. Sixteen fuel tube assemblies with the latest clip design survived the drop test satisfactorily. It is expected that this design will be accepted for production when slight modifications are made to improve the locking operation.

A test was made to determine if the static load of the NPR fuel elements during exposure to high temperature water would deform the supports. Eight two-foot long fuel tubes were tested for 162 hours at 338 C (640 F) and 150 hours at 375 C (707 F). On the basis of a previous correlation of creep data, the first exposure is equivalent to 33 weeks at 300 C,

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and the second exposure is equivalent to over 20 years at 300 C. Test results show that the relocation could be minimal over the life of the fuel.

Fuel Component Development. Two coextrusions were fabricated for thermocouple fuel elements. They consisted of one-inch diameter rods with 0.025-inch Zircaloy-2 clad, a 0.237-inch layer of 1.6 w/o enriched uranium, and a 0.476-inch diameter Zircaloy-2 core. The uranium was alpha extruded from a KSE-3 billet to make the four-inch coextrusion billet for these rods. No heat treatment was used after the alpha preextrusion.

A Zircaloy-2 clad matrix type core rod was coextruded. The coextrusion billet was made up of a four-inch Zircaloy-2 can containing 112, 0.3-inch diameter Zr-2 clad uranium rods. The coextrusion of this billet to a one-inch diameter rod resulted in a clad core consisting of uranium contained in a bonded cellular network of 0.005-inch thick Zircaloy-2.

Three 18-inch long fuel elements equivalent in size to an NPR inner tube are being fabricated for test irradiation. These fuel tubes differ from an NPR inner fuel tube in their outside surface which has a fluted surface instead of a circular shape. This shape is intended to allow for uranium swelling during irradiation without causing tensile strains in the clad. These three elements are end capped and welded and are ready for bond testing.

A computer program analyzing the elastic deformations of fluted cylinders has been used to analyze the volume expansions of shaped fuel elements. The numerical calculations of fluted elements formed by a series of tangential arcs are completed. The calculations predicted that the location and magnitude of maximum strain can be controlled by changing the radius of the tangential arcs.

Closure and Joining. Work was continued on the projection welded brazed closure on Zircaloy-2 clad KER inner tubes using the wedge shaped interface between the cap and the uranium. The wedge angle was increased from 60° to 75° which appeared to eliminate the unbonded areas encountered on the 60° wedge. Approximately 0.025-inch of uranium was acid milled from the end of the element to provide uranium-free cladding projections and a V-groove was machined in the uranium to match the wedge on the closure cap. The cap wedge was immersion plated with copper to aid in bonding the Zircaloy-2 cap to the uranium. The unbonded area encountered in the 60° wedge extended from the projection weld part way down the inside surface of the wedge. Two closure samples with a 75° wedge were destructively examined and appeared to be nearly one hundred percent bonded. The diffusion bond layer on the OD face is considerably wider than on the ID face of the wedge. The difference in diffusion layer thickness may be due to a greater current density across the OD face as this face is in line with the shortest distance between the welding electrode and the collet.

The production process for attaching NPR fuel element supports will utilize magnetic force resistance welders. Since previous development work has been done on pneumatic force machines equipped with spring loaded electrodes, it is necessary to repeat a certain amount of work to assure that consistent high quality attachments can be made. One of the magnetic force machines has been equipped with necessary tooling for manually welding NPR inner supports. This simultaneously welds both ends of the support. A group of 1000 welds is being made in the machine. These are being welded by process operators in 333 Building in order to familiarize them with machine operation. After welding, the supports are being destructively examined; the majority by simple shear test, a few by metallographic examination.

The design work to modify the "Fuel Element Support Spot Welder Fixture," Drawings H-3-20106, Sheets 1 through 7, is complete. The original design was inconvenient and suggested probability of back strain to an operator. The modified unit will permit semi-automatic welding of supports on N outer fuel tubes. These modifications, coupled with the support holding fixture previously reported permit a timed load cycle, weld cycle, and unload cycle.

Fuel Measurement. N Reactor fuel tubes, representing normal production, and tubes with dimensional anomalies were measured with the new Sheffield measuring equipment. Collection of the dimensional data was organized for either computer analysis or a combination graphic and numerical description of the fuel shape. Typically, the OD, ID, and wall thickness is recorded at nine stations equally spaced along the length of the tubes. Methods of numerical analysis of these measurements are being developed which give parameters typifying the geometrical characteristics of the fuel element. A computer program for the analysis of circumferential data from actual elements has been written. Mean radii, axial position vector, ovality, deviations from the first two Fourier components, and incremental curvatures are obtained from the analysis. A program is being written from which warp characteristics will be obtained.

Fuel Deformation Studies. Mechanical models for tubular fuel elements require knowledge of the resistance of the fuel element cladding to reversed strain cycling with small incremental increases in strain. A testing frame, extensicmeter, and furnace were assembled, but in initial testing buckling of the specimen occurred. New specimens and modifications to the testing frame have been made.

Facilities and Equipment. The modification to the ETR 6x9G7 and 6x6M3 loops has been completed. The 6x9G7 position is now loaded with tensile specimens for the structural materials program and the 6x6M3 with a stainless steel probe to determine gamma heating rates. The gamma-heat probe will be removed on or about September 5, and a full-sized NPR element will be inserted. This will be the first irradiation test of a prototype NPR fuel element.

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## 2. REACTOR PROGRAM

### Corrosion and Coolant Systems Development

Diffusion of Water Vapor Through NPR Core Graphite. The diffusion of water vapor through a 1-1/8-inch thickness of NPR core graphite has been measured over a range of graphite temperature from 400 to 800 C. Helium gas with different water partial pressures was moved past a graphite thimble held at temperature. The water which moved through the graphite (as a result of a $H_2O$ concentration gradient) was absorbed and weighed on a $CaSO_4$ desiccant.

The rate of transport of water through the graphite increased with graphite temperature up to a temperature (about 600 C) at which a significant fraction of the diffusing water was lost by the water-gas reaction with the hot graphite. Above this temperature, the net water transport rate decreased with increasing graphite temperature. For example, at 650 C the quantity of water transported through the graphite would be sufficient to maintain the protective oxide film on a Zircaloy process tube surface (up to 400 C) as long as the helium on the wet side of the graphite had a $H_2O$ partial pressure of 0.05 to 0.2 mm. For 800 C graphite a $H_2O$ partial pressure of 0.3 to 0.5 mm would be required. Experiments are in progress to measure the effect of hydrogen and carbon monoxide additions on water transport rates.

Decontamination and Effluent Activity in Present Reactors. Two single pass tubes in KE Reactor, 4963 and 5063, were decontaminated using Turco 4306-B. This decontamination removed all of the reddish film from the aluminum samples but did not reduce the radioactivity levels of these samples. A major reason for this low efficiency is redeposition of radioactive isotopes released from upstream aluminum process tube surfaces. Longer decontaminant contact times (and/or the use of a more effective decontaminant) should improve this decontamination efficiency. The use of Turco 4306-C has been suggested for subsequent decontaminations. Samples are being exposed in these tubes to measure corrosion rates and decontamination efficiency.

Rupture Tests of Unirradiated Fuel Elements in TF-9 (ELMO-4). Three defect tests were made with coextruded U-Zr-2 rods with weakened bonds in an attempt to more closely simulate irradiated rod rupture performance. One rod was heat treated at 800 C for eight hours. After rupturing for 40 minutes at 300 C, the ruptured area was 1-1/2-inch long x 1-inch wide. The rupture had not progressed radially around the rod, which is typical of most of the irradiated rods. The next two rods were heat treated at 850 C for eight hours to further weaken the bond. After rupturing for 40 minutes at 300 C, the rods exhibited very severe attack. The rupture in both rods had progressed completely around the core and was about two to three inches in length with a 1-1/2-inch wide opening in the Zr clad. In each rod it appeared that the bond had failed rapidly and allowed corrosion around the rod. The final appearance of the uranium core at the rupture was similar to unclad uranium after

corrosion tests. The uranium cores had been reduced from 0.53 inch to 0.25 inch in diameter. The appearance of the rods heat treated at 850 C was similar to several previous ruptures made with irradiated rods. Other rods with this heat treatment will be used for studying the effect of varying the water cooldown rate (within NPR capabilities) on the rupture severity.

Rupture Tests of irradiated Fuel Elements in IRP. The U-2 w/o Zr core element that had been irradiated in KER Loop 2 to 3200 MWD/T, and then rupture tested in the IRP at 300 C was transferred to Radiometallurgy for examination. This element showed an incubation time of 10-1/4 hours which was followed by an additional rupture period of 88 minutes. The element was broken into two pieces by the rupture. The ruptured end of each piece was swelled over the entire diameter and extending down the longitudinal axis about 1/2 to one inch. In contrast to this rather limited attack, a companion solid (unalloyed) uranium core element that was rupture-tested for only eight minutes was cracked and broken into nine pieces and was cracked and swollen the entire 18 inches of length.

Corrosion Test to Evaluate NPR Heat Exchanger. A test is in progress to determine the susceptibility of the NPR steam generators to deposit formation and stress corrosion cracking. A small dummy heat exchanger tube bundle is being exposed to alternate drying and wetting action in order to promote deposition of water impurities on its surface. The dummy tube bundle is fabricated from the same materials used in the NPR and received the same heat treatments. Exposure of the tube bundle to simulated NPR secondary system water (deionized water containing hydrazine and ammonium hydroxide) has been terminated after four weeks exposure between 150 C and 170 C. No deposits or stress corrosion cracking were found. The carbon steel tube sheet and supports had developed a tight black oxide film, and the stainless steel exhibited a dark golden oxide. Tests are now being run on the tube bundle using NPR secondary system water contaminated with 5% filtered Columbia River water. This is to simulate a raw water leak in the NPR secondary system. After a one-week exposure period numerous small pits were found on the carbon steel components, but no deposits were found.

Long-Term testing of Wyandotte 5061 Decontaminant. This test has completed six of eight scheduled cycles evaluating the Wyandotte-1113 Wyandotte-5061 process. Three cycles were completed during the past month. The 304 stainless steel and Zircaloy-2 samples, stressed and nonstressed, did not show any apparent chemical attack, stress corrosion, crevice corrosion, or stress cracking. The carbon steel samples showed uniform type corrosion with slight surface roughening. There was no indication of stress corrosion or cracking on the stressed samples. Galvanic and crevice corrosion was observed though not to a serious extent (approximately 1.5 mils after six cycles). The type 420 stainless steel was pitted over the entire surface by the chemicals used in the evaluation. The Haynes Alloy-41 and Haynes Stellite Alloys-6 and -12 showed the characteristic surface etching which accompanies the previously observed dendritic pitting attack. The A212-304 welded samples using

"IncoA" weld rod appeared to have less knife-line galvanic attack than the samples welded with 309 filler rod. The "IncoA" welded samples were stress-relieved and the 309 welded samples were both nonstress-relieved and stress-relieved. The AMS 5616 alloy, cast stock, exhibited definite pitting on the surface. The bar stock indicated possible pitting.

Dissolution of Ion Exchange Resins. Several tests have been conducted in the TF-10 Loop to evaluate the corrosiveness of a resin dissolution process developed by IPD. The process consists of three steps: (1) 6% $KMnO_4$, (2) 30% $HNO_3$, (3) 3% $H_2O_2$. The 6% $KMnO_4$ solution is recirculated for six hours at 90 C; the 30% $HNO_3$ solution for four hours at 70 C; and the 3% $H_2O_2$ solution for one hour at 70 C. A rinse step is added between the first and second chemical solutions with a limitation of pH 7. The 3% $H_2O_2$ solution is made up by adding 30% $H_2O_2$ solution to the spent $HNO_3$ solution. After this step is completed, a water rinse to pH 5 to 7 is used to end the process. Stainless steel samples sensitized and nonsensitized, stressed and nonstressed, were charged and the maximum observed corrosion was 0.005-mil per process. Zircaloy-2 stressed samples were also charged. There was no evidence of stress corrosion cracking during a microscopic examination. The Stellite-12 sample exposed during the above test showed the characteristic surface etching upon microscopic examination. However, subsequent metallurgical examination reports no surface pitting.

Structural Materials Development

Pre-Post Irradiation Evaluation of NPR Process Tubes. Harvey Aluminum Company initiated a program to recover approximately 75 NPR process tubes that contain one or more tears on the inside surface. The tears are removed by grinding and the resulting thin wall area is thickened by momentary application of heat and axial compression. A section of tubing containing one of these repaired areas was subjected to a 300 C burst test at Hanford. The hoop stress at failure indicated no harmful effects from the repair treatment. Typical results of 300 C burst tests of heavy walled Zircaloy tubing with varying amounts of cold work are shown in the following table:

| Type of Tube | No of Tests | Percent Cold Work | Average Hoop Stress (psi) |
|---|---|---|---|
| PRTR | Approx. 10 | 0 | 46,000 |
| NPR (Chase) | 4 | 18 | 55,000 |
| NPR (Harvey) (Repaired tube described above) | 1 | 20 | 63,000 |
| KER | 3 | 40 | 68,000 |
| KER | 3 | 60 | 73,000 |
| KER | 3 | 70 | 77,000 |

A Zircaloy tube was discharged from KER Loop 3 after 28 months exposure, and was cut into 5- to 8-foot lengths to facilitate handling. The tube was marked in such a way that the pieces can be reoriented and identified according to position in the reactor. After preliminary inspection and radiation measurement in the KE basin, the tube sections will be moved to the Radiometallurgy Building in the 300 Area for intensive testing and inspection. This program will include metallography for changes in microstructure and for amount and distribution of hydrides; and burst tests to provide data on stress and deformation to rupture, stress to produce a limiting deformation in a given time, and creep-rate curves.

## Nonmetallic Materials Development

Burnout Monitoring Program. Graphite burnout monitoring samples in 3478-D were discharged on August 10, after 294 operating days in-reactor. There was a sharp maximum (40%/KOD; i.e., per "1000 operating days") in burnout rate at a location about one-fourth of the way from the front face to the rear face. On either side of the peak the rates were less than 2%/KOD. Because the samples in the highest temperature and flux zone (near the center line) oxidized no faster than in the cooler zones (near the ends of the channel), the oxidant was presumed to be either small amounts of water or oxygen. Since the oxidant was substantially consumed in the front quarter of the channel, where the graphite temperature probably did not exceed 580 C, the possibility that the oxidant was $CO_2$ is discredited.

During borescoping of several VSR channels at C Reactor, it was observed that the ends of some of the filler blocks have been badly oxidized. The oxidized areas are somewhat circular and are symmetrical with respect to the center of the bar. They have maximum diameters of about three inches. Depth of penetration has not been determined. It was found that similar damage occurred to the ends of full size bars which were used by the Reactor Lattice Physics Operation in an exponential pile experiment. It is believed that the distribution of the oxidation damage is due to a nonuniform distribution of impurities in the graphite bar. This will be checked by obtaining ash patterns of the graphite samples from the exponential piles.

Processing Temperature of NPR Core Graphite (TSX). The electrical resistivity of transverse and parallel graphite samples cut from TSX bar 164 was measured before and after annealing for 15 minutes at 2900 C. This bar was located in the center of the graphitization furnace, and according to NPR graphite specifications should have been processed at 3000 C. The difference in resistivity after annealing was significant at greater than the 99% confidence level for both orientations. From this difference it is inferred that the final processing temperature of this bar was lower than 2900 C.

Thermal Hydraulic Studies

Heat Transfer Experiments for the Overbore Fuel Elements in C Reactor. Laboratory experiments were performed to determine the heat transfer conditions and fuel temperatures following a sudden reduction of coolant flow to an overbore process tube in C Reactor. These experiments were transient in nature where the changes in pressures and temperatures were measured following controlled changes in flow and heat generation rate.

The test section consisted of a 1.991-inch OD by 0.339-inch ID electrically heated rod in a 2.147 ID Zircaloy tube. The heater rod was equivalent to a 32-piece fuel charge and was centered in the process tube by 192 ceramic ribs of the same shape as those being used on the reactor fuel elements.

The mode of experimentation consisted of first establishing steady state conditions of flow and heat generation rate in the test section. Next, the flow was reduced suddenly by quickly closing a valve to a predetermined position. Readings of pressures, flows, and temperatures in the test section were monitored on fast acting recorders. Finally, a reduction in heat generation rate simulating a 1400 i.h. reactor scram was initiated when the heater rod temperatures either leveled off indicating stable film boiling or continued to increase to values jeopardizing the test section. During the runs the front header pressure was maintained constant at 400 psig.

Results were obtained for various sudden flow reductions at initial tube powers of 1000 and 1800 KW with outlet water temperatures of 130 and 160 C. Flow reductions to 10% of original flow for 1000 KW and 30% of original flow for 1800 KW were carried out without damage to the simulated fuel during the ensuing transient conditions. A thorough analysis of the experimental results was started to allow the establishment of maximum outlet water temperature limits for the overbore tubes in C Reactor.

Fuel Temperatures Resulting From an Inlet Pipe Rupture on a BDF Process Tube. Analysis was completed of laboratory experiments performed to determine the fuel temperatures during the shutdown transient following a rupture of an inlet pipe to a process tube on a BDF type reactor. The primary mode of cooling the fuel elements following such a rupture would be by the water available from the slightly pressurized rear header.

The test section used in these experiments was a full scale electrically heated mockup of I&E fuel elements in a BDF type process tube. With the test section operating under normal conditions, the inlet line was opened suddenly to atmosphere and the rear header pressure was maintained at a constant pressure. After approximately three seconds the heat generation rate in the test section was decreased at a rate simulating a 1100 in-hour scram of the reactor. Each run was continued

until all thermocouples in the heated test section had reached a maximum value and then started to decrease as the test section was cooled by the reverse flow from the rear header.

Data were obtained at various rear header pressures for initial tube powers of 800, 1200, and 1400 KW. The results indicate that the majority of central zone tubes in BDF type reactors would not be subjected to fuel jacket melting upon failure of an inlet pipe to a single tube with present operating conditions. These results are contrary to those presented for the K Reactors in HW-68214. The difference between the results for the BDF and K Reactors can largely be explained by the assumed control strength of the vertical safety rods and hence the difference in heat decay curves. A complete description of the experiments and a more thorough discussion of the results are presented in HW-70769.

Heat Transfer Characteristics of NPR Fuel Elements. The studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel elements were continued. Twenty-six additional boiling burnout conditions were obtained in the laboratory with an electrically heated test section equal in cross section to the center hole of the fuel elements. The test section for these runs consisted of a 12-foot long tube, 0.44-inch ID, with flow through the inside. The tube was heated by electrical resistance heating and boiling burnout conditions were detected by noting the temperature excursions as measured by thermocouples attached to the outside wall of the test section.

Boiling burnout data were obtained at fairly low flow rates (500,000 to 3,000,000 lb/hr-sq ft) and high steam qualities (15 to 62% steam by weight). For these conditions the heat flux varied between 200,000 and 450,000 B/hr-sq ft. These data were compared with data from similar test sections one-half and one-fourth as long. Although a direct comparison is difficult since the data do not overlap for an appreciable range, it appears that length did not affect the boiling burnout conditions over the range of length studied. It was concluded that for the flow conditions studied, a three-foot length of test section was sufficient to establish the flow patterns which might affect boiling burnout.

Hydraulic Studies. A report was issued (HW-70178) which presents data and results of a study of fluid mixing in a seven-rod bundle fuel assembly. The study was carried out some time ago, but because of the loss of interest for immediate applications, the work of data analysis and report writing was delayed.

A coaxial piping arrangement was utilized to introduce a salt solution into the inner coolant channels of a seven-rod bundle placed in a circular tube while regular water was introduced into the outer coolant channels. The saline concentration was measured in samples of the outer channel stream at various distances along the rod bundle mixing length and the relative salt concentration in these samples was used to describe the effectiveness of four- to eighteen-inch pitch wire wraps as coolant

mixing promoters. Analytical relations were derived to relate the chemical mixing rates to bulk coolant temperature disparity between the inner and outer channel coolant streams under nuclear heating conditions. In this way, the temperature disparity between the inner and outer coolant streams was predicted as a function of wire wrap pitch. These relations can be combined with pressure drop data published previously to indicate that wire wrap pitches of 10 to 18 inches cause near optimum mixing conditions in seven-rod bundles.

Shielding Studies

Shield Calculations. The computer code to calculate neutron and gamma attenuation by bulk shielding materials has been rewritten to include inelastic scattering. A summary describing the results of the program to date (as applied to ordinary concrete) was submitted and accepted for presentation at the winter meeting of the ANS.

A new program has been written to calculate the multigroup cross-sections used in the diffusion equations for the neutron shielding calculations. This program enables one to choose up to 35 groups and uses as input the RBU cross sections obtained from J. E. Schlosser's "BARNHOF" program.

Attenuation Measurements. The experimental work on the neutron and gamma attenuation of as-cured barite concrete is complete. The barite slabs are being baked at 320 C and will be placed in the bulk shield facility during the next shutdown of the DR Reactor.

B. WEAPONS - 3000 PROGRAM

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

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Project Management and Design

PRTR Construction. The paving and landscaping contract is 99% complete versus 100% scheduled as of August 31, 1961. Replacement of shrubs and maintenance of reseeded areas are in progress.

Preliminary testing of fuel element examination equipment disclosed that certain drives on the Profilometer-5X viewer were not working freely. The viewer was removed and the drives freed. In addition, optical tests indicated the need for a corrective lens in the diameter measuring unit of the Profilometer. This lens is being built. The manipulator was tested and several of the motions found inoperative. These are believed to be due to wiring errors at installation. The wiring is now being re-checked. The wide angle viewer was installed and performed satisfactorily. The Design Tests and Operating Manual have been written.

Plutonium Recycle Critical Facility (Project CAH-842). The total project is estimated to be 72% complete. In view of the late delivery of the instrument package and other procurement delays, as well as some equipment modifications recommended by the recently completed safeguards analysis, a new completion date of December 31, 1961, and additional funds in the amount of $40,000 are being requested.

The equipment installation contractor is about 53% complete. The thimble coolant blower, the reactor pumps, and the valve control panel were installed.

Replacement of defective parts in the fuel transfer lock was completed by the vendor.

Fuel Element Rupture Test Facility (Project CAH-867). Over-all construction is estimated at 19% complete against 70% scheduled. The J. A. Jones portion of the work is estimated at 17% complete as compared to 18% scheduled. The revised project proposal, extending the project completion date to June 30, 1962, has been approved. A revised project schedule has been prepared and submitted for approval.

Bids for the water plant-holdup tank portion of the project were opened August 17. Apparent low bidder was Lewis Hopkins Construction Co., Pasco, at $345,000. The fair cost estimate for this work was $348,000, and the project proposal estimate was $357,000

All items of G.E. procured equipment have been received or are in transit except for the electrical switchgear and motor control center. The late delivery of stainless steel pipe and fittings ordered by J A. Jones

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plus the recent strike by construction fitters has slowed work progress. Work by J. A. Jones Construction Co. on equipment and carbon steel piping installation has continued. Service piping installation is essentially complete, with tie-ins to existing PRTR systems remaining.

The cooling of a ruptured metallic uranium fuel element during charge-discharge operations is being studied. The present design utilizes a water-filled process tube to achieve 308 kw-min. of cooling - additional water is injected at the top of the PRTR Fuel Handler and is eventually funneled into the test section. A more direct method of water injection is sought. The method will probably require minor modifications of the PRTR Fuel Handler.

Component Testing and Equipment Development

PR-10 - Primary Loop Mockup. Plans made to transfer the spare primary pump rotating assembly to 309 Building for craft training has not been accomplished due to more urgent work.

The prototype pump with the self-adjusting seal assembly operated an additional 726 hours for a total of 9530 hours. The present seal leak rate is 0.25 g/hr.

The seal test stand operated an additional 172 hours and 23 starts for a total of 1528 hours and 200 starts.

The Aldrich Injection Pump operated at PRTR conditions for 655 hours during the month testing Disogrin U-cup packing. Operational testing of the packing was discontinued due to excessive leakage on August 24, 1961.

| | Hours | Ml/hour | Remarks |
|---|---|---|---|
| Plunger #1 | 905 | 3500 | 2 U-cups |
| Plunger #2 | 1117 | 2500 | 2 U-cups |
| Plunger #3 | 655 | 2000 | 1 U-cup |

Flexure Loop. The testing of the 3-clamp Grayloc transition union, S/S to Zr-2, for ETR use, was resumed on August 24, 1961 following repair of the immersion heater. It has operated for 13 hours and 2 thermal cycles with no indicated leakage.

Critical Facility Components. Testing of the source positioner has been completed and it is now ready for installation in the Critical Facility. The unit was operated over 100,000 cycles without failure.

The adjustable weir has been satisfactorily tested with the synchro position indicator. Performance met required criteria except for a travel speed of 3 1/4" per minute using the PRTR shim motors which

exceeded the 2" per minute criteria. A gear reducer may be installed to correct this variance if determined necessary. Installation of a gear reducer will not interfere with installation in the Critical Facility and the unit has been released to J. A. Jones, Minor Construction, for this purpose.

Delivery of the flexible hoses for the thimble was made at the end of this month. Testing of the thimble assembly has started.

Most of the machining work for the first prototype safety rod and control rod has been completed except for the work requiring the aluminum pipe and tubing. Due to mechanical failure of the swaging machine sizing of the aluminum tubes has been delayed. Off-site cadmium plating of the safety and control rods will take an additional month; however, prototype drop tests and operational tests will be started without these plated rods.

No information has been received from AEC Purchasing concerning detailed information on the radiation resistance of some questionable materials used in the Control Rod and Weir Synchro transmitter position indicating units. Testing of these units has been started and initial results indicate satisfactory mechanical and electrical performance. This testing has not included any exposure to nuclear radiation.

Rupture Loop Components. The outlet nozzle hold-down assembly mockup was thermal cycled 34 times to test the conical disk spring arrangement. The spring characteristic over a 1000 to 8000 lb. force range remained constant.

The Zircaloy-2 process tube to stainless steel nozzle connection was thermal cycled 34 times to test for sizing. The stainless steel consistently pulled the Zircaloy-2 process tube flange outward. Visual inspection of the Zircaloy-2 contact face clearly showed the contours and marks of the matching stainless steel piece. The test is being rerun with both contact faces having a mirror finish and a coating of $MoS_2$ for inducing slippage.

PRTR Operations

Reactor Operation. Mechanical and instrument difficulties continued to plague successful continuous operation. A total of 48 scrams occurred in 29 days, the majority of which were caused by (1) spurious trips from flow monitors and flux instrumentation, and (2) temperature and pressure cycling problems in the primary system. By the end of the month, as a result of engineering modifications, improved reactor operation was realized.

The most serious condition encountered during the month was process tube plugging. Foreign objects, later confirmed as being small pieces of a badly battered coffee can, were found in the inlet jumpers of 10

process tubes. A total of eight days' effort was spent flushing, disassembling, and inspecting the primary system and its components. Metal pieces varying in size from one-half inch to two inches square were removed from the inlet jumpers. A large chunk of the can was back-flushed from the inlet ring header. There has been no evidence of any tube flow reduction since August 21. It is believed that the can entered the system during process pump seal repair operation on August 9, although this is not conclusively proven, however. Maintenance and operating procedures are being revised to prevent a recurrence of an incident of this type.

Helium consumption during the month was a calculated 248,000 scf. A significant part of this loss occurred as a result of reactor scrams, plus frequent system purges for maintenance reasons. A piping modification to permit the use of an internal helium supply for certain liquid level signals has eliminated a constant input of helium of 300 scf into the system when no additional helium was really necessary. Some improvement in the helium consumption at month-end has been noted, but the loss rate is still sub-standard. Helium leak checking is being done during every shutdown to improve performance in this area.

The reactor loading was modified to 52 $UO_2$ and 33 Pu-Al elements and the shim free critical level was determined to be 62.6 inches. The increase of 8 Pu-Al elements helped the scram recovery time but the loading is still not adequate to overcome xenon poisoning following a scram from equilibrium operation. Scram recovery time appears to be about 1.5 to 2 hours based on one opportunity to observe the xenon buildup.

Operating experience at the end of the month started to improve. At 70 MW operation it was determined that power level changes must be made slowly to prevent pressure-temperature cycling in the primary system. Some of the most recent scrams have been caused by such cycling. In addition, it appears that a third boiler feed pump is required at power levels above 60 MW to maintain required minimum feed water pressure and boiler water quality. Several tests are planned to evaluate this problem more fully.

Reactor Maintenance and Modifications. The repair of PP-1 during the outage of July 24, 1961 was a failure because of $D_2O$ leakage through the secondary mechanical seals caused by improper notching and seating of the L-ring seal behind the secondary seal rotating face. This condition was corrected on August 8, 1961. Some seal damage occurred to PP-1 seals on August 24, 1961 when the seal temperature increased to 170 F and seal injection was found to be stopped due to drift of differential pressure across P-34 down to 30 psi. Steps have been taken to record differential pressure readings twice a shift or oftener during unstable conditions and to keep a control room hourly record of seal temperatures. A graphic training guide poster of the primary pumps and associated valving is being prepared to use in training classes that are scheduled to begin next month.

Installation of fixed bleed orifices to protect the boiler feed pumps against complete discharge valve closure was cancelled when Ingersol-Rand revised their calculations of the required bleed from 10.6 gpm to 35 gpm. Present planning involves use of an air operated valve to discharge 100 gpm back to the deaerator during flow shutoff to HX-1.

A low pressure helium compressor diaphragm failed on August 4. Diaphragms were replaced in both heads of the compressor; the failed diaphragm was found to be cracked across 2/3 of its diameter. Single diaphragms are now being used in this compressor instead of double diaphragms to see if longer life can be achieved. Indication of diaphragm failure on a high pressure compressor was received on August 13. Both diaphragms were replaced, but no failure was evident by visual examination. The diaphragms are being decontaminated for metallurgical examination.

$D_2O$ collection tank piping was revised and an additional tank was temporarily installed. These changes permitted separation of the collection of primary system leakage from that of the moderator and reflector systems, with the exception of some minor sources. Temporary piping was installed to permit $D_2O$ condensed from the pressurizer helium bleed to be returned via a collection tank and pump. This has resulted in savings of Operations' manpower.

A hydrogen addition line was connected to the primary $D_2O$ injection line so that hydrogen content in the helium system may be reduced.

A temporary flushing line and strainer was designed and installed between the inlet ring header and the reactor outlet piping to assist in flushing coffee can fragments out of the inlet ring header. Most of the weight of a can was removed in this fashion. The temporary piping was dismantled and stored after flushing.

The thermal barrier seal was replaced with a seal of new material which is expected to be more durable than the original seal.

The tracings for ion exchangers IX-2 and IX-3 were revised to show a screen at the top of the vessel in addition to the one presently existing at the bottom. This is to prevent backflow of the resin if a backflow condition should exist. An analysis was begun utilizing the ASME Unfired Pressure Vessel Code to determine if IX-2 and IX-3 could withstand 120 psig, a condition that could exist even though original design pressure was 50 psig. It was observed during this calculation that none of the ion exchange vessels are welded in accordance with the ASME code. The nozzle was abutted against, rather than inserted into, the shell wall and a required nozzle to shell weld was not shown. The tracings for all ion exchangers were then modified in order to conform to the code. The calculation then performed showed that IX-2 and IX-3 will withstand 120 psig at 150° F after being modified.

A design change revising the Helium Unloading Station was prepared in order to facilitate sampling at the railroad unloading station within the 300 Area. The modification consisted of: (1) adding a valve to the unloading line to prevent suspected "dieseling" of the helium against the C.P.V. globe valve, and (2) adding the pressure reducing, safety relief, globe, and needle valves necessary to take a sample at atmospheric pressure. The previous configuration forced the sample to be taken at 300 psig and did not have an adequate venting or safety relief system.

The third log-N channel was incorporated into the shutdown valve period trip circuit as well as into the scram valve trip circuit. This new channel still has not been incorporated into the overlap trip circuit, compressor run interlock circuit, and automatic control circuits.

All four high level safety amplifiers, including the spare unit, were revised by the manufacturer who incorporated his recent design changes. These units showed immediate improvement in operation, and it is believed that they will not again exhibit their former deficiencies.

A review of the current status and desirable changes in the reactor flux monitoring and control system was made. Specific recommendations for action were made where it was believed operating efficiency could be improved. In general, these recommendations included permanent incorporation of the second startup channel in the system, eventual replacement of the troublesome startup channel preamplifiers, completion of the intermediate channel triplication job, consideration of the by-passing of the intermediate channel period trips at full equilibrium power levels thus allowing them to be onscale at shutdown levels, and the establishment of an energetic preventive maintenance program.

An intermittent tube socket in log-N #2 unit was discovered and replaced. This may have caused the spurious openings of the shutdown valve which were noted during the last operating period. The actuator arm on the high trip relay in Linear Flux Amplifier #2 was found burned off and the relay was replaced.

Part of the Control Room Flux Monitoring Instrumentation load was transferred from EI-4 to EI-9. Both circuits are now loaded to approximately 50% of their rated capacity. Two each 2KVA constant voltage transformers have been ordered for these two circuits to replace the 3 KVA transformer that was damaged during the instrument motor/generator outage.

Design Change 36, which provides a manual override for the automatic closure of the P-12 valve upon power failure and provides more positive closure action of the MV-1 valve upon light water injection, has been installed in the light water injection system.

The pressurizer level controller was overhauled, the reset action changed, and snubbers were added in the sensing lines. These changes have improved the action of the controller and have eliminated serious cycling of the

control valve. Effect of level control on primary system pressure has been reduced and pressure control is now satisfactory.

A temporary system was devised and installed for removing condensate from a stack gas sample. This condensate was monitored for the presence of $D_2O$ and tritium.

A review of the present and contemplated status of the fuel element rupture detection system was made. Considerable effort will be necessary before this equipment will operate as required. The process channel sampling system has not operated as expected, and this is the most serious problem since representative samples are considered to be the key to successful fuel failure detection. Work was started on August 11, 1961, on a demonstration unit of four gas separators with new water traps. The fabrication work on the unit is about 90% complete, and the total job about 50% complete. Performance of the demonstration units will be used as a basis for design of modifications to the entire system. Some necessary revisions in the electronics for the system are also being made. Others are desirable for more flexible and understandable operation of the equipment.

The current completion status of Maintenance Procedure Manuals was reviewed with FPD Plant Engineering and priorities were established for revising and completing the manuals.

PRTR Technical Support

Planning and Procedures. A summary of the first two series of critical tests was prepared at the request of the Hanford Operations Office for transmittal to the Carolinas-Virginia Nuclear Power Associates.

The review and combining of PRTR Operating Standards continued. To date the number of standards has been reduced from 102 to 87.

Special tests were prepared for the secondary coolant system to determine proper operating conditions for improved boiler water quality. The first test, increased surface blowdown of the boiler, was under way at the end of the month. A special test was also prepared to evaluate the use of a sulfite regenerated anion exchange resin as a deoxygenation resin in the primary coolant system.

A review of the sampling schedule for the various coolant systems was completed and the operating procedure covering the schedule revised.

Engineering Analyses. Metallurgical examination of pieces of the coffee can found in the primary system revealed that the pieces had not been irradiated nor exposed to high temperatures. A total of 156 grams of the estimated 192-gram can weight was recovered from the primary system.

An extensive set of unit motion readings were taken during this report period, and it was found that the top primary shield, referenced to its vertical center line, has moved 0.022" north, 0.015" east, and has rotated clockwise about its center line 0° 1' 57". The bottom shield has not moved in relation to the biological shield.

A redetermination of PRCF critical loading configurations is under way. A revised set of macroscopic neutron cross sections has been calculated to represent PRTR Pu-Al fuel in three-group diffusion theory calculations. The cross sections more accurately take into account the effects of resonance self-shielding. Good agreement with results of PRTR critical tests has been obtained, which fact lends an optimism to the use of this revised set of nuclear data in PRCF studies. Considerations from this work include:

1. Effective multiplication as a function of moderator height for near-critical two-zone loadings.

2. Effect of flooding the reactor cell with $H_2O$.

3. Evaluation of control and safety rod worths.

A study of heavy water losses from the PRTR, including a study of causes, detection and control of $D_2O$ losses, was undertaken. The following information was developed:

1. Source of Loss

   Moisture samples were obtained from the stack gas on August 5 during 70 MW operation and were analyzed for tritium activity. The results of analysis indicated a possible loss of about 200 pounds per day to stack. The study could not uncover specific areas from which the losses were occurring. However, it is established that very small leaks from any $D_2O$ system in the form of drops could sustain the observed loss rate. Similarly, losses of about 100 scfm from the $D_2O$ recovery system could account for this loss under certain conditions. A third high loss potential area exists in the helium gas. Calculations based on $D_2O$-helium equilibrium indicated that substantial $D_2O$ vapor could be carried to the stack by the helium gas loss which had been occurring to date.

2. Loss Detection

   At the present time the shift $D_2O$ inventory provides a means for charting the losses. Methods by which the losses may be detected more rapidly were investigated. Monitor of the exhaust air with activity counting or humidity determining instruments are not of sufficient sensitivity to provide the necessary control of losses to tolerable limits. Undetectable losses in excess of 200 to 300 pounds per day may occur by use of these instruments. It is necessary therefore to utilize laboratory techniques for analysis

of moisture samples obtained from the exhaust air. The methods are not adaptable to a continuous monitoring system.

3. $D_2O$ Recovery from Exhaust Air

Should the present efforts to alleviate leak sources be unsuccessful, a $D_2O$ recovery system for the exhaust air may become necessary. Two criteria must be satisfied in such a system, and both have significant influences on the type of system which will be required. These are (1) the $D_2O$ isotopic content which must be achieved for economic reworking, and (2) the amount of moisture which can be carried to the stack as unrecoverable $D_2O$.

Ventilation air to the reactor process areas carry relatively large amounts of moisture. This moisture is of sufficient quantity that the vaporization of $D_2O$ at rates of 200 pounds per day will yield a $D_2O$-$H_2O$ mixture having a $D_2O$ purity of less than 10%, which is not economically reworkable. It becomes necessary that the inlet air dewpoint be lowered to provide a final purity at the exhaust which is higher than 10%. On the other hand, the exhaust air will carry out greater amounts of $D_2O$ per given total moisture content as the $D_2O$ purity becomes higher. To satisfy these factors, a $D_2O$ recovery system will require a desiccant drying system for the inlet air and a refrigeration unit which will ice out the $D_2O$-$H_2O$ mixture at the exhaust.

4. Month-End Barrel Inventory

The current system of the month-end barrel inventory was reviewed. Although the present system has not revealed significant errors in the accountability, the potential for erroneous reporting does exist. Corrective method includes accountability of all barrels, empty or otherwise, to preclude the possibility of overlooking a filled barrel.

Thermal Hydraulics Studies

PRP Critical Facility. Maximum fuel temperatures were calculated for a hazards analysis of fuel in the Critical Facility when cooled only by air. Based on free convection alone, the highest powered irradiated PRTR fuel element which could be brought into the facility for testing would reach a maximum temperature of about 1700-1900 F if suspended in air indefinitely. This could result in melting of PuAl cores (melting point - 1220 F), but the Zircalcy jackets (melting point - 3314 F) and $UO_2$ cores (melting point - 4990 F) would not melt. Radiation losses would reduce the maximum temperature somewhat, but its effect on the inner rods of the 19-rod cluster should not be great enough to prevent melting of PuAl cores.

If the fuel element were enclosed in an air-filled thimble, the temperature of the air in the thimble would increase, and the effectiveness of free convection would decrease greatly. In such a case, radiation and conduction of heat across fuel rods, air gaps and thimble walls would probably be the major heat transfer mechanisms. Previous calculations indicate that in this case melting of jackets might occur.

PRP Pressurizer Low Pressure Trip Limits. Calculations were made to provide a basis for decreasing the low pressure trips for the PRTR at low coolant temperatures. It was calculated that the low pressure at which a trip is required could be reduced considerably if so desired. For example, at a bulk outlet temperature of 500 F, the low pressure trip could be set at 860 psig compared to the present requirement of 1005 psig.

The fundamental basis for the PRTR pressurizer low trip is that no bulk boiling be permitted in the reactor. More specifically, the pressurizer, which is the element controlling the primary coolant loop system pressure, must have a pressure high enough to maintain the pressure everywhere in the loop higher than the saturation pressure.

The pressurizer low trip of 1005 was based on the saturation pressures associated with maximum permitted outlet water temperatures of 542 F and 535 F for a tube and for the reactor bulk outlet, respectively. The pressure provided a 5 F error allowance in the tube outlet and 12 F error in the bulk outlet temperatures.

Since the time when the pressurizer low trip was calculated, the maximum permitted tube outlet and bulk outlet temperatures have been set at 540 and 530 F, respectively. Furthermore, operating experience to date has shown that the tube and bulk outlet temperatures will be significantly lower than these maxima. These lower temperatures provide the reactor with a larger error allowance in the measurement of temperatures. Alternately, the lower temperatures could permit a lower pressurizer low pressure trip point.

## Plutonium Fuels Development

PRTR Aluminum-Plutonium Fuel Fabrication. One of the two vertical autoclaves was put back into operation the latter part of July after several major changes were made in the temperature and pressure controls. Since it was returned into operation, 400 fuel element rods and hardware for 12 clusters have been autoclaved. However, 75 fuel element rods were rejected after autoclaving and must be recycled through grit blasting, etching and autoclaving. This is an unusually large number of autoclave rejects and is attributed to instrumentation malfunction which caused the autoclave to overheat. This condition is being corrected.

Four fuel element clusters have been assembled this month, making a total of 41 Class I Mark I-H clusters fabricated for the PRTR. Seventeen plutonium-aluminum alloy cored fuel elements remain to be fabricated as replacements for the low exposure plutonium PRTR spike loading.

PRTR Aluminum-Plutonium Fuel Element Inspection. Three plutonium spike fuel elements were scheduled for inspection during the July 24 PRTR outage. An element was chosen representing each of the three different types of banding methods used on the Mark I-H at the present time; i.e., circumferential strip band, circumferential wire band and spiral wire wrap. Fuel element number 5075, in addition to using strip bands, has special end brackets with large Zircaloy pads to make contact with the process tube and test wear rate between fuel element and process tube. This element was removed from the reactor to permit borescope inspection of the process tube for wear caused by fuel element contact. The following notes were made while inspecting the three elements in the PRTR basin with an underwater periscope.

Fuel Element Number 5063. All three wire bands put on during the remote rebanding operation in the PRTR basin showed no change. Corrosion pits under the original bands also showed no change. Hanger pin was clear of corrosion and the safety pin was in place. All wire and pin welds showed no white corrosion product. The top end bracket gussets which contact the process tube showed no wear and were covered with black oxide.

Fuel Element Number 5024. This element used the spiral wire wrap banding method which seemed tight and in good condition. No mars or scratches were visible on the wire wrap. Some wire welds showed a slight white ring around the outer heat affected zone.

Fuel Element Number 5075. This element had the strip type bands which are put into the reactor unautoclaved. The bands were in excellent condition, no mars or scratches. The element evidently had not operated long enough to form the black zirconium oxide because interference colors were visible. All spot welds were white indicating welding trouble. End bracket pads were black and showed no signs of wear.

In general, all the fuel elements inspected in July looked very good with the one exception of bad spot welds. This element was a special fabrication using end bracket pads. The cause of the poor weld quality was traced to a bad bottle of argon shielding gas, hence, one fuel element was affected. A new procedure calls for testing each new bottle of argon gas used in wire wrapping and assembly welding by making four sample welds on a test specimen from each new bottle of gas. The test pieces are autoclaved and inspected before the bottle is released for use.

On August 11, fuel element number 5074, wire type bands, was examined at the request of PRTR Operations. The reactor was shut down after a pressure drop increase was observed in the process tube containing 5074. Nothing was found which would explain the increased pressure drop; however, the wire wraps of the outer fuel element rods were quite loose. The three wire bands were tight and the general condition of the cluster was good; however, a 1/8-inch gap could be seen between the spacing wire and the fuel rods in several places. On August 16 and 17, three fuel elements were inspected in the PRTR basin. Number 5046, wire type bands, showed loose spacing wires

a maximum gap of 1/16-inch between wire and fuel rod on all outer rods. The three wire bands were tight and other parts of the cluster were in good condition.

The next two fuel elements had been examined in July as reported earlier. Number 5075, which has strip bands, was unchanged. All wires were tight and the white corrosion product on the spot welds had not changed. Number 5024, which used the spiral wire wrap around the cluster, now showed a loosening of spacing wires on the individual fuel element rods. The gap between the rod and wire appeared to be less than 1/16-inch; however, the wire did not appear loose the full length of the rod. The spiral wire wrap around the entire element was tight and in good condition.

No conclusions concerning the cause of the wire loosening have been made at this time due to the complexity of the problem and the limited data available. Preliminary calculations show the wires should tighten when operation temperatures are reached. Several elements will be examined at the next scheduled PRTR outage.

$UO_2$-$PuO_2$ PRTR Fuel Element Development. Incremental loading is being developed as a technique for accurately controlling the plutonium distribution along the length of $UO_2$-$PuO_2$ type fuel elements. A manual powder loading machine was purchased to obtain the accurate increments required in the process. Test results indicated that the reproducibility of the increments delivered by the machine were within the desired tolerance limits. The machine was adapted for glovebox use by the addition of a filtering system. The filter adaption did not affect the accuracy of the unit as shown below:

| Increment Size | Standard Deviation |
|---|---|
| 13-17 g (-20 mesh $UO_2$) | 1.5% |
| 2 g (-325 mesh $UO_2$) | 1.0% |
| 50 mg (-325 mesh $UO_2$) | 2.5% |

Comparable data for $UO_2$-$PuO_2$ mixtures will now be obtained.

An additional test was performed to determine the variation of -325 mesh particles along the length of an element. Fused $UO_2$ was screened to remove the -325 mesh material, leaving a coarse fraction of -20 mesh to +325 mesh particles. Using the loading machine, a 15-gram increment of the coarse fraction and a 2-gram increment of the -325 mesh material were taken, mixed, and loaded in a tube. This operation was repeated until 100 increments of each size had been loaded. The tube was then vibrated for 20 seconds on a shaking table to consolidate the particles. The tube was then sectioned into five segments; the longitudinal variation being determined by screen analysis.

Results of this test are shown below:

| Section | % -325 Mesh in Segment | Absolute Deviation from Mean Composition | % Deviation from Mean Composition |
|---|---|---|---|
| 1 | 14.6 | + 0.8 | + 5.8 |
| 2 | 13.8 | 0.0 | 0 |
| 3 | 13.4 | - 0.4 | - 2.9 |
| 4 | 14.0 | + 0.2 | + 1.5 |
| 5 | 13.3 | - 0.5 | - 3.6 |
| Mean | 13.8 | | |

The over-all percent deviation from the mean composition was 9.4% for the incrementally loaded tube, as contrasted to over-all deviations of 67% and 97% for the first tubes loaded with pre-mixed oxides.

Design work is under way on a glovebox extension which will provide hood space for both the incremental loading and the decontamination of fuel elements.

Internal cracking has been observed in the Zircaloy cladding of several cold swaged test pieces. Destructive and nondestructive examination of the cladding is in progress.

Work is progressing on determining the quantity and identity of gases contained in the arc-fused $UO_2$ feed material. The gas evolution apparatus was calibrated. It is capable of accurately measuring an evolution of 0.2 cubic centimeter of gas at standard temperature and pressure. Calibration specimens have been heated to approximately 1100 C. Temperatures near 2000 C are expected with redesign of the induction coil and susceptor. An optical pyrometer corrected for emissivity and absorption in the intervening materials is being used to measure temperatures. An automatic two-color pyrometer will be utilized eventually.

Fuel Evaluation. Ten $UO_2$-$PuO_2$ capsules are presently being irradiated in the MTR. Six are low-density (65 percent of theoretical) specimens and four are high-density (90 percent of theoretical) specimens. One high-density sample (GEH-14-86) was discharged during the month at the MTR Cycle 160 shutdown. This capsule was inadvertently inserted into the position which was scheduled for GEH-14-68, a low-density specimen. As a result the capsule was irradiated in a maximum thermal flux of $0.57 \times 10^{14}$ nv which was approximately twice the maximum flux requested for the experiment, $0.32 \times 10^{14}$ nv. This means the maximum specific power would have been on the order of 34 kw/ft and the surface heat flux on the order of 780,000 Btu/hr-sq ft. The specimen was examined in the basin at the MTR and was found to be discolored and somewhat corroded. This $UO_2$ - 4.13 a/o $PuO_2$ specimen has accumulated the requested exposure (approximately 10,000 MWD/T) and is being transferred to HAPO for examination.

A prototypical, nonuniformly enriched, incrementally loaded fuel rod was fabricated by cold swaging. This element contained 63 $UO_2$ and 63 $PuO_2$ increments. The fuel distribution pattern was calculated for uniform power generation in the ETR. After swaging, the rod was cut to obtain analytical samples.

Phoenix Experiment. Pre-irradiation reactivity calibration measurements on the Phoenix capsules have been completed in the Advanced Reactivity Measurement Facility (ARMF). It was anticipated that irradiation of the first specimen in the MTR would commence during Cycle 161. Because of the proposed high heat fluxes on the samples, (about 1,000,000 Btu/hr-$ft^2$), the MTR Reactor Safeguards Committee decided that a hot-spot hot-channel analysis was required. This will delay insertion of the first sample until Cycle 162, which commences on September 5.

An ARMF calibration standard will be made for determining the amount of shift in the neutron energy spectrum due to the presence of the samples in the central measuring position. The sample will incorporate activation foils which can be removed for counting.

Euratom Fuel Loading. Sixteen of the Euratom test fuel rods have been completed and shipped. These each contain 18 pressed and sintered pellets approximately 0.373-inch diameter, 0.522-inch long. They are clad in Zircaloy with an internal inconel spring assembly. The joint design on the bottom end caps was modified to accommodate a fillet head weld. This change was necessary to reduce the possibility of heat affecting the inconel spring. X-ray inspection shows excellent weld quality in both the fillet head welds and circumferential butt welds.

The pellets averaged 94 percent theoretical density. Analysis showed a 1.46 weight percent $PuO_2$ which was well within the specified concentration limits. The average O/U ratio was 2.019. The isotopic analysis is shown in the following table.

Euratom Isotopic Analysis

| Isotope | Atom Percent |
|---|---|
| 239 | 79.863 |
| 240 | 17.099 ± 0.036 |
| 241 | 2.983 ± 0.010 |
| 242 | 0.0553 ± 0.0002 |

The final five rods for this loading will be completed within a week.

## $UO_2$ Fuel Development

PRTR Fuel Elements. Two PRTR 19-rod cluster fuel elements were inspected during a reactor outage. Both fuel elements were representative of the $UO_2$ elements generating the greatest surface heat flux and both were in excellent condition. There was no evidence of wire wrap loosening, corrosion, crud build-up, or surface damage.

A vibrationally compacted Mark II-C nested tubular fuel element is scheduled for charging after the next outage. This fuel element contains $\sim$ 19% more $UO_2$ than a conventional 19-rod cluster fuel element.

Hot Swaging. Eighty 8-foot long Zircaloy clad fuel rods were hot swaged. Additional rods are awaiting hot swaging. The fuel rods will be assembled into 19-rod clusters for the PRTR and for PRCF experiments. Optimum hot swaging conditions to achieve maximum density were established as 650-700 C, with a feed rate of two feet per minute. Fuel rods fabricated under these conditions consistently yield densities of $\sim$92%.

Micronized $UO_2$ which was vacuum outgassed at 800 C for 24 hours was successfully hot swaged. No fuel rod internal gas pressure problems were encountered during heating of the loaded fuel rods to 800 C prior to swaging. Low hot swaged densities (65-70% T.D.) which were obtained, are the result of low tapped densities (30-35% T.D.) and insufficient reduction of cross sectional area.

The reduction necessary to achieve maximum fuel density in a 1.25 inch OD, 0.035-inch wall stainless steel tube loaded with PWR-grade $UO_2$ (tapped density, 49% T.D.) is being investigated. A reduction of 66% of the original fuel rod cross sectional area by cold swaging produced a bulk $UO_2$ swaged density of 70% T.D. The stainless steel cladding thickness was decreased by only 0.005 inch. Further reduction to 15% of the original cross sectional area, by hot swaging is planned. The amount of residual cold work in the stainless steel cladding after various reductions by cold and hot swaging will be determined by hardness measurements.

Fused $UO_2$. Vacuum outgassing of samples of $UO_2$ used in PRTR fuel elements demonstrated that the volume of gas released at 1000 C is insufficient to cause excessive internal pressure in PRTR fuel rods.

The reduction in $UO_2$ particle size during swaging results in a greater volume of gas being extracted from swaged than from unswaged samples. The effect of exposure of unswaged samples of -20 mesh particle size to air does not appear to be significant, but considerably more gas is released from swaged samples exposed to air for long periods than from sealed swaged samples.

A similar effect is expected with other $UO_2$ samples of small particle size. For example, -100 mesh $UO_2$ (before swaging) probably absorbed a large portion of the extracted gas during the two years of exposure to air.

Electrodeposited $UO_2$. Electrodeposited $UO_2$ from a 20-lb batch prepared by Chemical Engineering Development was crushed to pass a 6-mesh screen and annealed in hydrogen at 1700 C for 12 hours. The particle density of the material after annealing was 10.82 g/cc (98.6% T.D.) as determined by mercury displacement. A representative sample was screened and blended for vibrational compaction. The particle size distribution of the mixture was 55% (-6 +10), 12.5% (-10 +20), 12.5 (-35 +65), and 20% (-200) mesh. The average bulk density of the $UO_2$ vibrationally compacted in a 0.505 ID Zircaloy tube was 89.3% T.D. (90.6% compaction efficiency).

Results obtained with this material further illustrate effects observed using fused $UO_2$; viz., that the topological characteristics of the material (particularly in the coarse fraction) significantly affect the compaction efficiency that can be achieved, independent of the particle density as determined by fluid displacement. Metallographic examination of representative particles of the electrodeposited $UO_2$ showed that some particles have highly irregular surfaces, with open voids that can apparently be penetrated by water, mercury, and other fluids, but not by fine particles of $UO_2$.

Recent modifications of the "Salt Cycle" process have produced relatively large crystals with low surface areas. This material promotes the high compaction efficiencies ( > 93%) that can be achieved using $UO_2$ prepared by high-energy forming or in some cases by fusion. Deposits of more than 100 pounds of $UO_2$ are being produced in a single cycle.

## Corrosion and Materials Studies

High-Temperature Oxidation Behavior of Zircaloy-2. The high-temperature oxidation kinetics of Lot 1021 Zircaloy-2 have been determined in both dried commercial $O_2$ (at 50 mm Hg pressure) and $H_2O$ vapor (at 26 mm Hg pressure), in the temperature range 500 to 900 C. The specimen and atmosphere in each run were heated from room temperature to test temperature simultaneously in a preheated furnace. Zero time was taken as being that time when the first weight gain was recorded; this occurred when the specimen attained 500 C (approximately). The specimen attained any given test temperature within three or four minutes of "zero time". Details of the test conditions are important, as there are indications that seemingly minor variances in procedure can lead to widely differing results.

The pre-breakaway oxidation of Zircaloy-2 in $O_2$ or $H_2O$ vapor in the temperature range of 500 to 900 C more closely approximates a parabolic rather than the cubic rate law characteristic of Zircaloy oxidation in oxygen and steam in the lower range of 300 to 400 C. In the higher temperature range, the high-temperature oxidation of Zircaloy-2 in $O_2$ conforms to the rate law:

$$W^{1.7} = 3.44 \times 10^7 \exp \frac{-27,800}{RT} t$$

where W = wt. gain, $mg/dm^2$
t = time in minutes
R = gas constant, cal/°K-gm-mole
T = absolute temperature.

The high temperature oxidation of Zircaloy-2 in $H_2O$ vapor is given by:

$$W^{2.25} = 1.32 \times 10^{12} \exp \frac{-44,300}{RT} t$$

Both rates more closely approximate a parabolic than the cubic rate law which is characteristic of Zircaloy oxidation in oxygen and steam in the range 300 to 400 C.

In general, above 700 C the initial (pre-breakaway) oxidation in water vapor is more extensive than in oxygen for any given time and temperature. Below 700 C oxidation in oxygen is more extensive.

Oxidation kinetics at 700 C and 800 C in water vapor using a sample brought to temperature in vacuo before admission of the water vapor conform closely to a cubic, rather than a parabolic rate law, even for long exposures. At 600 C, the two experimental techniques yield the same rate law (parabolic).

Zircaloy Breakaway Corrosion Phenomena. The cyclic oxidation behavior of Zircaloy observed in the above high temperature oxidation studies in either water vapor or $O_2$ is not as regular and clearly defined as that observed at lower temperatures (360 to 400 C). Oxidation in oxygen always shows at least one well defined cycle; oxidation in water vapor may or may not depending on the test temperature.

The time required to end the first cycle in $O_2$ oxidation in the range 625 to 900 C is given by:

$$\log t \text{ (min)} = 3.96 \times 10^{-3} T (^{\circ}C) + 4.4.$$

As the temperature is increased, the cycle time decreases.

When water vapor is the oxidant, the cycle time decreases with increasing temperature to 750 C. At temperatures of 775 C and above the time increases. For example, with water as the oxidant, at 900 C no breakaway was observed at 1500 min, while at 750 C breakaway occurred at 90 minutes. Though the pre-breakaway oxidation in water vapor is more extensive than in oxygen, the earlier breakaway in oxygen makes the over-all oxidation more severe.

Specimens oxidized in $H_2O$ vapor retain the black oxide film with some lightening in color if a breakaway effect is observed. For example, after 1500 minutes at 900 C, the sample exhibited a black oxide film even though spalling (at the edges) had occurred. Specimens oxidized in oxygen rapidly develop a beige oxide layer.

Corrosion of Stainless Steels in Supercritical Water. Samples of Types 304, 406, 430, and 446 stainless steel along with ASTM grade 212B carbon steel have been corrosion tested in the new supercritical autoclave facility at 550 C and 1000 psi for 30 days. Preliminary information on this test was presented in the June monthly report. At that time it was

shown that alloys which contained a higher percentage of chromium had lower corrosion rates. The present 30-day corrosion data have substantiated the previous results. The 406 stainless steel alloy with 13% chromium shows a penetration of 0.36 mil, compared with 0.01 mil for 446 stainless steel with 27% chromium. The 304 and 430 stainless steels showed penetrations of 0.29 and 0.31 mil, respectively. The ASTM grade 212B was penetrated 1.5 mils.

With the exception of the ASTM grade 212B carbon steel, the alloys appear to be corroding at a rate which is proportional to the log of time. That is:

$$\underset{(\text{mils})}{\text{Corrosion}} = k_1 \log \underset{(\text{days})}{t} + k_2$$

where $k_1$ is the slope and $k_2$ is the intercept. The values of $k_1$ determined for the 406, 304, 430 stainless steel alloys are similar: 0.18, 0.18, and 0.19, respectively. By plotting corrosion data for an 18-8 stainless steel reported by Uhlig for a 300-day test in 595 C steam, a value of 0.19 for $k_1$ is obtained, which is consistent with the small temperature dependence reported for stainless steel in this temperature range.

Corrosion of Copper and Silver in pH 10 Water. Four samples of copper and two samples of silver have been corrosion-tested in 275 C pH 10 deoxygenated water because of possible interest in such materials for fuel support surfaces. The pH adjustment was made with LiOH and the water was deoxygenated by stainless steel wool attached to the sample holder. After 720 hours in test, none of the samples showed any measurable weight change. The copper samples were slightly darkened, but the silver showed no visual indication of any effect of the corroding medium.

PRTR Process Tube Monitoring. The gas annuli for 82 tube positions in the reactor were measured in December 1960, and the remaining three in February 1961 as part of the PRTR tube monitoring program. Since then, only selected tubes have been measured as fuel elements were removed as part of the normal PRTR operating schedule. These gas annuli measurements showed only tube No. 1857 to have a gas annulus less than the minimum value calculated from pre-installation measurements. Analysis of the monitoring data yields the conclusion that the calandria is moving slightly with respect to the process tubes. In the case of tube 1857, with its built-in reduced spacing, the motion is sufficient to produce an annular spacing that varies from essentially 0 to 100 mils.

A borescope examination was also made in a PRTR process tube after it had been operated with a Pu-Al fuel element on which the width of the

film indicated: (1) no apparent change in the original localized corrosion marks at the top fuel element end bracket, and (2) a new set of localized corrosion marks about three inches lower and having the same general appearance as the original marks. No estimate of penetration could be made because of lack of detail. The borescope has been equipped with radiation-resistant lenses for the next examination.

Final drawings of the "Omniscope" type borescope having 180° hemispherical viewing have been approved. Delivery is scheduled for the first part of October. Drawings for the instrument probe insertion assembly for use with highly irradiated process tubes have been completed, and the purchase requisition has been forwarded to Purchasing for bid invitations.

Pre- and Post-Irradiation Evaluation of PRTR Process Tubes. Destructive testing and examination are continuing on PRTR tube No. 1154, which was removed from the reactor in July. Three areas of accelerated localized corrosion at points where the fuel element end bracket supports contacted the tube wall were replicated. The two areas at the lower end bracket were 120 degrees apart and measured 3/32 inch wide by 5/8 inch long and 4 to 5 mils deep. The section containing these two corroded areas was burst at room temperature. The burst pressure was 7450 psi. Inspection of the burst section indicated the rupture originated 5 to 6 inches away from the corroded areas and the crack passed midway between them.

The third replica of a corroded area at the top fuel element end bracket support measured 1/16 inch x 1/2 inch, and between 2 and 3 mils deep. Metallographic examination at this area confirmed the depth of penetration and exposed a layer of massive hydrides directly below the corrosion mark. This hydride layer was 2-1/2 mils deep, but exhibited very little diffusion of the hydrides into the adjacent metal.

The 33 PRTR replacement tubes have been ultrasonically tested for longitudinal and transverse cracks, and dye-penetrant tested on the inner and outer surfaces. Numerous dye penetrant indications were found and are now being conditioned out.

One tube was found to have a minimum wall thickness of 0.143 inch which is 0.013 inch under the specification of 0.156 inch. The thin wall covers an area approximately circular in shape and 1/2 inch in diameter. One tube that had a dye penetrant indication on the outer surface was being conditioned to remove the defect when a longitudinal crack was exposed beneath the small indication. Ten mils were removed from the tube wall without reaching the bottom of the crack which has a length of two inches. Three tubes have passed all testing and are ready for autoclaving.

PRTR Sheath Tubes. The development contract with Reactive Metals to evaluate the effects of high amounts of cold reduction and low temperature annealing in producing an ultra-fine grain size in sheath tubing is completed, and the 50 resulting 0.680 inch ID tubes have been received. Metallographic samples are being prepared, but results are not

yet available. All tubes were reduced in [illegible] steps of 57.5% and 57.6% reduction in area, respectively, by [illegible]. Some of the tubes were annealed between "rocks", and some were taken down from the hollow extruded tube shells to final size without annealing. The total cold reduction by Tube Reducing was 82.2%; however, some of the tube shells were not annealed prior to tube reducing resulting in total accumulated cold work without anneal of approximately 95% on 12 tubes.

Harvey Aluminum has completed the cold reduction of an experimental warm extrusion made at HAPO. The four-inch diameter billet for this extrusion was preheated at 1150 F. Some difficulty in locating the mandrel in the billet was experienced, and it is estimated the billet cooled to approximately 1000 F. It was then pushed at an extrusion ratio of 22:1. The resulting tube shell (1.25 inch OD x 0.143 inch wall x approximately 5 ft) exhibited a highly cold worked structure. Prior to shipment it was annealed in a salt bath at 1200 F for 15 minutes. It was then cold-drawn in 12 passes to a final size of 0.652 inch OD x 0.035 inch wall at Harvey Aluminum with a minimum of 10.5% and maximum of 14.4% reduction in area per pass. At a size of 0.8[illegible] inch OD x 0.[illegible] inch wall, it was cut in half; one half was annealed at 1200 F for 30 minutes in vacuum, and the other half was left in the cold worked condition. Both halves were then drawn to final size. The unannealed half had an 86.7% reduction in area without anneal. The tubing is being shipped to Hanford in the cold worked condition.

The depth of the calibrating standard grooves for the ultrasonic tests, transverse and longitudinal, has been reduced from 3 mils to 1 mil. This has resulted in raising the rejection level from about one percent to five percent of the tubes. The outside surfaces of these tubes are almost defect-free; however, the rejection rate has not dropped due to the presence of impressed material on the inner surface. The defects, when examined directly and under the microscope, appear to be different from those examined in the past. One of the more severe pieces of impressed material had three cracks under it ranging from 3 to 7.7 mils deep and about 12 to 15 mils long. The particles [illegible] bonded to the tube but do not appear to be Zircaloy as were some of the earlier impressed particles.

Radiometallurgy Studies

A layer of zirconium hydride was found at the surface of a fretting corrosion area in PRTR process tube 1134 (RM-331). The initial test capsule of injection cast Al-Pu alloy, GEH-14-23, is currently being examined. The core, which was originally bonded to the Zr-2 cladding, was pushed in the radial direction during irradiation and remained bonded only over one-half of the circumference. No hydrides were detected in the cladding (1[illegible]).

The cladding of rod #6 from GEH-12-20, purposely defected at the midpoint, exhibited a layer of zirconium hydride on the inner surface at each end of the 36-inch long rod. The layer was visible approximately eight inches from the defect and reached a maximum [illegible]

12 inches upstream and downstream from the defect (RM-618). Dimensional changes in GEH-14-46, a 15 w/o Pu - 12 w/o Si-Al alloy capsule, were slight during irradiation, and no bonding occurred between the fuel core and the Zr-2 cladding (RM-671).

The 30-mil ring of enriched uranium in Basic Swelling Studies samples from GEH-14, 281 and 282 showed considerable evidence of swelling in its scalloped appearance. The growth was only in the axial direction as the copper cladding apparently restrained radial growth. Replicas were obtained for electron microscope (RM-513).

Further details and interpretations of the above findings will be reported in connection with the development programs served.

## 2. PLUTONIUM CERAMICS RESEARCH

### Plutonium-Uranium Carbides

The composition/lattice spacing curves of PuC-UC alloys have recently been determined via back reflection x-ray techniques. Powdered uranium carbide containing 50.2 a/o C was mixed with Pu and C powders, pelletized, and arc-melted three times. Two sets of alloys were made up - one containing 46.5 a/o C and the other 44 a/o C in the PuC phase. Lattice parameters of arc-melted material indicated a maximum at 15 a/o UC and thereafter a gradual decrease to 4.959 a.u. for pure UC. Annealing at 1450 C in vacuum resulted in lower values for the carbon-rich PuC-UC alloys but still a maximum at 15 a/o UC. The carbon deficient PuC-UC alloys, on the other hand, exhibited a uniform decrease in lattice spacing from pure PuC to PuC - 60 a/o UC, while from this composition to pure UC they were constant at 4.959 A. The above data are preliminary because actual Pu, U, and C analyses have not been made; nevertheless, the data support earlier speculation on the existence of a solubility band of PuC-UC solid solutions due to the defect nature of the individual carbide structures.

A cylinder of pure plutonium monocarbide was arc-cast. Resistivity and bulk thermal expansion measurements will be performed after it has been ground to size. It is presently planned, after a series of suitable calibrations, to apply the Wiedemann-Franz Law to the resistivity of PuC in an effort to predict its thermal conductivity.

Additional efforts to obtain the zeta phase, $Pu_3C_2$, via low temperature anneals have proved unsuccessful, and it is evident that metallographic observations are necessary. The recent initiation of high temperature x-ray diffraction equipment should also aid identification of this elusive phase.

### Plutonium Oxides

A five-gram pellet of plutonium dioxide was melted in a tungsten crucible in an argon atmosphere in order to obtain data on $Pu_2O_{3+x}(PuO_{1.62})$. The sample was quenched from the melt and on examination was found to be

extremely porous, presumably due to oxygen evolution. The lattice parameter, 5.406 a.u., was slightly expanded and the O/Pu was 1.70, both indicative of an oxygen excess over the normal melted composition. The structure was fluorite, however, with no indication of the type A or C rare earth suboxide phase. High temperature x-ray diffraction analyses are presently being performed in order to define the relation between the oxygen deficient plutonium oxide and the thermal expansion hysteresis seen at 650 C. Thus far, two excellent x-ray diffractometer patterns have been obtained in vacuum at temperatures to 550 C. The sample is bound to a platinum resistance filament with an inorganic binder. Tungsten has worked quite well as an internal standard.

Plutonium Silicides

A stoichiometric mixture of $PuO_2$ and SiC was heated in a vacuum resistance furnace in an attempt to form $Pu_2Si_3$. X-ray diffraction indicates the product consists of $Pu_2Si_3$ plus an unknown phase. Chemical analysis shows that an excess of silicon is present. It seems reasonable that this second phase is another Pu-Si compound since x-ray diffraction reveals no Si, $SiO_2$, SiC, PuC, or $PuO_2$. The melting point and density will be determined.

Several arc-melting experiments were performed in an effort to form a single-phase plutonium silicide. Chemical analyses of the products indicate in each case, a loss of either plutonium or silicon. In one case, Si and alpha-Pu powders were blended for 16 hours prior to compaction into cylindrical pellets. Since $Pu_2Si_3$ was the desired product, the reactants were mixed in a 85/15 w/o Pu-Si ratio. X-ray diffraction analysis indicates the product is largely $PuSi_2$. Agreement with the ASTM diffraction data card for $PuSi_2$ is good. There are, however, a few additional reflections which have yet to be indexed. The compound is body-centered tetragonal and is isomorphous with $ThSi_2$. Chemical analysis will be run during the next reporting period as well as density and melting point determinations.

Thermal Emf and Electrical Resistivity

The apparatus for measuring thermal emf's and electrical resistivity have been completed and placed in operation. Thermal emf's have been measured on four different Pu-O compositions with the following results:

| | | |
|---|---|---|
| (1) | $PuO_{2.00}$ | 25 MV/°C |
| (2) | $PuO_{1.97}$ | 60 MV/°C |
| (3) | $PuO_{1.92}$ | 10 MV/°C |
| (4) | $PuO_{1.85}$ | 8000 MV/°C |

With the exception of $PuO_{1.92}$, the data fit a semi-logarithmic plot quite well. All of these samples contained considerable impurities and may account in part for the anomolous results obtained from $PuO_{1.92}$. The sign of the emf was also opposite from that expected, based on analysis of an oxygen deficient compound.

Electrical resistivity measurements have been made on 50 w/o $UO_2$ - 50 w/o $PuO_2$ and $PuO_2$ which indicate intrinsic activation energies of about 0.90 eV and 1.75 eV, respectively. This should also vary with composition and may be used to detect phase changes in this system.

$PuO_2$-$ZrO_2$ and $PuO_2$-MgO Irradiations

Zircaloy-clad capsules containing fuel mixtures of $PuO_2$-$ZrO_2$ and $PuO_2$-MgO are being prepared for irradiation testing in the MTR. Eight capsules of each fuel material will be irradiated. Five sintered and ground pellets are contained in each sample. The effects of plutonium concentration, center core temperature, and exposure will be investigated. It will be possible to compare the effects of irradiation on the two different fuel materials because they will both have the same number of fissionable atoms per cubic centimeter and the irradiation temperatures will be comparable. The sample compositions will be $ZrO_2$ with one and five mole percent $PuO_2$ and MgO with 0.45 and 2.26 mole percent $PuO_2$.

The $PuO_2$-$ZrO_2$ powders have been blended and pressed into pellets using 3 w/o carbowax as a binder. Analytical results on the 5 m/o $PuO_2$ material indicate good mixing of the plutonium. One of the $ZrO_2$ - 5 m/o $PuO_2$ pellets was sintered in hydrogen at 1525 C for four hours. It had a higher density than was obtained during previous work using a 20-hour sinter in a helium atmosphere.

The $PuO_2$-MgO powders have been blended by ball milling for 72 hours. The MgO is hydroscopic making it necessary to dry the powder before it can be used. Two MgO - 0.45 m/o pellets were sintered in hydrogen at 1525 C for four hours to a density of 90 percent of theoretical.

Two defected Zircaloy-clad capsules containing pure MgO pellets were exposed to 300 C water in a static autoclave for 24 hours. Weight gains were observed as a result of increased moisture content; however, no swelling or distortion of the capsules was observed.

In-Reactor Sintering Studies

The fabrication of the fuel core pellets for the in-reactor sintering studies on $UO_2$-$PuO_2$ and the direct comparison of the radiation behavior of $UO_2$-$PuO_2$ and enriched $UO_2$ has been temporarily delayed. The initial lot of pellets was rejected because of laminations. Fabrication of the second lot is being stalled because of a breakdown of the hydrogen sintering furnace. The capsules, originally identified as GEH-14-29, 30, 31, and 32, are now GEH-21-13, 14, 15, and 16, and are currently being considered for MTR Cycle 163 insertion (Sept. 25, 1961).

## 3. $UO_2$ FUELS RESEARCH

### Fission Product Migration

Radiochemical analyses have confirmed the extensive relocation of fission products in irradiated $UO_2$ fuel elements as earlier revealed by autoradiographic techniques which were previously reported. Similar evidence of non-uniform location of plutonium was obtained. Continued study is expected to provide data that will better relate changes in basic properties (melting point, thermal conductivity, etc.) of $UO_2$ to irradiation history and that will permit upward revaluation of limits imposed on the use of $UO_2$ fuel by accumulation of fission fragments.

### Electron Microscopy

Examination of the 1/2 inch diameter irradiated $UO_2$ test element GEH-14-189, continued. Skills and techniques are being developed to allow positive identification and examination of each zone across a radius of the surface replica. Zones are about 1/6" or less across and must be separated prior to electron microscope examination to assure area identification and correlation with light micrographs.

Preparations were made for evaluation of an Image Orthicon television system as an aid in electron microscopy. Tests are to be conducted at a vendor's laboratory under simulated microscope conditions of low image intensity and contrast. Several physical arrangements for transferring the image signal from microscope to television sensing element are being considered.

### Thermal and Electrical Conductivity

Curves for most of the conductivity measurements of the BMI/HLO cooperative program have been prepared. Oxygen/uranium ratios are being determined for all samples. Data received thus far show O/U $\leq$ 2.002 for five non-irradiated samples. If values for all other samples are also in the range, O/U ratio can be eliminated as a factor in interpreting conductivity measurements. Microstructures of samples used in the irradiated series are being studied. Correlation and comparison are difficult because several different methods were used for surface preparation of the various samples, prior to microscopy.

### Materials

Fused $UO_2$. A shipment of fused $UO_2$ was received which has an average O/U ratio of 1.93 - 1.97. The low O/U ratio is caused by inclusions of U metal in the $UO_2$. Vacuum gas extraction analysis shows that the material does not release significant quantities of gas when heated to 1000 C for 15 minutes. A volume of 0.09 cc of gas per gram of $UO_2$ was collected. The material will be used for determining the effects of

U metal inclusions on the in-reactor behavior of the $UO_2$. If current specifications for fused $UO_2$ can be relaxed to permit some U inclusions, the cost of preparing fused $UO_2$ will probably be further reduced.

Electrodeposited $UO_2$. A 60-pound batch of electrodeposited $UO_2$ crystals was received from the Chemical Engineering Development Operation. The material was deposited from a $KCl-PbCl_2$ system in a single operation, using recently enlarged facilities. A subsequent electrodeposition resulted in an electrode deposit of greater than 100 pounds of $UO_2$. The individual cyrstals are much larger than those previously available, which were deposited from a KCl-NaCl system, and are being prepared for fundamental studies.

## Uranium-Oxygen Phase Studies

Attempts to retain homogeneous $UO_{2-x}$ at room temperature have been moderately successful. Disks 5/8" x 1/16" were cut from adjacent positions in a 95% dense pressed and sintered pellet having an O/U ratio of 2.001. These specimens were heated to 2700 C ± 50° in approximately 20 seconds and immediately quenched to room temperature. The furnace atmosphere was helium containing 0.002% $O_2$. Lattice parameter measurements before and after heating showed a decrease in O/U ratio to 1.997 ± 0.002 in the annealed specimens. This departure from stoichiometry, while too small to be conclusive, indicates the existence of homogeneous $UO_{2-x}$ at 2700 C.

## High Energy Impact Formed $UO_2$

Metallographic examination of high energy impact formed $UO_2$ samples compacted in air at 1000-1200 C and heat treated after compaction revealed that air trapped in the $UO_2$ powder caused the material to swell on heating to 1300 C in hydrogen or helium. Voids formed in the $UO_2$ by the internal gas pressure were concentrated at the center of the specimens in some cases, indicating that some of the air escaped from the $UO_2$ near the surfaces of the particles. Density decreased from 98.5 to 92% T.D., when the $UO_2$ was heated at the rate of 200 C/hour. A final density of 96% T.D. resulted when the heating rate was 100 C/hour. Swelling was not caused by excess oxygen in the $UO_2$. The samples were made stcichiometric by hydrogen reduction at 800 C before heating to the higher temperature. The reduction treatment did not change the density of the $UO_2$ significantly. A sample of $UO_{2.04}$ reduced with hydrogen at 800 C became stoichiometric when heated in helium at 200 C/hour to 1300 C, and its density decreased from 98.5 to 91% T.D. Specimens compacted in vacuum did not decrease in density when heated to 1300 C.

## 4. BASIC SWELLING PROGRAM

### Irradiation Program

The irradiation of general swelling capsules #7 and 8, each containing three, axially split, hollow uranium cylinders, is continuing at constant temperatures of 525 and 575 C, respectively. These capsules have now received about 60% of their goal exposure. The annealing of the laboratory capsules is continuing, duplicating the temperatures of the in-reactor capsules as nearly as possible. Capsules #10 and 14 are now completely assembled and are being bench tested. Capsule #10 shows an open circuit between the heater lead and the sheath. Unless this can be repaired, this capsule will not be operated as a constant temperature capsule. However, with but a very minor modification it can be used to provide a much needed comparison between constant and cyclic temperature irradiations. Capsules #12 and 13 were successfully bench tested.

Four unmonitored NaK-filled capsules each containing six cylindrical U-U diffusion specimens have been prepared for irradiation. These were sealed in purified helium. It is intended that these capsules supply a sufficient number of specimens for various post-irradiation annealing studies. Fission gas diffusion from an enriched uranium shell into a metallurgically bonded depleted uranium core will be studied by metallographic techniques.

### Post-Irradiation Examination

A solid cylindrical specimen of uranium, GEH-14-36, which had been irradiated unrestrained in NaK at < 200 C to a burnup of 0.26 a/o has been annealed at 600 C for one hour. The specimen is currently being polished for subsequent etching and metallography. The porosity in this specimen will be compared with that present in similarly annealed uranium irradiated to 0.29 a/o but at higher temperatures and in a restrained state. The annealed specimen will also have its density determined and be examined for crack formation as a consequence of the annealing treatment.

Electron micrographs have been prepared of uranium specimens irradiated at controlled temperatures of 615 and 575 C to a burnup of 0.28 a/o, at 575 and 550 C to a burnup of 0.05 a/o, and at 330 and 260 C to a burnup of 0.03 a/o. With the exception of the latter specimens, porosity was observed in all cases. Select specimens were annealed at 615 C and 575 C, respectively, for 100 hours and are being reprocessed for hardness measurement, density, and metallography. The specimen irradiated at 575 C to a burnup of 0.05 a/o and thermally annealed at 575 C for 100 hours showed no change in microstructure from the original structure. The porosity in this specimen was extremely heterogeneous - no fine porosity, only clusters of relatively large pores, approximately 0.4 micron in diameter, with large distances between clusters. Micrographs of all of the specimens are being accumulated for determination of pore size-frequency relationships.

Fission Product Mobility

Efforts are continuing to determine the mobility of inert fission gases in uranium. The "glow discharge" release work has been temporarily interrupted to redesign some of the equipment, but the feasibility study of U-U diffusion couples that have a large concentration of fission products in one-half of the couple is continuing. Two unmonitored NaK-filled capsules, GEH-14-281 and 282, each containing a precharacterized U-U diffusion specimen have been opened. The specimens have been photographed and the precharacterized surfaces replicated as irradiated and after re-etching. Irradiation at temperatures below 600 F to 0.3 a/o burnup (nominal in the enriched shell) has resulted in relatively no change in the central 0.15 a/o U-235 core, but considerable change in the 3 a/o U-235 shell. In the enriched shell of uranium deformation has been so extensive that none of the Knoop hardness or Bierbaum microhardness indents could be recognized. These two specimens are being ground and polished for electron metallographic study of fission gas pores near the U-U interface and for microhardness traverses. They will then be used to determine proper annealing times and temperatures for developing porosity. The specimens still appear intact across the U-U interface.

Restrained Irradiations

Swelling experiments on eight Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and burnup are being conducted employing NaK-filled temperature monitored capsules. Volume and density changes in these rods irradiated in the MTR are being determined. Excluding two rods which have very low burnup, the uranium density decrease appears to substantiate swelling data from previous irradiations of Zircaloy-2 clad rods in NaK capsules. Above a temperature of approximately 350 C, swelling increases rapidly with increasing temperature. At 450 C the swelling is approximately eight percent per atom percent burnup. From a comparison of the effect of cladding thickness on swelling decrease, rods with nominal cladding thickness of 0.020 inch appear to swell less than rods with nominal cladding thickness of 0.030 inch. This is probably due to the fact that the thinner cladding results in a 30 C decrease in uranium temperature in the 0.020 inch thick clad rod. This lends credence to the postulate that Zr-2 cladding offers little in the way of restraint, although, admittedly, the difference in operating temperature makes a precise comparison difficult. Metallographic studies of the uranium and cladding on several of these eight fuel rods is planned.

## 5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

### In-Reactor Creep Measurements

During the month the heaters of capsule II-2 became inoperable due to a loss of electrical continuity. The exact point of failure is not yet known. The discontinuity may have occurred at the point where the heater leads were silver soldered to the inconel pin of a helium tight header. The techniques used in soldering resulted in a joint which was not free from flux. The combination of the corrosive nature of the flux, high temperature and nuclear environment is believed to have weakened the joint. The loss of heaters of capsule II-2 eliminates the possibility of creep testing. Both capsule II-2 and II-4 will be discharged as soon as possible to allow charging of a third generation capsule. The remaining two second generation capsules will be used for ex-reactor tests paralleling in-reactor tests of third generation capsules.

### Capsule and Instrument Development

Capsule III-2, a third generation capsule having a 20% cold worked specimen, has been checked out in the laboratory. The strain measuring system, thermocouples, and heaters formed exactly as required. The thermal transport was observed to be convection controlled, that is the power required to maintain a given steady state temperature increase with increasing helium pressure. At 500 psi, 460 watts were required to maintain a temperature of 200 C. The mass of the section affecting the specimen temperature is 480 grams. In a gamma field of one watt/gram the capsule should then operate at a temperature a little greater than 200 C in absence of electrical power. Since 605 watts are required to maintain a temperature to 245 C, the third generation capsule will be capable of creep testing at the lowest temperature of interest, namely 250 C in a gamma field of one watt/gram. The 2000:1 gear box used to turn the micropositioner weighs 261 grams. In a one watt/gram gamma field, the gear box temperature is expected to be considerably higher than desired. Modification of the gear box to lighten all components and provide for cooling of internal parts by convection was conducted. The gear box weight was reduced to 165 grams and holes were drilled in the housing to allow easy helium access to the box interior. The lightened gear box will be installed in the next third generation capsule prepared for charging. The gear box from that capsule will in turn be modified for use in the following capsule.

### Pre-Irradiation Material Characterization

Determination of activation energies for the creep of Zircaloy-2 has continued. Activation energies found for annealed material at 412 C and 434 C were 59,600 and 56,200, respectively. The extensive laboratory modification which has slowed this study is almost complete. Six new precision creep machines were added to the laboratory during the modification. These new machines will greatly accelerate the ex-reactor creep study.

## 6. GAS-GRAPHITE STUDIES

### EGCR Graphite Irradiations

The H-3-3 capsule in which EGCR graphite is being irradiated was successfully removed and reinstalled in the GETR during the Cycle 26 shutdown. This operation was required so that the guide tube which holds the capsule could be reamed out at the lower end. With the capsule now seated at the same reactor elevation at which H-3-1 and H-3-2 were irradiated, the sample temperatures are duplicating previous capsule history.

The first tentative flux monitor results from the H-3-2 capsule confirm the calculated values reported last month. The remaining flux monitors are presently being counted.

The H-3-FM flux monitor capsule irradiated during Cycle 24 in the E-7 position of the GETR has been disassembled. Nearly all the cadmium covers on the uranium vials had melted and/or vaporized. All nine flux wires were recovered and gross gamma scans were made. These wires were cut into 1/4 inch long segments which are being counted. The titanium and sulfur foils are also being analyzed.

### Combustion Studies of EGCR Hazards Evaluation

A series of tests were conducted in the EGCR Burning Rig to test a fuel channel mockup composed of EGCR moderator graphite and silicon carbide coated fuel sleeves. The fuel sleeves in these tests contained stainless steel fuel element shear pins and uncoated fuel element spider slots milled on the inside of the graphite sleeves, as required by fuel specifications. Results of the tests were as follows:

| Maximum Graphite Temperature (°C) | Inlet Air Temperature °C | | Air Flow Rate lb/hr | Observed Rate of Temperature Rise |
|---|---|---|---|---|
| | Annulus | Center | | |
| 620 | 60 | 260 | 378 | -40 C/hr |
| 620 | 60 | 400 | 186 | -5 C/hr |
| 635 | 100 | 320 | 287 | +60 C/hr |
| 620 | 80 | 400 | 100 | +30 C/hr |
| 635 | 100 | 320 | 186 | +120 C/hr |

By comparison of these results with previous results it may be concluded that coated graphite sleeves with uncoated positioning slots would be no more resistant towards combustion in the EGCR than uncoated graphite sleeves.

### Irradiation of EGCR Sleeve Materials

Samples of Speer 901, EGCR moderator, and CSF graphites were irradiated in ETR hot capsules. Irradiation temperatures were calculated to be from 1200 C to 1400 C. Exposure was approximately $2.5 \times 10^{20}$ nvt, E > 1 Mev

(~5000 EGCR equivalent MWD/AT). Preliminary results indicate that the 901 contracts slightly more in the parallel extrusion direction than in the transverse; showing an anisotropy ratio (parallel/transverse) of 1.7. EGCR moderator graphite contracts considerably more in the parallel direction than the transverse and shows a ratio of 10. This ratio is expected to decrease at higher exposures. Relative comparisons of materials in the parallel direction shows Speer 901 is about the same as EGCR moderator graphite and both are better than CSF. These samples are undergoing further irradiation.

Thermal Cycling of Irradiated Coated Graphite

Five samples of Si-SiC coated graphite which had been irradiated to 3000 MWD/AT at 500 C have been thermal cycled in air from 250 C to 1200 C. All had received air oxidation tests prior to cycling. C-8 had failed the oxidation test but was cycled to see the effect on a poor coating. Some coating disintegration was noted, but no large pieces spalled off. Results are summarized in the following table.

| Sample No. | Cycle Time | No. of Cycles | Percent Wt. Change | Remarks |
|---|---|---|---|---|
| M-11 | 117 hrs | 824 | + 0.003 | Good |
| C-5 | 96 " | 670 | - 0.002 | " |
| C-18 | 103 " | 779 | + 0.0003 | " |
| C-8 | 8 " | 64 | - 0.27 | Failed (see above) |

Graphite Compatibility With Helium Containing Water Vapor

Modifications to the "vacuum" balance are being made to enable a high vacuum to be obtained for outgassing samples prior to testing. In the meantime, determinations on the effect of temperature on mixtures of He, CO and $H_2$ are being made. The reaction:

$$CO + H_2 = C + H_2O$$

thermodynamically favors the right-hand side at temperatures below approximately 675 C. There is some evidence in recent experiments of increased water content in the exit gas after passing through an 830 C furnace.

An apparatus employed to study the thermal reaction of graphite with helium containing low concentrations of water vapor has been modified for use in the investigation of this same reaction under gamma irradiation. The equipment has now been installed in the gamma facility and a test is under way with helium containing 430 ppm of water vapor.

Surface Complex Studies

Recent results have shown that the majority of the results previously reported were due to a phenomenon associated with replacing one gas with

another in the recording balance system rather than to an effect on the graphite. Work is continuing in an effort to establish what part of the observed weight changes can be attributed to the graphite.

Effect of Impregnation on High Temperature Contraction

In a cooperative program with the General Atomic Division of General Dynamics, the effect of impregnation and subsequent heat treatment on the radiation stability of graphite is being investigated. Graphite samples of parallel and transverse cut TSX, and parallel samples of HLM-85, a candidate material for the HTGR, were included. Each sample series consists of four samples. The first samples were taken after the initial step of annealing to 2900 C for 15 minutes. The second sample was taken after two furfural alcohol impregnations with a 900 C bake following each impregnation. The third sample was heated to 2650 C after impregnation, and the fourth to 2900 C. A total of 24 samples comprise this program.

All processing has been completed and samples have been loaded into "hot capsules" for irradiation in the ETR.

Speer Carbon Company Contract, Chemical Additives in Graphite

Samples of ten graphites manufactured by Speer Carbon Company under the above contract have been shipped to HAPO. They are being prepared for irradiation to determine the effect of additives on dimensional stability. Included in the samples received are a standard graphite containing no additive, graphites in which 0.5, 1.0, 2.0, and 4.0 percent standard $Fe_2O_3$ was added to the base mix, and graphites containing one percent additions of purified $Fe_2O_3$, FeO, $Fe_3O_4$, $FeSiO_3$, and Fe. Eight additional graphites are currently being graphitized and purified. They were mixed with one percent additions of $Cr_2O_3$, $CrCl_3$, CuO, $U_2O_3$, $ZnO_3$, $Ni_2O_3$, $Al_2O_3$, and $Al_4C_3$. Density determinations made by Speer Carbon Company on the graphites containing iron additions indicate a two percent addition of standard $Fe_2O_3$ produced the highest density, 1.75 g/cc. Graphite with one percent additions of purified and standard $Fe_2O_3$ produced densities of 1.66 and 1.72 g/cc, respectively. Analyses of the additives revealed only trace quantities of impurities in the purified $Fe_2O_3$ while the standard $Fe_2O_3$ contained small amounts of $SiO_2$, ZnO, $Al_2O_3$, PbO, and CoO. The impurities appear to have influenced the increase in density. Density increases alone have not proven to be indicative of the dimensional stability of graphite when the increases were attained by pitch impregnation. It will be of interest to determine what correlation if any exists between dimensional stability and density gained by the use of additives.

Gas Loop Project Management and Design (Project CAH-822)

Gas Loop construction is approximately 92% complete versus 99% scheduled as of August 31, 1961. The J. A. Jones Company installation work is approximately 92% complete versus 95% scheduled. Miscellaneous electrical work and completion of insulation and framework painting are scheduled

for next month, at which time the main loop will be ready for design tests. The helium shroud coolant loop testing will be deferred until after installation of the in-reactor prototype in B Cell. Installation of the in-reactor section in channel 1542 depends on successful demonstration of the prototype, PRTR scheduling, and delivery of the main blowers.

A visit was made by Mr. Neill and Mr. Dudley of ORNL to discuss design parameters of the Gas Loop for consideration in possible future uses of the Gas Loop Facility. The visit was arranged through the Civilian Reactor Development and Research Division of HOO, AEC.

Testing of the prototype $CO_2$ diaphragm compressor has started.

## 7. GRAPHITE IRRADIATION DAMAGE STUDIES

### National Carbon Company Contract

Samples of lampblack-based material, heat treated to a maximum temperature of 1400 C, have been discharged after exposures of 608 and 1378 MWD/AT while being irradiated at about 600 C. The contraction rate of this material in both orientations was approximately 0.4% per thousand MWD/AT, or twice the rate for similar material processed to 3000 C. These results augment previous data indicating high contraction rates in nongraphitic material under high temperature irradiation.

Parallel samples of anthracite-based graphite heat treated to 3000 C displayed dimensional changes similar to reactor grade materials after the exposures cited above.

Hot worked graphites of both parallel and transverse orientations were also included in this irradiation. As expected, an initial slight expansion was observed in both oritentations at the lower exposure. Parallel samples contracted slightly after 1378 MWD/AT.

### Irradiation Temperatures in Cold Test Holes

Thermocouple measurements were recently completed in the cold test hole, 2B at KE Reactor, and results indicate that graphite sample temperatures are higher than the nominal 30 C quoted for this facility. Virgin graphite samples reached a temperature of 50 to 60 C. Because the thermal conductivity of irradiated graphite is lower than in virgin samples, the temperatures of high-exposure samples should be higher by 10 C or more.

Both stored energy and length change in graphite irradiated in cold test holes have displayed a tendency to saturation. The irradiation of the high exposure samples was started at 30 C. In view of the now higher temperatures, it is likely that annealing of damage accumulated at lower temperature accounts for part of the tendency toward saturation. For this reason the saturation-stored-energy of cold test hole samples is probably lower than the maximum stored energy for 30 C irradiations. Length

changes of cold test hole samples also are probably lower than length changes which would have accumulated if the irradiation temperature had been maintained at 30 C.

## 8. ALUMINUM CORROSION AND ALLOY DEVELOPMENT STUDIES

### Aluminum Corrosion

Testing continued on the corrosion of X-8001, Zr-2, and sensitized 304 stainless steel at 300 C in water adjusted to a pH of 4.5 with $H_2MoO_4$. The current test has been operating somewhat longer than 2500 hours, although aluminum corrosion data are only available up to 1630 hours at this time. The corrosion rate of the X-8001 alloy at 25 fps changed from 0.16 mil/mo to 0.92 mil/mo after 825 hours. The corrosion rate at 40 fps has been 0.92 mil/mo since testing began. Apparently the formation of a protective film was prevented at 40 fps, whereas at 25 fps a protective film was formed initially but changed in character after 825 hours. This was borne out by the observation of loose, flaky films on the more recently discharged coupons as well as lower film weights on these coupons compared with earlier coupons. Total penetrations after 1630 hours range from 1.0 to 1.2 mils at 40 fps, and to 0.7 mil at 25 fps. Comparison data using high purity water at 300 C show a rate of 3.3 mils/mo and indicate some inhibition is being obtained.

### Evaluation of Nickel-Plated Aluminum in High pH Water

The test was terminated in TF-5, in which Ni-plated aluminum was exposed to 290 C, pH 9.0 LiOH water. After five weeks of operation, full penetration of the can wall (0.045 in.) was achieved. In general, sharp corners and apparent coating holidays were penetrated and the underlying aluminum was pitted. The 0.001 inch nickel-plate was not greatly undercut and the corrosion of the aluminum was not accelerated in these defect areas. The nickel plating tested had received a two-minute heat treatment in molten AlSi.

### Revision of H-1 Loop

An order has been placed for the deionizers for H-1 Loop. After the former KER pumps are installed, the loop will be available for operation with nonfueled samples (coupons). A preliminary testing program has been drafted. The first tests will include a comparative evaluation of alloys and a study of factors leading to deposition of films on samples in the flux zone.

## 9. USAEC-AECL COOPERATIVE PROGRAM

The response of the ultrasonic test equipment varies with the physical dimensions of the defects in Zircaloy sheath tubing; however, the exact relationship between length, width, and depth of a defect and the response of the instrument remains to be established. Several series of defects

are being fabricated. One series of defects is being made with the same depth and width but different lengths, another with the length and width held constant but with different depths, another with constant depth and length but with different widths, and a set with the physical dimensions the same but with different orientations with respect to the tube axis. The electro-jet machined grooves will be replicated to assure precise duplication of groove shape to avoid uncontrolled variables. Using machined defects in the study of ultrasonics has raised the criticism that the shape and orientation are different from real cracks. In an attempt to make a defect more nearly like a crack, 0.680-inch ID tubing with machined defects will be drawn to 0.495 inch size holding the wall thickness to 0.035 inch. It is anticipated that the machined defect will close during drawing and hence may more nearly simulate a crack.

## 10. IRRADIATION EFFECTS IN STRUCTURAL MATERIALS

As reactor concepts become more diversified, it is increasingly more difficult to keep pace with the need for information about the effects of irradiation on reactor structural materials. The purpose of this program is to investigate the combined effects of radiation and reactor environment on the mechanical properties of structural materials. Special attention will be given to the determination of mechanical property changes produced in metals by irradiation at elevated temperatures in contact with water. Modification of the ETR 6x9 loop for the purpose of this program was completed. A specimen assembly, along with a mockup assembly for the critical facility, was delivered to the ETR for irradiation starting with cycle 39. This cycle began late in the month. The irradiation assembly contains 504 Zircaloy-2 tensile specimens which were machined from rolled plate both in the longitudinal and tranverse directions. Specimens in the annealed, 10, 20, and 40 percent cold worked conditions were inserted. Goal exposures range from $2.0 \times 10^{19}$ to $1.6 \times 10^{22}$ nvt. As the Zircaloy-2 specimens reach their goal exposure, they will be discharged and replaced with types 348 and 304 stainless steel specimens, of which about 800 have been received. Blanks for notched tensile and bend specimens have been cut for final machining. The irradiation of these materials near 300 C will cause some cold work recovery and structural changes due to temperature effects alone. To duplicate the in-reactor operating history, thus divorcing the neutron damage effects for study, arrangements have been made to expose control specimens in an ex-reactor hot water loop. Additional specimens for these tests are being prepared.

Low temperature irradiations are also in progress on both notched and uniform tensile specimens of Zircaloy-2 and tensile specimens of zirconium - 2 Nb - 2 Sn alloy. Of the 19 capsules charged into the ETR F6 and G6 positions, eight have been discharged, decanned by Radiometallurgy, and transferred to the 326 Building for testing.

## D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Considerable fundamental information on the effects of neutron radiation on metals has been accumulated, but only recently has it been recognized that basic material parameters, such as purity, play an important role in determining the extent of property changes. Previous studies at HAPO have shown that impurities markedly affect damage production and recovery in various metals representing all three major crystal systems. The objective of the present program is to develop a model which accurately describes the nature of neutron damage in a pure body-centered cubic metal to determine how controlled impurity additions alter this damage state, and to establish the mechanisms of damage recovery. Molybdenum has been selected as a suitable metal for initial study because a large proportion of damage is retained at room temperature and transmutations and residual radioactivity are minimal. A number of single crystal and polycrystalline specimens containing known impurity levels will be irradiated at ambient reactor temperatures, and the following tests will be conducted: (1) mechanical property measurements and determination of deformation mechanisms; (2) examination of thin foils by transmission electron microscopy; (3) x-ray diffraction determination of lattice parameter, line broadening, and extinction; (4) measurement of electrical resistivity and macroscopic length. Kinetics and mechanisms of damage recovery will be determined through the use of lattice parameter, resistivity, and macroscopic length measurements. The recovery studies will be supplemented by measurements of stored energy release from irradiated polycrystalline specimens.

A total of 225 inches of 1/8 inch diameter molybdenum single crystals of various orientations has been obtained. Known amounts of carbon have been added to these crystals, with carbon levels in three ranges: 10-30 ppm, 100-200 ppm, and 400-500 ppm. An order has been placed for thin foils of the same composition. Work thus far has been directed at finding a suitable technique for obtaining reduced sections on tensile specimens without greatly disturbing the crystal. Electrolytic machining and mechanical grinding followed by heavy etching appear promising.

Design of a differential calorimeter for stored energy measurements is complete and construction is in progress.

Molybdenum foils, 0.003 inch in thickness, of nominal 99.99% purity have been successfully thinned for direct electron transmission microscopy. Dislocations and grain boundary structures are revealed, but dislocation motion due to thermal heating stresses by the incident electron beam did not occur. Microtensile specimens for the electron microscope were prepared with an available jig. Contrary to the behavior of similar aluminum specimens, they deformed and fractured at the grip ends. A new jig is therefore being designed for preparing tensile specimens. In lieu of availability of the molybdenum foils on order, commercial grade (99.99%) foil specimens in the as-rolled and vacuum annealed (at 830 C) state have been sealed in evacuated capsules and submitted for irradiation in a Hanford Snout Facility. These foils will permit preliminary electron microscope study on the susceptibility of molybdenum to clustering of defects formed by neutron bombardment.

E. CUSTOMER WORK

Radiometallurgy Service

The diameter of the second overbore element increased about 15 mils during irradiation. In both elements the grain size of the uranium on the internal surface was extremely small to a depth of 10 mils (RM410). Failure of the X-8001 clad, enriched production element from 2657 DR was caused by corrosion which penetrated the sidewall in a hot spot (RM426). The ruptured element from tube 2986 DR which was cracked transversely in several places was so badly damaged that little information was gained from the examination. However, it was determined that the transverse cracks originated at the internal surface and the metal quality was consistent with production standards (RM427). A pin hole in the male weld was the cause of failure of the enriched bumper element from 2867 H (RM428). Nine samples were dissolved for burnup analysis, one sample was dissolved for iron analysis, and fission product gas was collected from six ceramic fuel components.

Metallography Service

Zircaloy-clad fuel elements exposed to a temperature of approximately 1300 C for one hour exhibited different degrees of alloying between the uranium and the Zircaloy, as reported last month. One of these elements had been closed with a 5% beryllium-alloy brazed end cap while the other had been closed with a simple weld around the end caps. The uranium in the brazed element dissolved enough Zircaloy to make approximately a 2% Zr-U alloy. The uranium in the other element dissolved very little Zircaloy and was still essentially unalloyed uranium.

Uranium attack of the can and caps was much more severe in the cap region of the 5% beryllium brazed element than on the welded element. Because of the location and degree of attack, it was surmised that attack of the Zircaloy was accelerated by the beryllium present in the braze regions. Although this increased alloying attack thinned the jacket rather drastically, it apparently did not contribute to premature failure in the furnace test.

X-ray diffraction analysis of a zirconium oxide region in autoclaved Zircaloy-2, which was exposed by mechanically polishing away the Zircaloy metal, is currently in progress.

Other work during the month will be reported in connection with the respective research and development programs served.

Samples Processed During the Month:

| | |
|---|---|
| Total Samples | 292 |
| Replicas | 19 |

Photographs

| | |
|---|---|
| Micrographs | 391 |
| Macrographs | 80 |
| Electron Micrographs | 198 |
| | 669 |

NPR Charging Machine

Installation of the mockup assemblies is 85% complete and testing of the machine and components is 15% complete. Charging machine subassemblies which have been operated include the cross travel drive, vertical lift, plug conveyors, idler rollers, transfer arms, and front drive rollers.

The main work during the month has been in wiring the electrical control system which consists of six electrical cabinets with 225 relays, 150 indicating lights and 50 switches of various types. The electrical work is 65% complete.

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Manager, Reactor and Fuels Research
and Development

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# PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

## MONTHLY REPORT

## AUGUST 1961

## FISSIONABLE MATERIALS - 02 PROGRAM

### REACTOR

#### Optimization of Retubed C-Pile Lattice

The final material buckling for C-II-N fuel elements with air coolant is $114 \times 10^{-6}$ $cm^{-2}$. The extrapolation lengths are 1.1 inches perpendicular to the process tubes and 1.0 inches parallel to the process tubes.

#### Lattice Parameters for Large Diameter Fuels

PCTR measurements have been completed for a 1.66 inch solid fuel element of natural uranium in a 6.5 inch lattice moderated by graphite. The analysis of the data to obtain $k_\infty$ and f is not yet complete.

An experiment to determine the reactivity worth of spline material is being planned. The worth of the spline material relative to the worth of copper will be measured at the position at which the cell was poisoned when its $k_\infty$ was measured.

#### Exponential Measurements of Large Diameter Fuels

The fractions and ranges of fast neutrons emitted by radium-beryllium neutron sources were measured and reported by Davenport, Lynn, and Richey (HW-26207). The constants were determined by fitting a sum of three exponentials to foil data taken between 10 cm and 75 cm from the neutron source. Cadmium-covered indium foils were used as detectors. New fractions have been determined by fitting the same data but including points up to 95 cm from the source. The old and new fractions are given in Table I.

TABLE I

| Range | Old Fraction | New Fraction |
|---|---|---|
| 30.74 cm | .3462 | .3244 |
| 43.24 cm | .6416 | .6533 |
| 64.14 cm | .0122 | .0223 |

#### PCTR Safety Specifications

Hazards calculations have been made for three different core loadings for the PCTR. Integrated power levels were obtained at which various reactor components would melt or vaporize in case of an uncontrolled nuclear excursion. The core loadings considered were a natural uranium fueled core, a Pu-Al fueled core, and an aqueous Pu solution core. This work was done in support of the Revised PCTR Hazards Report.

Exponential Measurements on N-Reactor

The material buckling of the natural uranium NPR fuel elements with water coolant was measured in the condensed lattice exponential pile. The lattice spacing was 7.56 inches. The final buckling is $-177 \pm 3 \times 10^{-6}$ cm$^{-2}$. The extrapolation lengths are 1.0 inches perpendicular to process tubes and 0.8 inches parallel to process tubes. The buckling measurements involving natural uranium are now complete and are summarized in Table II.

TABLE II

Material Bucklings for Natural Uranium

| Lattice | Buckling (in.$10^{-6}$ cm$^{-2}$) Wet Fuel | Dry Fuel |
|---|---|---|
| Condensed | - 177 ± 3 | - 178 ± 3 |
| Mockup | - 95 ± 2* | - 93 ± 4 |

*An average of two independent measurements.

The measurements show that, within the uncertainties involved, the mockup and condensed lattices are at "cross-over" for the natural uranium fuel elements. The "cross-over" point is at that lattice spacing for which the buckling does not change upon loss of coolant.

Two programs have been written for the IBM-7090 to analyze exponential pile control rod data. CORE-I uses one-group theory and CORE-II uses two-group theory. CORE-I is now in use and CORE-II is being debugged.

PCTR Measurements for N-Reactor

The peaking of the "1/v" flux near the end caps in NPR fuel has been measured in the PCTR. The peaking is magnified by the presence of a 0.220 inch water gap between the inner tubes of fuel in two adjacent fuel elements. Two series of measurements were made: (1) with the end caps centered under a transverse vent and (2) with the end caps centered between two transverse vents. The data have been reported in HW-70727. The flux peaking does not depend upon the position of the vent. The peaking at the ends of the outer and inner fuel tubes is 23 percent and 44 percent, respectively.

Transport Theory Development Work

The $S_n$ analysis method for solving the multi-energy adjoint-and-flux transport equation has been generalized to provide rigorous satisfaction of energy-dependent albedo boundary conditions, by use of a chain-compounded nest of three-pass radial-angular extrapolated-integration loops. Because widespread difficulties in applying the $S_n$ analysis method to mirror-reflected cells have been reported throughout AEC installations, the derivation seems worth summarizing here, for immediate dissemination prior to ANS journal publication.

The method stems simply from the observation that linearly independent solutions of the transport equation can be combined linearly to obtain solutions satisfying pre-specified albedo boundary conditions; but the multi-dimensional intricacy of the transport equation requires careful optimization of the mathematical logic to eliminate the need for storing multiple solutions, to minimize machine time, and to avoid numerical instability.

The logic begins with inward integration of outward adjoint and inward flux, and progresses to outward integration of inward adjoint and outward flux after albedo reflection at the inner boundary surface. At the outer boundary, inward adjoint and outward flux re-enter three-pass loops, as illustrated in the $S_4$ flow chart of Figure 1:

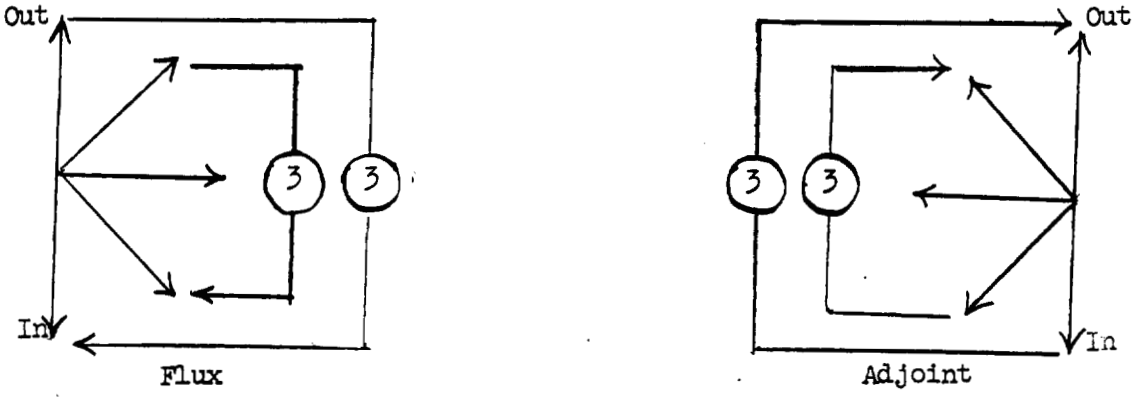


Figure 1: Three-pass albedo loops, for $S_4$ angular basis.

On the first pass through each loop, the outer boundary adjoint field $\phi^*(I,n,l,M-m)$ and flux field $\phi(I,n,l,m)$ are set equal to the outer surface source $\phi_o(n,l,m)$ (which is taken as zero if not provided as input):

$$\phi_1^*(I,n,l,M-m) = \phi_o(n,l,m), \qquad (1a)$$

$$\phi_1(I,n,l,m) = \phi_o(n,l,m). \qquad (1b)$$

The indices ($i = 0,I$; $n = 1,N$; $l = 1,L$; $m = 0,M$) label radii, energies, polar angles, and azimuthal angles, respectively.

On the second pass through each loop, the emergent fields are multiplied by the outer surface albedo $A_o(n)$ and added to the outer surface source to form the second entry field:

$$\phi_2^*(I,n,l,M-m) = \phi_o(n,l,m) + A_o(n)\,\phi_1^*(I,n,l,m), \qquad (2a)$$

$$\phi_2(I,n,l,m) = \phi_o(n,l,m) + A_o(n)\,\phi_1(I,n,l,M-m). \qquad (2b)$$

On the third pass through each loop, the first two entry-exit surface fields are combined linearly to form the final entry fields needed to satisfy the specified outer albedo boundary conditions:

$$\phi^*(I,n,1,M-m) = \phi_o(n,1,m) + A_o(n)\,\phi_2^*(I,n,1,m) - \left[\phi_o(n,1,m) + A_o(n)\,\phi_2^*(I,n,1,m) - \phi_2^*(I,n,1,M-m)\right]^2 / \left[\left[\phi_o(n,1,m) + A_o(n)\,\phi_2^*(I,n,1,m) - \phi_2^*(I,n,1,M-m)\right] - \left[\phi_2^*(I,n,1,M-m) - \phi_o(n,1,m)\right]\right], \quad (3a)$$

$$\phi(I,n,1,m) = \phi_o(n,1,m) + A_o(n)\,\phi_2(I,n,1,M-m) - \left[\phi_o(n,1,m) + A_o(n)\,\phi_2(I,n,1,M-m) - \phi_2(I,n,1,m)\right]^2 / \left[\left[\phi_o(n,1,m) + A_o(n)\,\phi_2(I,n,1,M-m) - \phi_2(I,n,1,m)\right] - \left[\phi_2(I,n,1,m) - \phi_o(n,1,m)\right]\right]. \quad (3b)$$

The analysis is available for external distribution, as a part of GE-HAPO program S-X (Neutron and Photon Transport, Variational Optimum Formulation, Plane-Cylinder-Sphere).

## Digital Computer Programs for Reactor Analysis

The rough draft of the HFN descriptive document is about half finished. A separate informal document(1), describing the generalized input routine used with HFN, has been submitted for reproduction. Copies will be sent to all HAPO FORTRAN users with the next issue of FORTRANSLATIONS. The card decks and an abstract of the input routine have been submitted to the FORTRAN program library in 713 Bldg.

Computer program FIT-1(2) has been modified to permit the solution of problems using two very tightly coupled thermal groups, such as the absorption spectrum model. Previously attempted runs using this model had driven FIT-1 into unstable oscillations. Using HFN, it was experimentally determined that the two thermal groups could effectively be partially decoupled by coupling each group to itself (i.e., using a non-zero self-scatter transfer cross section, $\Sigma_{jj}$, in each group). FIT-1 was modified to accept the "self-coupling" cross section as input, and both HFN and FIT-1 have successfully run absorption spectrum calculations.

## Green's Function Treatment of Two Region Exponential Piles

Since the Hanford exponential piles have a fuel region distinct from a base region, they are representative of a more complicated exponential assembly than

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(1) Lilley, J. R., "A Generalized FORTRAN Input Routine," HW-70893, August 29, 1961.

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

the homogeneous type analyzed previously. A first step in analyzing such a pile is to represent it as a two-region assembly--a base region consisting of moderating material having a characteristic diffusion length and a fuel region having a characteristic buckling. The Green's function analyses for such two-region assemblies have been completed for both point thermal sources and point fast sources. The fast sources were treated by age theory and the pile considered to be uniform for fast neutrons. The results are somewhat more complicated than similar results for a single region pile. A thermal point source type two-region correction is currently being used in analyzing pile data. It is hoped that a fast source type two-region correction will improve the analysis of experimental data and permit data from a wider region of the pile to be useful. This would, in turn, allow more accurate buckling measurements from the same assembly.

Computational Programming Services

Debugging continues on the rewritten version of the General Atomics code, KERNEL. Revisions were made to VTOCL, the exponential pile data reduction code, to permit the inclusion of data taken at uneven increments along the vertical axis. A rough draft has been prepared of an HW document describing the recent revisions to COFIT2.

Instrumentation

Except for a number of 329 Building 110 VAC power interruptions, the prototype experimental Fast Scan Fuel Failure Monitor performed properly throughout the month. The complete sample system was in operation.

Considerable data were obtained for three types of fission neutron detectors, which use $U^{235}$ foils, for reactor use. Measurements were made of noise levels, signal-to-noise ratios, neutron-caused pulses, and alpha-caused pulses.

A trip was made to GE-APED, San Jose, to discuss the nuclear instrumentation being fabricated for N reactor.

Twelve air monitors of the air-borne particulate fission product type, developed for use at N reactor, were ordered. These will be fabricated by Technical Associates, Inc., as direct copies of our developed unit.

In preparation for the N reactor diffusion length measurements, assistance was rendered to Operational Physics, IPD, concerning experiments to verify the poison detection methods previously proposed, and a cost estimate for instrumentation was prepared.

Advice and assistance was given to Reactor Plant Design concerning bid reviews and performance tests of equipment being offered for bid consideration for the NPR Fuel Failure Monitor.

The optical readout traverse mechanism for measuring graphite distortion in the old reactors has been completely assembled. Tests are being run to measure its performance. Design sketches are being prepared for a traverse mechanism which will use electrical readout transducers. Such a unit will make the traverse measurements in less time. The design changes being made incorporate changes

that will be useful in any other optical readout mechanisms which may be used

Two head units for the radiation ratio pyrometers for measuring graphite moderator temperatures have been given their final calibrations. Both are still very sensitive to focus adjustments. An attempt to use a ground glass diffuser to reduce sensitivity to focus was unsuccessful because the diffuser scatters too much radiant energy out of the radiation beam. No test has been made using a field lens in the place of the diffuser. A radiation ratio pyrometer of completely different design is currently being tested. This unit is expected to operate without any need of focus.

Systems Studies

Feasibility studies concerning an NPR Plant Simulator have continued in a cooperative effort with IPD engineering and operations personnel. A document has been drafted describing the uses and justifications, the facility requirements, and possible steps for procurement; and recommending authorization to proceed with preparation of a detailed scoping study and proposal. Efforts were made to obtain the excessed ANP analog computer equipment for the NPR Simulator, but word was received at month's end that it was assigned to Aerojet-General Corporation for the nuclear rocket program.

A meeting was called by Operational Physics Operation, IPD, to discuss equipment requirements for the proposed automatic control experiment at 100-D reactor. It was attended by representatives from Systems Research Operation, HLO; Instrument Development Operation, IPD; and Operational Physics Operation, IPD. Various methods of obtaining reliable equipment configurations were discussed. It was decided to attempt to purchase suitable multiple-winding magnetic amplifier controllers for the measurement and control signal functions. These units were recommended by Instrument Development Operation on the basis of reliability, simplicity, and previous plant experience. It appears that this type of control device can form the nucleus of a highly reliable control system if it can meet the stringent repeatability requirements of the system. Systems Research Operation has asked that tests be made as required to determine that all temperature trip points set on the control units will be repeatable to within 0.1°C for an indefinite period. If this degree of repeatability cannot be obtained with the proposed controller, a null-operated bridge system, similar to one proposed in HW-69851, may be required. Details on the method of actuating control rods have not been worked out. A general philosophy of operation was discussed but the details will be delayed until after the type of control device to be used is determined.

The xenon poisoning equation constants for both ground state and metastable xenon have been determined and a stability study is being conducted using the GEDA computer.

Analytical work on a reactor model for the spatial-dependent reactor kinetics is complete. A report is being written and should be ready for initial issuance soon. When the initial writeup is complete, an attempt will be made to program a simple reactor model for checkout and initial result purposes.

The main analog program has been completed for the NPR secondary loop. Subprograms will be wired to the main program to study scram transients and loss

of load transients. The study will determine under what conditions instability will occur, particularly due to the interchange of energy between two dump condensers.

Work was resumed on the space- and time-dependent reactor speed-of-control simulation, using the EASE and GEDA analog computers. The reactor was simulated as a side-to-side array of nineteen vertical slabs. This simulation allowed investigation of local effects, including the effects of local VSR malfunctions. The simulation was then changed to represent a reactor consisting of a top-to-bottom array of nine horizontal slabs. This model affords simulation of VSR speeds and drop times. It is also possible to observe the effects of safety rods going in only part way. Several power and fuel temperature curves were obtained and forwarded to the customer. Due to the time for safety rods to reach the bottom of the pile, reactor power and fuel temperature curves obtained with the top-to-bottom model were substantially different from those obtained with other models. It is expected that a more realistic simulation will be programmed and run as soon as additional computing equipment is made available.

A reactor instrumentation study was made to determine the effect of time delays introduced by the instrumentation on the reactor outlet temperature as a function of reactivity. The study consisted of determining the maximum rate of reactivity addition which could be introduced without allowing the reactor outlet temperature to exceed a given value. This was performed for various instrument delay times and for various settings of the scram trip point.

## SEPARATIONS

### Critical Mass Experiments with Plutonium Solutions

Critical mass studies were continued with plutonium nitrate solutions in a 14-inch diameter stainless steel sphere. The results of measurements completed during the month are summarized in the attached table. The critical mass values are for the total plutonium including the Pu-240.

In each case the critical volume and mass were determined from extrapolation of neutron multiplication curves with the control and safety rods withdrawn. For several different reasons, criticality was not achieved in these experiments. In some cases the critical volume exceeded the sphere volume of the criticality vessel, and secondly, due to failure of the control rod drive mechanism, the experiments were purposely restricted to sub-critical measurements.

During the critical approach experiment on August 8, the limit switch failed to function properly as the control rod was being inserted. As a consequence, the screw drive for the magnet assembly became unthreaded at the gear box. In order to effect repairs, the upper section of the control and safety rod drive assembly were then removed and dismantled in the mixing hood at the Laboratory. Modifications are currently being made to the limit switch in order to prevent this kind of malfunction in the future. The control rod will be reassembled, decontaminated, and installed, as soon as these modifications have been completed. The control rod assembly was removed without spread of plutonium contamination--an extremely difficult undertaking.

## CRITICAL MASS EXPERIMENTS WITH PLUTONIUM SOLUTIONS IN 14-INCH DIAMETER STAINLESS STEEL SPHERE

| Date | Experiment Number | Pu Concentration (gm/l) | H/Pu Atom Ratio | Acid Molarity | Total Nitrate (gm/l) | Valance State of Pu in Solution | Reflector Condition | Estimated Critical Volume (liters) | Estimated Critical Mass (Kg Pu) |
|---|---|---|---|---|---|---|---|---|---|
| 8-4-61 | 1141009 | 88.4 | 270.3 | 1.78 | 180.2 | $\geq$ 99% $Pu^{+4}$ | 0.072-inch stainless steel | 23.3 | 2.06 |
| 8-8-61 | 1141010 | 63.8 | 382.3 | 1.86 | 149.0 | $\geq$ 99% $Pu^{+4}$ | $\frac{1}{2}$-inch paraffin | 20.8 | 1.33 |
| 8-21-61 | 1141011 | 280.7* | 70.2 | 5.00 | * | " | " | 25.5 | 7.16 |
| 8-23-61 | 1141012 | 250.1* | 78.6 | 5.26 | * | " | " | 25.3 | 6.32 |
| 8-24-61 | 1141013 | 178.2* | 121.3 | 4.16 | * | " | " | 22.0 | 3.92 |
| 8-29-61 | 1141014 | 219.5* | * | 4.26 | * | " | " | 24.0 | 5.18 |

* Final chemical analyses not completed at time of this report.

Since the safety rod was working satisfactorily, approval was obtained to conduct subcritical multiplication measurements without an operative control rod, pending re-installation of the rod.(1)

The experiments were then continued under the operating limitations and instructions set forth in HW-66266 (Hazards Summary Report), HW-68857, and Authorization No. EA-CML-61-1, with the following special conditions:

1. The control rod was not used.

2. The systems were not made critical.

3. The volume of solution in the critical assembly vessels was not at any time to exceed the estimated critical volume minus 0.2 liters.

   Since the control rod worth was determined to be 0.2 liters of solution or less, the above limitation presented no additional hazard. When criticality was approached with the control rod in the solution, the amount of solution added (near critical) also had to be limited to amounts less than the worth of the control rod. Therefore, up to a volume limit of 0.2 liters short of criticality, the subcritical experiments were as safe as those in which the control rod was used and criticality reached by withdrawing the control rod.

Several of the principal purposes of these experiments have been to determine the critical concentrations in the full sphere and to obtain basic information on criticality conditions as a function of concentration.

The most significant results to date of these experiments have shown that the critical volume is not a single-valued function of the concentration of the fissile isotope when Pu-240 is present in the system. This means that a given volume may have more than one critical concentration. This multiplicity of just-critical values of concentration occurs in the region (of the critical volume vs. concentration curve) where the energy spectrum is shifting from an approximately thermal spectrum to a very fast spectrum. As the spectrum hardens, a larger fraction of the flux lies in the effective region of the Pu-240 resonance, i.e., the Pu-240 resonance, when flux weighted, is a more effective absorber. The critical volume, of course, decreases again as the spectrum approaches that of an unmoderated (fast) reactor, and the Pu-240 resonance (at $\sim$ 1 ev) becomes less effective. For a given volume there can be as many as three "just critical" concentrations - separated by regions of concentration which are supercritical and subcritical.

For a given volume, the curve of critical volume vs. concentration has the following general shape when considering the effect of Pu-240.

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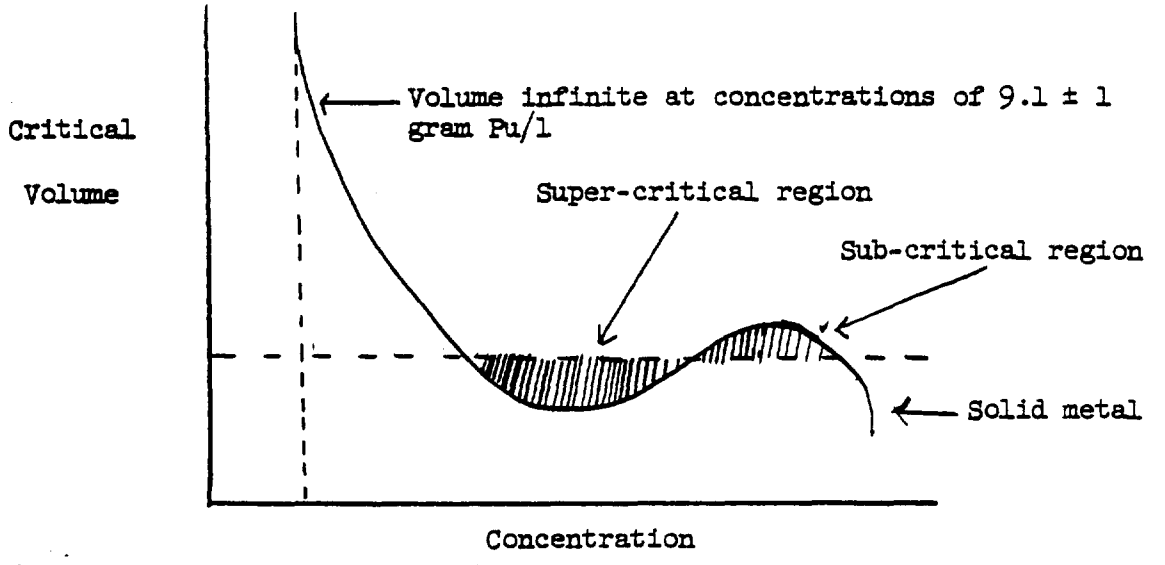
(1) Authorization No. EA-CML-61-3, Request for Authorization to Perform Subcritical Multiplication Measurements with the Control Rod Removed.




## Data Correlation - Development of Nuclear Codes for Criticality Calculations

### Status of Computer Codes

Two computer codes, the AIM-6 and TEMPEST, were placed into operation during the month of August. AIM-6 is a multi-group diffusion code that will replace the 9-Zoom code which is presently being used in the analysis of critical mass data. The AIM-6 code will carry out criticality search on the following options: 1) buckling search, 2) dimension search, 3) poison search, 4) poison boundary search, and 5) fuel loading search. Also, the code being written in Fortran is more easily modified for our special problems. The TEMPEST II code, a Fortran version of the SOFOCATE code, will be utilized to determine the thermal group cross sections for AIM-6 and later transport calculations. The TEMPEST II code will calculate a thermal neutron flux spectrum based upon one of the following approximations: 1) Wigner-Wilkins light moderator equation, 2) Wilkins heavy moderator equation, or 3) a Maxwellian distribution. The code will provide cross sections averaged over the tabulated flux spectrum.

### Monte Carlo Calculations of $k_\infty$ for Hydrogen Moderated Systems of Three Percent Enriched $UO_3$

As reported in the July report, a tracing of 1,000 neutron histories in a three percent enriched $UO_3$ system with a hydrogen-to-uranium ratio of 43.87 indicated that the resonance capture in U-238 exceeded the expected value by a factor of two. The difficulty appears to be due to inaccurate cross section data for U-238 stored on the HISMC data tape. This has been verified by a comparison of the resonance integral calculated from resonance parameters for U-238 and the integral determined from the cross section data on the HISMC tape. A revision of these cross sections is presently being carried out to

correct this difficulty in the cross section data.

Criticality Hazards Specifications

1. Nuclear Safety in HLO

A specification waiver was approved for the Plutonium Metallurgy Operation.(1) The waiver permits the batch limits for the Balance and Mold Outgassing hoods to be increased from 4.5 Kg of plutonium metal up to 7.0 Kg for a special series of tests.

2. Nuclear Safety - Training and Education

Talks on nuclear criticality were presented to the Non-Metallurgical Materials Development Group, HLO, and to the graduate students of the 1961 AEC Health Physics Fellowship Program.

Miscellaneous Experiments for Nuclear Safety Specifications

The analysis of the data from the measurements in the PCTR of the limiting concentration, i.e., the concentration for which $k_\infty$ = unity, of a $Pu(NO_3)_4$ solution has been completed. As was reported previously, difficulty was encountered in evaluating the effect of the stainless steel containers on the measured reactivities.

A plot of $\Delta\rho$ versus the stainless steel thickness of the containment tanks was used to correct the values of $\Delta\rho$ for the effect of the stainless steel even though the long extrapolation makes the results doubtful. A least squares fit was then made to the three points used in the plot of $\Delta\rho$ versus stainless steel thickness, and the result of the fit agreed very well with the extrapolated curve. The value of the limiting concentration (uncorrected for the effect of Pu-240 and nitrate) is 9.7 ± 1 gm/l.

In order to correct this value for the effect of the Pu-240, Pu-241, and nitrate present in the solutions used in the measurement, machine calculations were made using the 9-Zoom code to determine the limiting concentration for the experimental solution and for a hypothetical plutonium-239 water solution. The experimental value for the limiting concentration was reduced by an amount equal to the difference in the two calculated values to give an "experimental" value of 9.1 ± 1.0 gm/l for the limiting concentration of a plutonium-239 water solution.

Considerations are now being given to a measurement of the limiting concentration in the PCTR for a solid system using a mixture of plutonium oxide and plastic, since in this case it would not be necessary to use stainless steel containment tanks.

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(1) Letter from P. F. Gast to T. C. Nelson, Nuclear Safety Waiver - 231-Z Building, July 19, 1961.

Mass Spectrometry

The heavy element mass spectrometer for this program operated routinely throughout the month although about five operating days were lost due to real or scheduled interruptions of electrical and water service. Isotopic analyses were provided for ten plutonium samples for CPD.

A series of measurements was completed on the isotopic analyses of five uranium standards. The results of these measurements were statistically analyzed to determine accuracy and precision of analyses performed on this spectrometer. The systematic non-linearity of measurement of isotopic ratio was determined to be of the order of one percent for the extreme ratios of zero and infinity. A quantitative measure of variability of an individual measurement and absolute accuracy versus mass ratio was obtained.

A serious difficulty was encountered in attempts to perform isotopic analyses on plutonium samples. This difficulty took the form of an extremely erratic and unstable ion emission from the source. While the source of the instability was not determined a procedure of operation was developed which provided stable emission. Over a dozen analyses were performed without failure on 0.05 microgram loadings of plutonium samples using this procedure. Unfortunately this procedure requires a much longer time per analysis than a corresponding uranium sample so that the sample capacity of the spectrometer is reduced for plutonium samples.

Instrumentation

Consultation continued on the tracer lathe control systems for CPD. The application of our new transfer function analyzer has enabled us to measure accurately the dynamic characteristics of the amplifier and valve motor. It is now possible to measure phase shifts of two degrees where previously 30 to 60 degrees was the limit of accuracy. Additional measurements are being made to determine the characteristics of the remaining parts of the tracer control system.

Development and consultation for the Critical Mass Laboratory continued on a buckling measuring instrument, low frequency pulse generators for reactor pulse neutron tests, and a period calibrator for the reactor period meter. Maintenance engineering at the Critical Mass Lab concerned mostly the six channels of instrumentation used for reactor control.

A new control rod drive system also was proposed for the Critical Mass Laboratory experiments. The system will use a Thyratron-controlled motor as a drive, a magnetic clutch as a torque limiter and safety feature, and an existing selsyn system for the position indicator. The presently used rod drive system is inadequate.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Cross Sections

Measurements of the $Pu^{239}$ fission cross section in the energy region of 0.02 to 0.05 ev were continued. These measurements were made using a Ge(113) crystal reflection in order to study the accuracy with which order corrections could be made using standard filter techniques. The order corrected cross section

compared with the expected shape to within the statistical precision of the data of about 2.5 percent.

Slow Neutron Scattering Cross Sections

The series of measurements to determine the spectrometer resolution and efficiency functions has been completed. The data necessary for background corrections were obtained for neutron energies of 0.05, 0.10, 0.15, 0.20, and 0.25 ev.

Analysis of the measurements of the quasi-elastic scattering of neutrons of 0.147 ev energy from water is still in progress. The computer program GAUSS-FIT has been used to obtain best values of the magnitude and width of the assumed Gaussian quasi-elastic component of the scattering by the criterion of least squares. The study of the effects of uncertainties in the non-elastic background is incomplete.

Fast Neutron Cross Sections

The preliminary total cross section data obtained last month using the pulsed source-time of flight technique with the Van de Graaff were subjected to analysis. In the preliminary measurements it was not possible to obtain reasonable cross section data for neutron energies greater than about 10 mev. This effect resulted from the sharp peak in the $Li(d,n)Be^8$ neutron spectrum at about 14 mev. Instrumental instabilities caused a wide variation in results in the region of the peak in the spectrum. Measurements of the total cross section of aluminum from 3.5 to 10 mev were the only reliable data obtained. Some 55 points over this interval agreed within the accuracy of the data of about 10 percent with values reported in the literature.

The replacement of a faulty tube in the vernier chronotron during the month resulted in a great improvement in channel width stability. Measurements which were made showed a constant channel width within 0.4 percent statistics for 200 usable channels.

The time-of-flight system was used to analyze a number of tritium targets purchased by Radiological Physics. The increase in magnitude of the neutron groups associated with the buildup in time of deuterium and carbon on the targets was observed.

Instrumentation

The magnetic storage drum for the 1000-Channel Slow Neutron Time-of-Flight Analyzer arrived after numerous delays. Tests performed to date show that specifications are met or exceeded. All components for the analyzer have now arrived. Read and write amplifiers for the magnetic drum have been designed. A few will be fabricated for further testing of the circuits themselves and of the drum.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

The Critical Facility of the PRP

A letter has been written to PRTRO. This letter describes the experiments which are being planned for the Plutonium Recycle Program - Critical Facility by Nuclear Physics Research. The preparations which are being made for the experiments were also enumerated in the letter.

An order has been placed for a 5 curie (80 gram) Pu-Be neutron source for the PRP-CF. The source will be purchased at the standard price of $1125.00 and will have a neutron strength of approximately $8 \times 10^6$ n/sec. The order was placed with Nuclear Materials and Equipment Corporation, Apollo, Pennsylvania.

The possibility of procuring bismuth or lead-bismuth alloy tubes of various thicknesses for shrouding irradiated fuel elements that are to be tested in the PRP-CF has been further investigated. Information has been received indicating that it is not feasible to extrude pure bismuth. However, there is a possibility of extruding a lead-bismuth alloy providing the bismuth content is not too high. No problems are anticipated in extruding lead shroud tubes.

The design drawings of the safety and control rods for the PRP-CF have been reviewed. Fabrication is proceeding on the basis of these drawings.

PRTR Startup

The results of the startup experiments which were conducted during Series III have been analyzed. In addition, a summary which relates various Critical Test numbers, multiplication numbers, period numbers, and fuel loadings to each other has been prepared for the Series III experiments.

A summary which relates the shim configuration numbers, multiplication numbers, and the position of the shims to each other has been compiled for all the tests.

Normalization factors have been measured for the string of $BF_3$ tubes which were arranged vertically in the PRTR. These factors were used to correct the vertical flux data. The data have been plotted and functions $Y = A \cos B(x-c)$ which best fit the data were obtained for the cases for which there were no shims in the reactor.

This set of results and summaries is being duplicated and will be distributed in the near future. Another set had been distributed earlier. Except for possible corrections, this stage of the analyses is complete. The formal presentation of the results by the Physics Subcouncil remains to be done.

Low Exposure Plutonium Lattices

a. Foil Normalization Irradiations

An internormalization of the various detector foils used in the Pu-Al lattice experiments has been done on a rotator in a graphite core in the

PCTR. The purpose of this experiment was twofold.

First, it is necessary to have such a normalization in a known spectrum in order to obtain information about counter efficiencies and foil geometry factors. This information is needed for the work directed at obtaining the spectral variation of $1 + \alpha$ which occurs upon poisoning a Pu fueled lattice in the PCTR.

Secondly, a recheck was needed of the internormalization between a set of Pu-Al foils used earlier in the lattice experiments in order to clear up an apparent discrepancy in the foil activity data.

In addition, an internormalization was made between the various types of copper detectors used in the enriched uranium dioxide lattice experiment. These data are needed to correlate the flux traverses in the fuel, stainless steel cladding and end caps, and copper poison.

b. Spectral Variations of $(1 + \alpha)$ for Pu-239

Additional work has been done during the month on determining the change in $(1 + \alpha)^{239}$ which occurs upon poisoning a plutonium fueled lattice in the PCTR. Absorption and fission rates for Lu, Cu, Au, and Pu-239 have been obtained for Hurwitz flux and absorption spectra for the energy region in excess of 1 ev. In most cases these rates represent small corrections to the results obtained earlier for the energy region from 0.0 to 1 ev. Similar corrections for energies greater than 1 ev have been obtained for the spectrum-averaged values of $\alpha$, weighted with the Pu-239 fission cross section.

Pu-240 Effective Resonance Integral

Final specifications for the Pu-Al rods for the Pu-240 effective resonance integral experiment have been delivered to Plutonium Fuels Development Operation. These specifications are based on a very precise mass spectrographic analysis by Experimental Nuclear Physics Operation of the HX and LX plutonium which will be used in the Pu-Al rods.

Spectral Matching by Reactivity Measurements

Some experimental evidence has been obtained which indicates that it may be possible to match the neutron flux and/or the adjoint flux ratios at the center cell and an adjacent buffer cell of a sample lattice by means of reactivity measurements. If a lattice is poisoned to unit multiplication and if either the neutron flux or the adjoint flux ratio at some point in the central cell is identical to the same ratio at a corresponding point in an adjacent cell, then the mismatch error in the inferred value of $k_{ex} = k_\infty - 1$ for the lattice is zero.

The measurements were made in the PCTR using an oxide-fueled graphite lattice poisoned to within about 4 percent of unit multiplication. The center cell of the 3 by 3 array was a three-piece unit consisting of a central test section and two end buffers. In the ideal case, if the lattice is poisoned to unit multiplication, there should be no change in the reactivity of the PCTR when the central test section is replaced by a vacuum. In this experiment the multiplication was not exactly unity and, in addition, an air-filled cavity remained

when the test section was removed. Thus a reactivity change $\Delta\rho$(cell) was observed when the poisoned test section was substituted for the air-filled cavity.

This change in the reactivity of the PCTR was first observed with the three-piece test cell positioned at the center of the 3 by 3 array. A full length buffer cell (complete with graphite, fuel and poison) was next moved to the center position and the complete test cell was moved to the unoccupied buffer position. The reactivity coefficient of the poisoned test cell at the buffer position was then compared to its reactivity coefficient at the central position. This procedure was carried out for two cases, one with the flux ratio at the center position matched to that at the buffer position and the other with the flux ratio purposely mismatched at the two positions. The results are shown in Table I.

TABLE I

| | Matched Case | Mismatched Case |
|---|---|---|
| $\Delta\rho_{cell}$ with Test Cell at Center Position | (3.08 ± 0.05) ¢ | (3.39 ± 0.05) ¢ |
| $\Delta\rho_{cell}$ with Test Cell at Buffer Position | (3.02 ± 0.05) ¢ | (4.18 ± 0.05) ¢ |
| Gold Cd Ratio at Center Position | 1.954 ± 0.016 | 2.084 ± 0.017 |
| Gold Cd Ratio at Buffer Position | 1.967 ± 0.016 | 2.230 ± 0.018 |
| Change in $\Delta\rho_{cell}$ from Center to Buffer | (2 ± 2) % | (23 ± 2) % |
| Change in Cd Ratio from Center to Buffer | (0.7 ± 1) % | (7 ± 1) % |

A theoretical justification and additional experimental evidence must be obtained before it can be concluded that the equality, $(\Delta\rho_{cell})_{center} = (\Delta\rho_{cell})_{buffer}$, is necessary and sufficient proof that either the flux ratios or adjoint ratios are matched.

Neutron Spectrum Studies

The Program LULU has, as its input, values of parameters which characterize the lutetium isotopes. The parameters are coefficients of a polynomial which fits a curve of spectral index versus the non-1/v parameter g and which fits a curve of resonance integral ratios $\frac{RI_{et}}{RI_{ec}}$ versus spectral index. These coefficients have now been determined. Four different curves of resonance-integral ratios were used. Each curve corresponds to a different assumption about how the distribution of slowing-down neutrons is joined to the Maxwellian distribution. In addition, the coefficients have been used to generate a table of values of a

particular function which facilitates hand calculations of spectral indices.

Effect of Absorbing Rod on Neutron Energy Spectrum

The study of the neutron flux near an absorbing rod with a Breit-Wigner resonance continued. The analytical solution to this problem has been programmed in a code called ARMIE III. A sample case has been solved of a 1.5 cm radius Pu-Al absorbing rod, 1.8%, Pu-239 by weight, in a heavy gas moderator at a moderator temperature of 300°K. The .297 ev Pu-239 resonance depresses the flux spectrum in the vicinity of the absorbing rod by about 20% at the resonance energy, when compared to the spectrum of a 1/v absorber having the same low energy absorption.

Round-off errors limit the usefulness of the program to values of E/T less than 12 for a rod radius of 1.5 cm, with the maximum E/T increasing with increasing radius.

Code Development

C-6

The program which generates a 100-group cross section data tape from the RBU basic library has worked successfully on several debug runs. The code will soon be used to make a more complete data tape to be used with the C-6 slowing down spectrum code. As a result of this work to obtain cross sections for C-6 from the RBU data tape, a code now exists which will obtain either group averaged or point cross sections given a completely arbitrary array of energies.

GE-ANPD Nuclear Data Tapes

Copies of the GE-ANPD 19-level and C-Fine nuclear data tapes have been made available in the Hanford 7090 tape library. The 19-level data tape contains the microscopic cross sections $\sigma_s$, $\xi\sigma_s$, $\sigma_{tr}$, $\sigma_a$, and $\nu\sigma_f$, and the corresponding macroscopic cross sections for a variety of isotopes, elements, compounds, and alloys at 19 epithermal energies from $10^7$ to .0253 ev plus Maxwellian averaged thermal group cross sections at 68 F, 500 F, 1000 F, 1500 F, 2000 F, 2500 F, and 3000 F. The C-Fine data tapes contain the same five microscopic cross sections for certain isotopes and elements using several thousand epithermal energy levels to portray the resonance detail generated by the Breit-Wigner single level formulas. The contents of the 19-level tape are described in APEX-515, XDC 59-11-72, and XDC 60-6-148. There are three C-Fine tapes: CF1 has 2759 epithermal levels; CF2 has 3615 epithermal levels; CF3 has 4968 epithermal levels; each has thermal cross sections for the same seven temperatures as on the 19-level tape. The contents of the C-Fine tapes are shown in Table 1:

TABLE 1

Contents of C-Fine Tapes

| Material No. | Element or Isotope | CF1 | CF2 | CF3 |
|---|---|---|---|---|
| 1 | U-235 | X | X | X |
| 2 | H(Bound) | X | X | X |
| 3 | O | X | X | X |
| 4 | Be | X | X | X |
| 5 | U-238 | X | X | X |
| 6 | Fictitium ($\sigma_s$=1, $\sigma_a$=o, A = ∞) | X | X | X |
| 7 | Accumulation ($\sigma_s$=o, $\sigma_a$(.0253 ev)=1,1/v) | X | X | X |
| 8 | C | X | X | X |
| 9 | Al | X | X | X |
| 10 | U-234 | X | X | X |
| 11 | U-236 | X | X | X |
| 12 | Fe | X | X | X |
| 13 | Ni | X | X | X |
| 14 | Cr | X | X | X |
| 15 | Zr | X | X | X |
| 16 | Nb | X | X | X |
| 17 | Y | | X | X |
| 19 | Mn | | X | X |
| 20 | Co | | X | X |
| 21 | Ti | | X | X |
| 23 | Mo | | X | X |
| 42 | Li-6 | | | X |
| 43 | Li | | | X |
| 44 | B-10 | | | X |
| 45 | B | | | X |
| 46 | Xe-135 | | | X |
| 47 | W | | | X |
| 48 | Th-232 | | | X |
| 52 | Sm-149 | | | X |
| 54 | Sm | | | X |
| 55 | Eu | | | X |
| 56 | Gd | | | X |
| 57 | Pu-239 | | | X |

The tape identifications in the 7090 library are shown in Table 2:

[redacted]

[redacted]

1230188

TABLE 2

ANP Tape Identifications

| Reel No. | Loc. | Name |
|---|---|---|
| 3671 | 981 | 19-level Hi-density |
| 2028 | 982 | 19-level Lo-density |
| 3091 | 983 | CF1A Hi-density (Master CF1) |
| 1642 | 984 | CF1B Hi-density (working copy CF1) |
| 2294 | 985 | CF2A Hi-density (Master CF2) |
| 3845 | 986 | CF2B Hi-density (working copy CF2) |
| 3995 | 987 | CF3A Hi-density (Master CF3) |
| 3933 | 988 | CF3B Hi-density (working copy CF3) |

The 19-level nuclear data tape is required for running ANP program $G_2$, a one-dimensional, multi-energy slowing-down diffusion calculation (see below). The C-Fine tapes are used with ANP program C-Fine, a slowing-down calculation with fundamental mode buckling to account for leakage, and ANP program RAPT, which computes group averaged albedos for rod, annulus, or slab geometry.

A comparison of data on the ANP tapes with data processed from the RBU basic library will be necessary to determine where inconsistencies exist. For compatibility, agreement of the epicadmium absorption and fission integrals for infinite dilution should be a minimum requirement.

Program $G_2$

This program, a one-space-dimension, multi-energy, slowing-down diffusion calculation, was obtained from GE-ANP and has been checked out on the Hanford 7090. It solves the coupled slowing-down diffusion equations.

$$\frac{-D(u)}{r^{\lambda}}\frac{\partial}{\partial r}\left[r^{\lambda}\partial\frac{\phi(u,r)}{\partial r}\right] + \left[\Sigma_a(u) + D(u)K_1^2(u)\right]\phi(u,r) = \frac{S(u)}{k}\int \nu\Sigma_f(u)\,\phi(u,r)du - \frac{\partial q(u,r)}{\partial u}$$

and

$$\frac{\partial q(u,r)}{\partial u} + \frac{q(u,r)}{\gamma(u)} = \frac{\xi\Sigma_s(u)}{\gamma(u)}\phi(u,r)$$

in slab ($\lambda=0$), cylindrical ($\lambda=1$), and spherical ($\lambda=2$) geometry. Cross sections are piece-wise continuous, but up to 50 material regions may be described. The spatial solution, using standard difference techniques, will accommodate up to 500 lattice points. Continuity of flux and current is assumed at material interfaces and energy-dependent albedos are provided at the inner and outer boundaries. Two slowing-down models are available: Selengut modified age $\left[\gamma(u) = 1\right]$, and Coveyou-Macauley (or Wigner) $\left[\gamma(u) = \xi(u)\right]$. Cross sections in 19-energy detail are read from the ANP 19-level tape (see above) and combined with the appropriate atomic densities or volume fractions to form the regional macroscopic cross

sections. The program output consists of the fission eigenvalue, k; the spatial distribution of fission density normalized to a volume average of unity; the flux and slowing-down density at each level as a function of radius; two-group activation integrals as a function of radius; and few group constants for each region. Typical running time will be around five minutes. The program requires tape units A-4, A-6, and B-5 for scratch tapes and reel 3671, location 981, (19-level nuclear data tape) on A-5.

RBU

The first three test cases for the Monte Carlo have produced excellent neutron flux spectra in the thermal region, using an improved flux definition. A particle loss associated with floating number truncation has been corrected by a half-word rounding routine.

An infinite homogeneous medium of $H_2O$, U-235 has been simulated as a separate test case for the combined Monte Carlo, diffusion and burnup codes. No results for this case have yet been obtained.

Discussions concerning the use of measured differential cross section data in the Monte Carlo were held with personnel of Phillips Petroleum Co., Atomic Energy Division. Assistance was given them in setting up an MTR test problem for RBU.

MXW

The MXW code has now been completely debugged and modified for increased speed of operation and reduced input preparation requirements. The output of the code is cross section data in the form required for MELEAGER input.

MELEAGER

Minor changes were made in the reactivity initializer subroutine to facilitate its use in the "CHAINED MELEAGER" code. The chain consists of MELEAGER, Quick, and Pure, linked together in such a manner that the physics results from MELEAGER are the input for the economics codes.

Instrumentation and Systems Studies

A 200-channel gamma analyzer was moved to PRTR to facilitate studies and corrective measures concerning the PRTR Fuel Failure Monitor. The analyzer is now being checked to determine if there was damage incurred by the movement to PRTR. Suggested modifications for the Fuel Failure Monitor are progressing well. Probe terminations have been changed, cooling fans were installed, and the input scan switch is being changed. It is estimated that performance tests on the system can begin in a month.

A prototype general purpose scaler for the PRCF was fabricated and tested. The design was developed to fill the need for a simple, dependable, but fast scaler for routine counting tasks. The present prototype features nixie readout, printer readout, one microsecond pulse pair resolving time, and all solid state or cold cathode tube circuitry. Whenever possible, commercially available modules are used. The expected cost is less than $1,000. Long term reliability tests

will be started soon.

Occasional assistance is being given in the adjustment and testing of the periscopes in the PRTR fuel examination cell. Information regarding the changing of the design drawing to As Builts is being organized.

A circuit malfunction in one of the sensing units of the PRTR gas annulus measuring equipment necessitated replacing both eddy current sensing coils in the defective unit. After the coils were replaced, the calibration was checked and the instrument found to be functioning properly. Design of a new probe assembly which can accommodate a 0.9-inch-diameter borescope is in progress. Several possible designs are under consideration but further mockup testing is required to select the design most capable of providing the required mechanical stability.

Fabrication of the ultrasonic probe assembly to be used in measuring the wall thickness of the PRTR process tubes is approximately 95% complete. Fabrication progress was hindered considerably this month when the transducer holders were sent to Technical Shops to be silver soldered into the probe body, and were welded instead. The extreme warpage which resulted required that all four holders be almost completely re-machined to restore the required dimensional tolerances.

A preliminary study of the dynamic characteristics of the PRTR deaerator has indicated that the original design specified components which would not provide a stable system. The system is being simulated on an analog computer for further study. The full problem has been programmed and patched. A one-hour checkout on the computer was obtained late in the month and two problem areas in the simulation detected. A simple model has been derived for use in obtaining approximate controller settings. The simple model shows the time constant of the valve controlling steam to the deaerator to be important. This time constant is most likely too long at present. As yet no information on valve constants has been provided by PRTR engineers.

The PRTR Gas Balance System Stability study has not yet been completed. Work on the gasometer damping was continued. It appears that both static and sliding friction should be used to obtain fully satisfactory results. A circuit which will simulate both these types of friction has been designed. An attempt will be made to incorporate this circuit into the full simulation as soon as computer time is available.

Two analog runs were made on the EASE computer of PRTR critical facility power excursions for the purpose of hazards analysis. The analog circuit used was the same as was used for previous studies. The circuit includes analog memory and automatic computer mode switching, enabling the simulated reactor to undergo power excursions of eleven decades without the necessity of reading out the values of the delayed neutron groups and the fuel temperatures at the end of each two decades. It is estimated that the use of this technique resulted in a total computer operating time about one-fourth of that necessary in the use of the conventional method.

## PHOENIX FUEL

An investigation into the use of "Phoenix Fuel" for water-moderated compact power reactors has been started. It has been reported that reactors employing Phoenix Fuel can be designed to have relatively fast reactivity curves over a substantial portion of the reactor operating life time. Such favorable reactivity behavior can, however, also be achieved by the use of self-shielded burnable poisons in fully enriched, U-235 systems.

While there are some obvious disadvantages to the use of Pu fuel elements, three possible advantages of Phoenix Fuel as compared to self-shielded burnable poisons might be realizable.

1. Since self-shielded burnable poison specimens occupy substantial volume, a core using Phoenix Fuel should have more "fuel meat" volume available. In small, alloy cores, which are fuel limited, this might be an important advantage. A corollary effort is also the availability of more heat transfer surface in the core employing Phoenix Fuel.

2. The temperature defect in small, water-moderated cores employing self-shielded poisons is very large requiring the availability of extensive control rod blading to compensate for this reactivity defect. A core containing Phoenix Fuel could have a substantially smaller temperature defect and should, therefore, show an over-all reduction in control requirements.

3. The Xe-135 defect in a core employing plutonium should be somewhat less than in the fully enriched core, implying a further reduction in control requirements.

A comparison of the two cores based solely on control requirements is, however, not sufficient. In addition, the control rod worth in the two cores must be ascertained. This problem is presently under investigation.

## NEUTRON FLUX MONITORS

With assistance from Operations Research, a computer program was designed specifically for determining optimal Pu nuclide detector composition. Required inputs to the computer code consist of effective cross sections for capture and fission of each nuclide and estimates of the relative amounts of each nuclide required. The output of the program code consists of a printout which displays a set of compositions which are the best possible for a stated time interval and a given latitude of sensitivity variation of the detectors to neutrons.

The code was satisfactorily tested against one case of optimized detector composition which was determined in a manner independent of the present code. Subsequent use of the code will consist of verifying or improving composition for actual tests. The code can also be used as a means of determining detector composition for a particular in-core location for any reactor for which the in-core detector is applicable.

Additional equipment has been received and personnel assignment changes have been made so that active investigation of several possible new microwave techniques for in-core flux monitoring may begin next month.

## NONDESTRUCTIVE TESTING RESEARCH

### Electromagnetic Testing

Detailed procedures have been outlined for designing and calibrating an instrument for detecting small individual parameter excursions in the multiple parameter eddy current test method being developed. These procedures are based on the experimental determination of the loci of the response vectors in some orthogonal signal space as the parameters are varied, one at a time. Plots of the projections of these loci on the coordinate planes are used to compute a transformation to oblique coordinates aligning themselves with the tangents to these loci; then the instrument is experimentally calibrated to read out a parameter variation along each coordinate. Though this method is suited to any orthogonal basis, the first experimental work is being done using the four dimensional space provided by the sine and cosine components of two separate probing frequencies combined in one probing signal.

The assembly of test equipment for checking these procedures using a simulated test specimen is essentially complete. The equipment includes (1) synchronized 100 KC and 10 KC generators, (2) a power amplifier for test coil excitation, (3) the simulated test coils and test specimen, (4) an amplifier, (5) band-pass filters for the 10 KC and 100 KC signal components, (6) a 100 KC 360 degree phase shifting device, (7) commercial amplitude-phase detectors, and (8) summing circuitry to provide the required transformation of signal coordinates.

The test coils and test specimen are being simulated using a multiple loop type model comprising an exciting coil, a sensing coil, and four coils having series plug-in resistances. The six coils are of equal diameter and are mounted coaxially in fixed positions. A second set of coils closely matching the first set is used in conjunction with the first set to give a near null signal output for chosen nominal values of coil loading resistances.

Measurements are now being made, varying one parameter (series coil resistance) at a time, from which the transformation to the new coordinate system can be computed. The summing circuitry for instrumenting this transformation is complete except for four isolating amplifiers, which are now being wired.

Following the evaluation of these procedures using the simulated test specimen, tests will be made using laminated metal specimens.

### Heat Transfer Testing

A possibly new type of instrument for quantitatively mapping the value of a variable on a two-dimensional surface has been developed. The first application will be in producing area maps of fuel element surface temperature during heat transfer testing. However, it should also be possible to apply the instrument in eddy current and ultrasonic studies. Values of the variable being mapped are displayed as lengths of line segments plotted in positions on the

map which correspond to positions on the fuel element surface. Centers of the lines are equally spaced, regardless of length. Hence, the map appears dark in regions where the temperature is high, since the line segments are longer, and light in low temperature regions. An immediate qualitative picture as well as a quantitative readout is thus obtained. The first prototype has been tested using simulated heat transfer test signals. Performance was satisfactory, and the first model for heat transfer testing applications is being fabricated.

Research aimed at development of a new type of emissivity independent radiometer suitable for recording rapid changes in surfaces has continued. The basic instrument principles are described in HW-68574. Evaluation of various auxiliary sources for use with this instrument is under way.

Zirconium Hydride Detection

The resistivities of Zircaloy-2 samples containing hydrogen concentrations to 15,000 ppm (by weight) have been measured to experimentally determine the rela-

clamping and rotating flat and curved Zircaloy plates. Fabrication will start soon on a test tank and associated drive mechanisms similar to those used by Canadian GE for production testing of tubing. This appears to be the most favorable mechanical system for our first prototype.

A Curtiss-Wright Immerscope will be used initially for the electronic portion of the prototype. The electronic and ultrasonic limitations of this instrument are being evaluated. A preliminary check determined that the instrument meets factory specifications.

Several series of reference "defects" in tubing are being fabricated by the Structural Materials Operation for use in the experimental studies.

## PHYSICAL RESEARCH - 05 PROGRAM

### Mechanism of Graphite Damage

Measurements of electron radiation damage to graphite continued. Preparations were made for making annealing studies of resistivity changes in graphite up to a few hundred degrees centigrade.

## BIOLOGY AND MEDICINE - 06 PROGRAM

### Atmospheric Physics

In Air Force supported programs, the first series of diffusion experiments at Vandenberg Air Force Base, California, was completed on August 4. A total of fifty-two field trials were conducted using the Hanford Fluorescent Tracer Technique, of which forty-two were subjectively assessed as successful, five were marginal, and five were poor. Meteorological conditions embraced by these experiments ranged from strong atmospheric stability to strong atmospheric instability with a range of wind speeds, and several instances of fog.

New information was obtained on diffusion and transport over rough coastal terrain. Preliminary analyses of the data showed that the tracer material passed over the ridges during unstable conditions but followed the valley contours during stable conditions. Measurements in constrictions in valleys showed that the air flow accelerated in the area of convergence with the tracer plume becoming narrower in these regions.

All of the exposed filters were received at Hanford and were processed on the Hanford developed assaying equipment to determine the mass of zinc sulfide material collected on each filter. Data collected during the earlier test series at Cape Canaveral, Florida, were forwarded to the Air Force for further analysis. Meteorological data collected in support of these experiments have not yet been received from the Air Force.

A research team from the University of Michigan arrived at Hanford during the second week of August to operate their raindrop spectrometer in conjunction with our experiments with precipitation scavenging of airborne particulate material from the atmosphere. The raindrop spectrometer was installed and Hanford personnel trained to maintain and operate it for use during the fall rains. An artificial rain source located atop a ninety-foot pole was

used for checking equipment and procedures and for conducting experiments to determine the scavenging efficiency of individual raindrops on zinc sulfide particles. Only one successful experiment was completed in one week of trials. Data from this experiment were being reduced at month end.

Two stable diffusion experiments were conducted during the month, both of which were successful. Additional samplers providing time resolution of particle collection placed on towers 3200 meters' distance from the source showed pronounced differences in tracer arrival and departure times at different elevations during the experiments. Also, changes in height of the tracer plume due to transient changes in atmospheric stability were evident.

DOSIMETRY

Our previous studies of detection of the bremsstrahlung from P-32 in vivo indicated that maximum counting rates were obtained over the subject's chest. Later studies showed that background counting rates in this position had wide variations between individuals. Studies were begun in which the bremsstrahlung counter was placed over the subject's head. Initial results indicate that variations in the background counting rates are very much smaller. It may be that these smaller variations will compensate for the reduced sensitivity in this position to make it the desirable counting location.

Five different arrangements of scintillation counters were studied for use in measurement of I-131 in humans. The best arrangement appears to be a pair of 2" x 2" or 3" x 3" NaI crystals placed close to the thyroid gland. It is estimated that activities as low as 30 pc could be detected reliably in this way.

While trying to make an array of 1/3" x 2-1/2" NaI crystals for low energy gamma ray detection it was found that the crystals could not be matched because of different absorption in the crystal containers. Attempts are being made to obtain matched crystals. The background pulse spectrum from these counters shows very clearly the effects of lead X-rays produced in the lining of the whole body counter cell.

The counter that has been in use for the detection of plutonium in wounds for the past three years failed. It was found that the crystal had turned yellow. A new crystal was found. It had a better reflector than the old one which resulted in better resolution of the plutonium X-rays and also permitted better measurement of the 6 kev plutonium X-rays. Measurement of the latter has already been shown to be useful in determining the depth of the plutonium in the wound.

Training of a member of the Colorado State Public Health Department in whole body counting studies was completed.

The manager, Radiological Physics, attended a meeting of the ICRU ad hoc committee on quantities and units held at Copenhagen, Denmark. The committee completed a report for submission to the ICRU. He also visited whole body counting laboratories at Lund and Stockholm, Sweden and Leeds and Harwell, England. The Swedes are much interested in high levels of Cs-137 found in Laplanders and attributed to high activities in reindeer meat. His body burden of Cs-137 was observed to have increased by 2 nc during the trip. This

was attributed to a meal of reindeer meat that he ate.

The positive ion accelerator operated satisfactorily during the month. A controller based on an incremental potentiometer was installed that automatically controls either a source holder or an instrument positioner.

The neutron time-of-flight system was used to study the contamination of tritium-titanium targets. When bombarded with deuterons these targets showed neutrons from reactions with the tritium but also some from reactions with deuterium in surface layers on the titanium or inside the platinum backing of the target and from carbon deposits on the surface of the targets. In some cases the contamination produced about half the total number of neutrons released. There were wide differences between different targets and between different points on the same target.

Tests made with internal Pu-Be sources on the new precision long counter that was just delivered show this counter to agree with the original one to within 0.2 percent.

Development was completed of an IBM method of analyzing inverse square experiments. All of the existing data for the precision long counter were recalculated by this method. The elimination of personal bias resulted in slightly higher estimates of uncertainty in some of the results. The rate of growth of the neutron emission rate from the standard Pu-Be source used internally in the precision long counter was changed from 2.6 ± 0.2 percent to 2.1 ± 0.5 percent per year.

Attempts are being made to persuade NUMEC, the present supplier of Pu-Be neutron sources, to set aside 1500 grams of high purity Pu-239 for making standard neutron sources. It is hoped that isotopic and calorimetric analyses can be made of this material periodically for a number of years.

Together with External Dosimetry Operation, a study was made of the angular response of neutron film badges.

Precision long counter and double moderator measurements were made on five plutonium sources supplied by CPD.

The activation of the Sb-124 source was completed and the source was placed in the gamma ray calorimeter. The half life measurements will extend over a considerable time. A plutonium source was fabricated to permit calorimetric measurements for comparison with mass spectrometer isotopic measurements.

RADIATION INSTRUMENTS

Except for commercial chart recorder troubles, the complete experimental prototype alpha coincident-count air monitor operated satisfactorily for the month. Tests, again, indicate that the system will alarm properly for alpha air concentrations of $2 \times 10^{-10}$ μc/cc of $Pu^{239}$ within six to eight minutes even under high Radon-Thoron conditions. The system will be ready for field tests after the recorders are satisfactorily repaired.

One experimental prototype pocket-size ionization chamber register indicating dosimeter was completed and tested throughout the month. This unit uses a modified "pencil" dosimeter, transistorized pulse circuitry, a miniature register, and a capacitor chamber voltage supply. As the pencil discharges, the quartz fiber touches an incorporated quartz rod which automatically recharges the pencil and produces a pulse. The pulse is amplified to drive the register. Tests indicate that each register unit equates to about 10 mr accumulated gamma dose. By use of other types of modified pencil dosimeters, such as beta or neutron sensitive, neutron and beta dose information can also be obtained. Only a different pencil dosimeter is needed for such use, as the basic circuitry is adequate for any such applications. Three more prototype units are to be fabricated, including one for fast neutron use.

Development work was completed on the alternate type of pocket dosimeter which uses a modified pencil dosimeter wherein the quartz fiber is illuminated by a tiny light. As the fiber moves during discharge, it passes a machined slit in a metal cover. This effect causes a pulse in a detecting CdS cell, and the pulse, through transistorized circuitry, then activates a resonant air column annunciator. Proper charging of the pencil dosimeter, with a standard HAPO pencil charger, can then be used to selectively produce an alarm for any desired accumulated dose level from 10 mr to 200 mr for the standard pencil unit. A second CdS cell is used in the unit to balance out temperature effects of the one detecting CdS cell. Laboratory tests, to date, have been satisfactory.

Continued development was made on a new type of transistorized pulse height analyzer circuit. Temperature compensation circuitry was developed to permit use of the unit from 0°F to +140°F. Such a range will permit application to field use instruments as well as laboratory types. Other circuitry work included that of stabilization of a number of low power scaling circuits for portable field instrument use. These circuits, with others, are being used in an experimental field instrument for use by Biology personnel.

Discussions were held with interested Biology Operation personnel concerning an instrument development system to completely automate the Biology Operation Counting Room. A proposal was made to include most of the detection and analyzing counting systems now used.

An experimental prototype background suppression beta-gamma combined hand and shoe counter, clothing monitor, and background monitor was completed, tested, and installed at 105-D for demonstration and field tests. Tests to date have been satisfactory, with the unit able to detect and alarm on standard Ra (D-E-F) sources even under high background conditions that "swamp out", or render completely ineffective, the standard "FIVE-FOLD" HAPO hand and shoe counters. The new prototype unit uses all scintillation detectors and is completely transistorized. In tests to date, the new unit has, conservatively, proved to be a factor of five better for hand and shoe monitoring than is the standard HAPO "FIVE-FOLD".

A noise suppression circuit for use with low-level, low-energy photon and X-ray detection systems was partly completed in development. Tests were started with breadboard circuitry. The circuit uses a gate to detect positive polarity noise signals and renders the regular ampliflier ineffective for this signal. It has been noted that noise has, typically, both positive and negative polarity characteristics; whereas the desired signal is only

[redacted] [redacted]

negative. Thus, proper gating should tend to reduce the noise level and improve the signal-to-noise ratio.

Using a new fabrication procedure, eight experimental silicon surface barrier diode detectors were fabricated and tested. For the smaller units of about one $cm^2$ area, resolutions (full width at half maximum) of about one percent were obtained for 5.48 Mev alpha particles. Resolutions of two percent were obtained for three $cm^2$ area diodes.

Definite improvements were made in the transistorized circuitry for the scintillation combined alpha, beta, gamma experimental hand and shoe counter. Transistorized scaler units were substituted for the registers previously used for the alpha channels, since the long dead time of registers effectively reduced the alpha detection ability. Using the scaler units, for a 500 d/m $Pu^{239}$ source distributed over a 4-x-8-inch area, the indicated signal-to-background ratio was 8:1 for a 15-second counting period. Thus, 100 d/m of $Pu^{239}$ can easily be detected and indicated above normal background levels. This is an improvement factor of 3:1 over the previous system. For the beta-gamma channels, a standard 22,000 d/m Ra (D-E-F) source distributed over a 4-x-8-inch area consistently produces a signal-to-background ratio of 3:1 or better. After further tests, the instrument will be taken to Purex for demonstration and field tests.

Tests were made, in cooperation with Atmospheric Physics, concerning a new field type of zinc sulfide particle detection system for use in air particle transport studies. A combination heating and ultraviolet light activation system was employed to enhance zinc sulfide particle light emission detected with a phototube. General field tests using only the ultraviolet light for activation indicated correct operation; however, the efficiency of detection was less than one percent. A new unit is being designed to incorporate the originally proposed idea of using a combination heater and ultraviolet light.

The Automatic Film Densitometer System modified and developed for Radiation Protection Operation was completed, tested, and delivered. All system portions developed by Nucleonic Instrumentation have performed correctly.

Extensive modification effort was started concerning the HLO Radiotelemetry System consisting of 19 data stations, a repeater station, and the central station located at the Atmospheric Physics building. Principal modifications have consisted of chopper input changes, power supply modifications, 400 cps generator changes, and some temperature stabilization. One modified data station is ready for field test. In addition, the wind charger units are being considerably modified for better performance.

Advice and assistance was rendered to Atmospheric Physics concerning the spectrometer instrumentation used for determination of raindrop sizes.

The Ampex tape transport mechanism purchased by Atmospheric Physics Operation was shipped with the wrong type of record-playback head assembly. A replacement assembly was received and installed. The tape transport mechanism was then tested, using electronic components from the analog computer tape delay units. Satisfactory operation was obtained.

Atmospheric Physics Operation requested assistance in determining the feasibility and cost of transmitting meteorological data from the present location

to a proposed new site. Transmission of the data was found to be feasible and a rough cost estimate was submitted.

## WASHINGTON DESIGNATED PROGRAM

### Isotopic Analysis

The mass spectrometer for this program provided isotopic analyses for program samples and calibration standards according to goal schedules. Approximately five operating days were lost due to real or scheduled interruptions in water and electrical service.

Isotopic analyses were provided for four plutonium and uranium samples for FPD and Plutonium Metallurgy.

## TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month and there were no unscheduled shutdowns. Most experiments were on a two-shift basis.

The investigation of the PCTR $k_\infty$ measurement technique was nearly completed during the month. This experiment is being done by a consultant on the staff of the Massachusetts Institute of Technology. It is the first time work in the PCTR has been done on this basis.

The coarse face position indicator equipment was designed and ordered, and should be ready for installation during September.

Two foil irradiations for calibration of $LuO_2$ foils were made in the TTR during the month.

## CUSTOMER WORK

### Weather Forecasting and Meteorological Service

Consultation service was rendered on meteorological and climatological aspects of 1) NPR containment, 2) NPR emergency systems, 3) large electrical transformer operation in desert regions, and 4) exterior pipe and vessel painting schedules for fall months. Precipitation summaries were prepared for Radioecology studies.

| Type of Forecast | Number Made | % Reliability |
|---|---|---|
| 8-Hour Production | 93 | 87.0 |
| 24-Hour General | 62 | 86.9 |
| Special | 194 | 89.7 |

A temperature average of 80.2 established the past month as the hottest August of record. This replaced a previous mark of 79.4 set in 1958. A maximum of 113 on the 4th was three degrees higher than any previously observed August temperature and was only two degrees under the all-time record high of 115 observed in July, 1939. 100-F Area, which more nearly approximates the site of the 1939 observations, registered a high of 120 on August 4 this year.

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Lightning strikes on the 14th and 15th started numerous grass fires. As many as thirteen separate fires were counted during one observation on the evening of the 14th. Altogether, there were more than sixty fires which burned an estimated 30,000 acres of the Hanford reservation during a three-day period.

Instrumentation and Systems Studies

Considerable effort was expended concerning the Columbia River Monitor for RPO, HLO. Two probes were water-jacketed to improve phototube stability at the very low radiation levels being monitored (0-50 micro-roentgens/hour). Noticeable improvement was apparent with the water jacket. New wiring, signal cables, and input signal networks were installed. A new DC amplifier was installed on loan to replace one defective amplifier in the system. The only real problem remaining is that of the apparently unreliable 110 VAC power situation at the monitoring house.

The experimental Field Instrument being designed for Biology Operation was completed in fabrication and is now being tested and slightly modified for field use.

Fabrication was continued on the electronic circuitry and detector portion of the Automatic Laundry Monitor being designed for the Laundry Operation.

Fabrication continues in the 328 Electronics Shop on two prototype transistorized miniature GM survey meters with both count-rate meters and resonant air column "speakers" for RPO, HLO. Fabrication also continued on two miniature "palm-size" gross alpha transistorized monitors using silicon diode surface barrier detectors for Finished Products Chemical Technology, CPD.

Modification effort continued on the FPD uranium surface contamination monitor for NPR fuel elements. Efforts are being made to reduce the background to provide better sensitivity.

Calibration of micro-displacement systems to be used by Physical Metallurgy Operation for in-reactor creep measurements has continued during August. Analysis of calibration data obtained during evaluation of a Schaevitz DRS-100 system has been completed and the results incorporated into the evaluation report, Physical Measurements Memorandum 61-18. A summary of results follows:

| Function | Linearity* | Reproducibility* |
|---|---|---|
| 0.3 inch range | | |
| Indicator | ± 0.76% | ± 0.66% |
| Recorder | ± 0.80% | ± 0.40% |
| 0.04 inch range | | |
| Indicator | ± 1.12% | ± 0.74% |
| Recorder | ± 0.70% | ± 0.70% |
| 0.004 inch range | | |
| [redacted] Indicator | ± 1.58% | ± 1.58% |

* Above figures are based on calculations using a 95% confidence interval.

The over-all system performance, in addition to the requirement of transducer accessibility for periodic alignment purposes, indicates it would be inadvisable to incorporate the Schaevitz Engineering DRS-100 readout system into the present "sealed-capsule" in-reactor creep measuring program. The reference system has now been converted for use in calibrating a new Physical Science Corporation 0.030-inch-range transducer, but actual calibration has been delayed pending delivery of the readout system, a Physical Sciences Electromicrometer.

## Optics

A total of 520 man-hours of shop work was performed during the five-week period (July 30 to September 3) included in this report. The work included:

1. Fabrication of components for the corner radius microscope to be used by Finished Products Operation.
2. Repair of four camera shutters.
3. Fabrication of a wall thickness probe for PRTR measurements.
4. Cleaning and polishing of one lead glass window.
5. Repair of one borescope for IPD.
6. Repair of one crane periscope head for Redox.
7. Evaporation of gold on silicon diodes for Nucleonic Instrumentation, HLO.
8. Assembly of one traverse mechanism.
9. Repair of one micrometer thickness gage.
10. Coating of ten lamps with stainless steel for White Bluffs Tube Shop.
11. Fabrication of a set of three dydimium glass standards.
12. Fabrication of a set of objective lenses for the Lenox borescope.
13. Servicing of two Karea underwater viewers.
14. Fabrication of prisms for the corner radius measuring microscope, the groove depth microscope, and a transit.

## Physical Testing

Testing work continued at a high level this month with major emphasis on NPR pressure tubes, PRTR pressure tubes, and fuel element sheath tubing. A total of 9,040 tests were made on 6,077 items totaling 92,227 feet in length. Test work included: autoclaving; borescoping; dimensional measurements (micrometric); eddy current; magnetic particle; penetrant (fluorescent O.D. and I.D.); radiography (gamma-ray and X-ray); stress analysis; surface treatment (alkaline cleaning, pickling for autoclaving and conditioning, steam detergent cleaning, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements). Work was done for 32 organizational components representing most of the operating departments and service organizations at HAPO. Advice was given on 41 different occasions on general testing theory and applications.

Only 85 NPR pressure tubes remain to be received on the order of 1,054. Almost all of the testing work at present is concerned with conditioning work being done on tubes that have been in a hold status. The vacuum-blast equipment has been installed and preliminary runs made on a number of tubes. Satisfactory operation on the O.D. surfaces has been demonstrated. Two days' work time was lost as a result of a work stoppage involving pipefitters.

Testing work on the PRTR spare pressure tubes is going foward. A preliminary light pickle has been given all of the tubes to facilitate the penetrant examination. Fluorescent penetrant testing of the outside and inside diameter surfaces of all the tubes has been completed. Conditioning work on those tubes showing penetrant indications has been partially completed. Nine tubes are now ready for autoclaving. Arrangements have been made with Kaiser Engineers to have their operating people assist in the pickling and autoclaving of the PRTR pressure tubes on a work order basis and scheduled in with NPR pressure tubes.

Field radiography was conducted at PRTR, NPR, 1706-KER, and 105-KE. Ultrasonic thickness measurements were made on a large number of vessels as part of a pressure vessel survey at the 100-F Area. Strain gage applications were made on 105-KE rear face crossheaders as part of a program to determine the effect of newly installed expansion joints. Strain gages have been fabricated for the 105-C overbore tube project.

Fuel element sheath tube testing is now receiving major emphasis with the arrival on plant of sizeable amounts of tubing. Testing rates of 200 tubes per week will be established as has been accomplished in the past to provide feedback to the supplier.

The micro displacement readout system is now in place in the 306 Building and is in operation.

Several jobs using the newly acquired 100-curie cobalt-60 gamma-ray source were completed: A 3-$\frac{1}{4}$-inch-diameter Zircaloy casting was radiographically examined, a 6-inch-diameter heavy-wall stainless steel pipe weld was radiographed, and enriched pellets imbedded in $UO_2$ samples were radiographically located.

In an effort to anticipate reactor rear face problems, the prototype ultrasonic contact probe for testing Parker fittings was taken to the White Bluffs rear face mockup for a functional test. Due to lack of space around the fittings, the probe could not be rotated for a complete test of the fittings. At best, only 1/3 of the fittings could have been tested. The probe has been completely redesigned and two specially-mounted crystals were obtained from Automation Industries, Inc. The new probe assembly is complete but has not been tested.

## ANALOG COMPUTER FACILITY OPERATION

### Studies

The major analog computer problems considered during August include:

1. NPR Plant Simulator
2. NPR Secondary Loop
3. Reactor Speed of Control
4. Reactor Instrumentation
5. PRTR Deaerator
6. PRTR Critical Facility

Equipment Operation

Computer operations were as follows:

| GEDA | EASE | |
|---|---|---|
| 154 | 147 | Hours Up |
| 22 | 21 | Hours Scheduled Downtime |
| 8 | 16 | Hours Unscheduled Downtime |
| 0 | 0 | Idle Time |
| 184 | 184 | Total Hours |

Percentage of computer operation during the month: EASE 90; GEDA 80.

Maintenance

Since one technician has been able to devote nearly all of his time to the maintenance of the computers, the EASE is now nearly 100 percent operational. The GEDA still has a number of things to be worked on, but its general overall condition has improved.

In calibrating the operational relays on the EASE, it was found best to build up an oscillator circuit on the EASE computer and use its output to calibrate the relays for an optimum square wave output.

The oven conversion on the GEDA has been completed and all checks necessary to determine the general condition of the computer have been run.

A large number of contacts were replaced on the patchbay and several resistor cards were found needing adjustment.

A great deal of trouble had been experienced with the first ten integrators on the GEDA. This problem was corrected when all the wiring between the ten microfarad capacitors and the patchbays were removed.

INSTRUMENT EVALUATION

The rechargeable Ni-Cd battery tests have now cycled throughout 36 charge-discharge operations with no change of battery performance.

One high-level, inexpensive, gamma dose-rate monitor detector consisting of a CdS cell and a small terphenyl-in-polyvinyltoluene detector was exposed to an accumulated gamma dose of $3 \times 10^7$ r before the CdS glass envelope darkened and the response dropped. The organic detector was unchanged. IPD personnel now want a similar unit except with good response to $2 \times 10^8$ r accumulated dose. CdS cells with a flint glass envelope may solve the requirement; however, no such item is available to our knowledge.

All 50 high range (0-5000 r/hr upper range) CP-TP portable dose-rate meters have been accepted for use. A slight amount of nonlinearity occurs above about 3500 r/hr. Chamber voltage and/or chamber size modification will alleviate this problem if it becomes necessary.

Thirty Model II Scintran alpha monitor instruments, fabricated off site from Nucleonic Instrumentation developed circuits, arrived on plant. Thirty plastic-head alpha detector probes developed here were also fabricated and received. Slight wiring errors, bad solder connections, bad high voltage regulators, improper cable connectors, and missing diodes were among the various troubles found and corrected.

The gamma compensated beta-gamma transistorized combined hand and shoe counter, clothing monitor, and general background monitor instrument was satisfactorily placed in demonstration field test service at 105-D.

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# CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

## RESEARCH AND ENGINEERING

## FISSIONABLE MATERIALS - 02 PROGRAM

### IRRADIATION PROCESSES

#### New Production Reactor Effluents

The effectiveness of adding 10 ppm stable cobalt to mixed NPR decontamination waste solution to promote the scavenging of radiocobalt was confirmed. No improvement in the removal of radiostrontium or radiozinc was realized from this addition. Thus, it may be desirable to add at least two salts to the waste, calcium for the removal of radiostrontium and either 200 ppm $Fe^{+2}$ or 10 ppm $Co^{+2}$ for the removal of radiocobalt.

#### Reduction of Reactor Effluent Contamination

Pressure drop across the screen in the inlet to the reactor effluent pilot scale aluminum bed forced a shutdown to permit the screen replacement. A heavy mat of algae-like material had nearly blocked the flow. Continued operation of this bed has confirmed that the plugging difficulty must be circumvented before such beds can be successfully used for reactor effluent decontamination. Samples are currently being taken to permit the final evaluation of this method of reactor effluent decontamination.

Laboratory research was initiated to evaluate the effectiveness of ground disposal practices in the reactor areas. Initial work is on the effects of temperature and pH on the sorption by soil of phosphorus, arsenic, neptunium, and chromium. These data will provide information on the capacity of 100 Area soils for sorption of the respective nuclides. The research will also provide information on anion sorption reactions with soils, as some of the nuclides occur in this form.

Temperatures of water in wells located in the vicinity of the Gable Butte-Gable Mountain anticline indicate the presence of a definite thermal boundary. This suggests a hydrologic separation of the waters north and south of the anticlinal ridge. The warm ground waters detected in the vicinity of the 100 Areas is therefore assumed to be due primarily to reactor operations.

The sample handling and ion exchange components of the automatic arsenic monitor were fabricated and the entire instrument moved to the 146-FR Building where it will be finally tested. A ten-day functional test of the forward and backward scaling circuits and related timing functions showed the electronic system to be reliable.

#### Uranium Oxidation and Fission Product Volatilization Studies

The analysis of data and final rough draft of a document (HW-70652) on high temperature effects on prototypical NPR fuel elements were completed. Two conclusions, not previously reported, made from additional metallographic examinations were:

(1) at 1200 C in an air atmosphere the 25 mil Zircaloy-2 inner can wall would be penetrated in approximately one hour, and (2) at about 1300 C the destruction of the Zircaloy-2 jacket by U diffusion becomes significant. Below this temperature, oxidation of the jacket is the primary mechanism to cause failure.

Reactor Effluent Water Studies

Studies are continuing in laboratory equipment with the aim of firming up experimental approaches to be taken in in-reactor equipment as this becomes available. These studies are aimed at: (1) the acquisition of additional detailed analytical data to further define the problem, and (2) the evolution of new approaches to the solution of the problem.

For example, current studies are seeking to ascertain if any changes occur in the chemical forms of arsenic or phosphorus on passage through the reactor which might prove instructive in terms of inferring the mechanism by which these materials are retained in the reactor. Likewise, analytical studies are being pursued on current reactor water plant high alum tests. Study of these tests may prove instructive in terms of explaining the fact that the water treatment is showing only nominal reduction in arsenic and phosphorus species in the reactor influent water but substantial reductions in the As-76 and P-32 in the effluent water.

Other studies are aimed at effecting reduction in As-76 and P-32 by altered water treatments yielding more effective removal of the parent materials and by introducing agents which will alter the reactor film in such manner as to reduce retention of these parent materials in the reactor. Preliminary findings indicate some promise for the latter approach in that substantial differences are seen in the rate of removal of As-76 when water of different trace composition is passed through heated columns of aluminum turnings on which As-76 had been previously sorbed.

SEPARATIONS PROCESSES

Disposal to Ground

The presence of Co-60 at a concentration of $2.6 \times 10^{-6}$ μc/cc in a depth sample from well 699-54-57, 1.5 miles north of 200 East Area, establishes the source of the waste as the 216-BY scavenged waste cribs. These cribs were abandoned in 1956. Based on the existing knowledge of ground water flow, subsequent movement of the waste should continue at a relatively slow rate.

Well 699-53-55, about one mile north of 200 East Area, encountered basalt about 150 feet deeper than predicted. This confirms the conclusions earlier reached that the basalt surface in the north part of 200 East Area and north of that area is considerably more irregular than previously thought, and probably extensively eroded. The irregular surface will channel radiocontaminants now in the ground waters into quite irregular courses. Wastes may be able to enter the basalt series through erosion channels that possibly expose permeable horizons there.

Preliminary interpretation of ground water temperature data indicates that some thermally warm water from the separations areas is moving southeastward, and may have reached the Columbia River just north of the 300 Area. The ground water temperature at the water table in wells in this area is 2-3 C warmer than that in wells located north or south of the zone. A tongue of warm water also extends southward from the 200 Areas to within about two miles of the Yakima River. The temperatures measured in wells on either side of the buried Yakima Ridge anticline a[redacted]location reveal the effectiveness of the ridge as a barrier to

further southward movement. Directly south of 200 West Area the water in wells north of the ridge is about 4 C warmer than that in wells to the south. Farther east this temperature difference disappears, probably indicating water movement through breaks in the basalt anticline.

## Ion Exchange Contactor Development

A study to gain more fundamental knowledge on the behavior of solid liquid systems has been initiated. The first phase involves an investigation of how forces are transmitted in an ion exchange resin bed. Data from the initial experiments lead to the calculation of a coefficient of friction for the 10-20 mesh resin-water system from 4 to 30 times as large as a similar coefficient previously reported. Three possible explanations of this discrepancy are: (1) a relatively large quantity of fractured beads discovered on subsequent microscopic examination of the resin, (2) an improvement in technique in the present work, and (3) a significant difference in the frictional properties of resin and containers.

The experimental equipment included a screened piston in a 3-1/2 inch Plexiglas cylinder. The screened piston was connected to a pneumatic piston which, through controlled air pressure, provided a means for obtaining a constant "push" force on the resin beds of varying heights placed in the Plexiglas cylinder. The pressure drop across the bed was measured as water was passed down through the bed. The water velocity was regulated to maintain a desired rate of piston travel.

An analytical expression was developed relating the average vertical stress required to move a column of resin countercurrent to the flow of interstitial liquid as a function of the height of the bed and the fluid pressure drop across the bed. The development required the assumptions that (1) the coefficient of friction is independent of the radial stress, and (2) the radial and vertical normal stresses are equal.

# WASTE TREATMENT

## Batch Calcination

The batch calcination of simulated, Purex high-level wastes was studied in bench scale and pilot plant scale experiments. The investigations included solution foaming and liquid level detection during the boil-down step and internal pressurization during the calcination step.

The waste composition which previously had exhibited internal pressurization in 3-inch diameter by 7-inch high pots was used as the feed solution for studies in a 4-inch diameter by 15-inch high pot and in a 15-inch high annular pot fabricated from 6-inch and 3-inch pipe. In the 4-inch pot, a layer of solids rose approximately six inches to the top of the pot. Post-calcination inspection revealed a 6-inch high void section between two layers of calcine. In the annular pot, no evidence of internal pressurization was apparent. A run reported last month using this annular pot and the same feed composition gave similar results. Evidently pot size and/or pot geometry is a factor in the generation of internal pressure during the calcination step.

A high acid (6.2 M) simulated waste solution was used for a run in the 6-inch annular pot to study foaming. Extensive foaming occurred during the boil-down step and a reduction in the boil-off rate was required. An air sparge was used to control the foaming but was only partially effective.

As observed in a previous run, the presence of up to 0.075 M lead acetate did not cause foaming or affect calcination.

A pilot plant run was made using a pot 8-inches in diameter and 5-1/2 feet high. A 16-inch diameter by 2-foot high disengaging section surmounts the pot and extends out of the furnace. A fluorothene lid was used to permit visual observation.

The addition of feed to the pilot plant unit was continued until the nitrate decomposition gases obscured vision. The furnace temperature was held at 500 C. Pertinent observations were:

(1) The boil-off rate was uniform (1.9 liters/(hr)(sq.ft. of heated surface).

(2) Splashing became worse as the solution became more viscous. The pot wall one to 1-1/2 feet above the liquid surface became coated with a 1-inch layer of solids. Some of the solution splashed up to the fluorothene lid.

(3) After the solution was siphoned from the pot, a uniform, 1/2-inch coating of solids was observed on the pot wall below the normal liquid level.

(4) There was a 8- to 10-inch layer of solids on the bottom of the pot.

## In-Tank Waste Solidification by Submerged Combustion

The submerged combustion unit has been readied and has undergone about 6 hours of operation with water during a familiarization run. Operation was smooth and uneventful throughout the test at a rate of $1 \times 10^6$ Btu/hr. Tests of solidificatic of simulated Purex OWW (sodium carbonate solution) will be started shortly.

## Waste Transfer

The mechanics of water-jet sluicing are being investigated in small scale studies with 1/8-inch diameter flow nozzles and plaster of Paris targets. First results show that the proportionate rate of material removal increases with flow rate and decreases almost exponentially with target submergence. The studies will continue to aid in interpreting data from full-scale in-tank sluicing tests.

Difficulties encountered in sampling Purex 241-A-103 waste sludge with a non-rotating axially forced coring device have prompted investigation of a commercial core drill. A soft steel rotary clay bit and special double core barrel will be used in the drill. Bit loading factors and coring performance (drilling plaster of Paris) will be studied in 321 Building cold tests prior to "hot" sampling.

## Off-Gas and Condensate Treatment

Samples of the airborne effluent from a dry waste incinerator being tested in the Z Area were analyzed for particle size distributions. The mean particle diameter was found to be 0.9 microns upstream from the scrubber, and 0.5 microns downstream from the scrubber. The mass distribution was computed, assuming the particle mass to be proportional to the particle diameter cubed. The mean mass diameter thus determined was 6 microns upstream from the scrubber and 2 microns downstream from the scrubber.

Experimental study of mineral bed decontamination of Purex Tank Farm condensate was extended to the removal of radiocerium, as an example of the rare earths. Results indicate that greater cerium removal by ion exchange is achieved when the pH of the condensate is reduced to 3. at pH 9, radiocerium decontamination factors were usually less than 2 with clinoptilolite, but at pH 3 both clinoptilolite and a cation exchange resin gave decontamination factors ranging from 8 to 200. Cerium tends to be peptized to a colloid in low-salt solutions at a pH greater than 3, and may not be removed efficiently by ion exchange materials. The adsorption capacity of IR-120 cation exchange resin for radiocerium from the waste (containing 0.002-0.012 M $NH_4^+$) is greater than that of clinoptilolite.

## TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

### Strontium-90 Program

Hot Semiworks Recovery - Approximately 300 kilocuries of Sr-90 were recovered from a crude feed containing about 360 kilocuries during the third Hot Semiworks "hot" run. The cerium in the product was about 30 to 50 percent above the desired specification, but all other contaminants were well below the desired maximum limits. Production of near product specifications in one solvent extraction cycle was primarily attributed to the use of DTPA (diethylenetriamine penta-acetic acid), as a rare earth complexing agent. Previous runs have used EDTA as a complexant.

During the run, continuous backcycle or "spin" of part of the product to the feed was employed to reduce the final volume of product. The product, containing about 1 M citric acid, was then concentrated two-fold and stored to allow strontium radiation to destroy the citric acid.

Out of specification product from previous runs was also reworked through one cycle of solvent extraction to reduce the cerium contamination (about 7-fold above specification). However, through operating difficulties, a cerium decontamination factor of only about two was obtained.

At month's end agreement on product specifications was reached with the Martin Company which allowed all of the product inventory of about 500 kilocuries to be blended into one batch with a Sr-89/Sr-90 curie ratio of about 0.17 and a Ce-144/Sr-90 curie ratio of about 0.002 as of January 1, 1962.

### Other Fission Product Recovery

Preparation of Cerium-Free Rare Earth Fraction by Solvent Extraction - A flowsheet for the preparation of a cerium-free rare earth fraction from Purex crude which appears operable in the Hot Semiworks equipment involves: (a) extracting calcium, strontium and rare earths in the 1A column, (b) stripping strontium from the organic in the 1B column, (c) batch stripping the organic with 1-2 M $HNO_3$, (d) oxidizing cerium in the aqueous phase with permanganate and batch extracting cerium, and (e) batch stripping the final organic to remove cerium. The aqueous solution containing non-cerium rare earth would be treated with citric acid to reduce permanganate and manganese dioxide to manganous. If necessary for use in the 325-A Building demonstration of promethium recovery by ion exchange, the rare earths could be separated from much of the calcium and manganese by an extraction-strip cycle.

Simulated crude-cut solutions spiked with appropriate tracers and unwashed 0.4 M D2EHPA-0.2 M TPB-Shell Spray Base were used in batch contact studies to determine strontium, cerium and promethium behavior under proposed 1A column conditions. Acetate and EDTA were used to complex iron and lead. While distribution ratios observed were generally lower than in previous studies with HEDTA, they were high enough to indicate fair recovery of promethium at an aqueous to organic flow ratio of two. The data indicate a pH of 3.5 as optimum for the 1A column extraction section.

Mini-mixer settler runs were then made simulating the 1A column conditions considered optimum based on batch contact studies. Feed-to-organic flow ratio was about two. The scrub solution was 0.25 M $NaNO_3$ at a flow rate 1/20 that of the feed. Three similar runs were made. In no case was more than 25 percent of the promethium extracted. No explanation has as yet been found for this discrepancy between batch contact and mini-mixer-settler data. At month's end, batch contact data defining the effects of substituting citrate for EDTA are being obtained in an attempt to find more favorable operating conditions for the 1A column.

The proposed extraction of rare earth elements as well as strontium and calcium in the 1A column will result in increased solvent loading. To compensate for the higher loading, it is proposed to use 0.5 M D2EHPA (vice 0.4 M) in the solvent. The effect of this increased solvent concentration on the stripping of strontium in the 1B column was studied in batch contact experiments. Although strontium distribution ratios under 1B column conditions are higher at 0.5 M D2EHPA than at 0.4 M, they are still low enough that satisfactory stripping of strontium should be obtained.

Studies were made to determine optimum conditions for the use of permanganate for cerium oxidation. The procedure suggested by Butler and Ketchen [I&EC, 53, 651 (1961)] of ORNL was adapted to the present flowsheet. Solutions simulating a 1 M $HNO_3$ strip of the organic phase after strontium removal were treated with potassium permanganate. Following a "pre-contact" period, the aqueous was contacted with organic extractant (D2EHPA-TBP-SSB) for a given time. Then citric acid was added to dissolve manganese dioxide and reduce excess permanganate thereby aiding in phase separation. Cerium distribution was determined as a function of permanganate concentration, "pre-contact" time, contact time, and time after addition of citric acid. Cerium distribution ratios in the 100 to 500 range were obtained with initial permanganate concentration of 0.025 M, pre-contact times of zero to 30 minutes, contact times of 10-30 minutes, and times after citric acid addition up to forty minutes. As proposed by Butler and Ketchen, cerium can be stripped from the organic phase with nitric acid-hydrogen peroxide solutions. Cerium distribution ratios ($E_a^o$) ranged from 0.004 to 0.025 in 20-minute equal-volume contacts of the organic phase with aqueous phases 1-2 M in $HNO_3$ and 1-5 percent in $H_2O_2$.

The aqueous phase remaining after cerium removal will contain calcium, rare earths, manganous ion and residual citric acid. The feasibility of separating the rare earths, in particular promethium, from calcium and manganous ion in a single batch contact with solvent was examined. The best compromise in extraction conditions appears to be a citrate concentration between 0.25 and 0.5 and pH between 1.5 and 2. A single equal volume batch extraction of the aqueous with 0.4 M D2EHPA - 0.2 M TBP - SSB should recover greater than 90 percent of the rare earths with manganou and calcium decontamination factors of 4-6 and 1.5-2, respectively.

Purex Head-End Promethium Recovery - B Cell tests of the peroxyacetate precipitation process (for the separation of trivalent rare earths from cerium) have established a flowsheet for plant testing in early September. Radiation-induced dissolution of the precipitate was found to be excessive in initial liter-scale 1WW runs, using flowsheet conditions developed in earlier work with cold or tracer level synthetic feed (HW-62505). However, it is possible to overcome this effect by: (1) using 1.2 M hydrogen peroxide in the initial precipitation, or (2) conducting the initial precipitation with 0.4 M hydrogen peroxide and adding additional hydrogen peroxide to the supernatant at four hour intervals, beginning two hours after the initial precipitation. Such treatment prevented dissolution of cerium for periods of up to 50 hours. Either technique should be satisfactory for plant use with the second probably preferred. That the observed decomposition of the cerium(IV) peroxyacetate cake was due to radiation and not to a chemical catalysis (by impurities present in actual 1WW but absent in the synthetic solutions) was shown by the lack of any significant dependence of rate of decomposition on temperature. Present B Cell activities include repeating the modified flowsheet with fresh 1WW (that used in the foregoing experiments had aged for several months), using lead carrier to improve promethium recovery, and testing a somewhat more complex flowsheet which would yield three products--cerium, promethium and strontium.

Other experiments have been aimed at finding an alternate precipitation scheme for cerium-promethium separation, while avoiding use of corrosive halides or of oxidants which would volatilize ruthenium. Room temperature permanganate oxidation followed by the precipitation of cerium(IV) hydroxide was scouted and found unsatisfactory. Although cerium(IV) normally precipitates at much lower pH than the trivalent rare earths, either it or $MnO_2$ serves as a carrier for the latter.

Another scheme, the use of a mixture of dichromate and peroxide, shows promise. The use of 0.02 to 0.05 M dichromate and 0.1 to 0.2 M $H_2O_2$ at pH 4 to 5 results in the precipitation of over 98 percent of the cerium while most of the promethium stays in the supernate. The precipitate, believed to be a cerium(IV) peroxychromate, filters or centrifuges readily and can be easily redissolved with dilute nitric acid. Hot-cell experiments are pending.

Cesium Concentration for Shipment - A new high-integrity cesium-Decalso shipping cask is under consideration. Due to the small size of the cask and the desirability of large individual shipments, processing to increase the cesium concentration and decrease the sodium-to-cesium ratio (relative to neutralized Purex supernatant) is required in order to realize higher Decalso loadings. A laboratory investigation has been completed to develop a process for doing this in Purex head-end equipment. Cesium is precipitated from neutralized Purex supernatant with a slight excess of nickel or zinc ferrocyanide and the precipitate centrifuged, washed and the cesium dissolved (as cesium carbonate) by heating with a slurry of solid silver carbonate. The dissolved cesium is then loaded onto Decalso for shipment. Details of the experiments, recommended procedure, and effect of variables are given in an informal report (HW-70874). Nickel ferrocyanide was found to be somewhat superior to zinc ferrocyanide and precipitated approximately 99 percent of the cesium in the pH range 9.7 to 10.4. Since the pH of tank-farm supernatant is about 10.0 to 10.5, no acidification appears necessary. A two-fold excess of silver carbonate was generally adequate for satisfactory metathesis and the cost of reagents, since the reactions are very nearly stoichiometric, is very nominal.

The capacity of Decalso for cesium was also measured as a function of sodium-to-cesium feed ratio. The capacity at a 20,000/1 ratio (corresponding to 103-A supernatant) is 0.43 grams Cs/liter of Decalso, about 30,000 curies for a 400 gallon STT. The capacity (for loading at room temperature) increases to a value of 2.3 g/l at a ratio 4500/1, 8 at 900/1, 23 at 100/1, and 90 at 10/1. These figures show that heat transfer, rather than Decalso capacity, will limit the size of individual shipments in the contemplated cask, since the sodium/cesium ratio of the product from the carbonate metathesis is expected to be in the range 10/1 to 100/1. A decrease of sodium/cesium ratio to a value of about 1000/1 is all that is required to permit loading 100,000 curies onto 100 gallons of Decalso.

Other experiments on the Decalso loading and ion-exchange processing of cesium showed:

1. Cesium extracted from 103-A supernatant with a tetraphenyl boron-amyl acetate solution can be quantitatively absorbed on Decalso directly from the organic phase. Decalso loading could therefore follow a single-column solvent extraction without the necessity of a stripping column.

2. The sodium-cesium ratio can be reduced to a value of 1000 or less (for subsequent high capacity loading on Decalso) by absorption on a Duolite C-3 column followed by elution with dilute acid.

3. The capacity of Decalso for cesium is a function of temperature, low temperatures favoring absorption and high temperature favoring elution. The capacities of Decalso for cesium (from 103-A supernatant, 50 percent breakthrough) at 25 C and 9 C were greater by factors of 1.7 and 2.4, respectively, as compared with a column loaded at 60 C. Present practice is to load STT's at about 50 C (due to jet heating). An increase in capacity could be realized by using a lower temperature, and any new cask should incorporate cooling coils.

4. An increase in the pH of 103-A supernatant, by adding sodium hydroxide equivalent to 0.25 M/l, increased the cesium loading capacity of Duolite C-3 by a factor of 2.3 (in qualitative agreement with Chemical Effluents Technology results). However, the capacity of Decalso was decreased. In the case of Decalso, flow rate is also very important, low flow rates giving the highest loadings.

Phosphotungstate and Phosphomolybdate Precipitation of Cesium - A series of scouting experiments have been initiated to determine the applicability of phosphotungstic and phosphomolybdic acid for the precipitation of cesium in various Purex process streams, particularly from highly acidic solutions where other carriers are ineffective. The effects of nitric acid, sodium nitrate, sodium nitrite, ferric nitrate, temperature, time of digestion, and amount of precipitant were investigated in these experiments. Both phosphotungstic acid ($H_3PW_{12}O_{40}\cdot XH_2O$, MW ca. 3200) and phosphomolybdic acid ($H_3PMo_{10}O_{34}$-24 $H_2O$) were effective carriers over a wide range; however, phsophomolybdate was poorer than phosphotungstate by a factor of about two and the precipitate was much slower in forming, requiring over 16 hours for completion. Therefore, phosphotungstic acid appears to be superior for all applications. Excellent cesium precipitation (losses <1 percent) were observed from a 4 M $HNO_3$ to pH 7, using as little as a two-fold excess of phosphotungstic acid over the amount required for the tricesium salt. If these promising results are borne out by experiments with synthetic and actual 1WW, it would appear that phosphotungstic acid could be used effectively for the removal of cesium from acidic 1WW.

A-Cell Operations - Strontium-90 which had accumulated in a waste cask (effluent from HAPO-1A Decalso loadings) was successfully reprocessed through the ion-exchange columns to recover approximately 12,000 curies for future research use. Following this operation, the Dowex-50 resin was removed from the columns and the entire system thoroughly flushed in preparation for experiments on the anion-exchange recovery of technetium-99 from Purex 103-A supernate.

Effect of Temperature on Dry Shipment of Decalso - The final HAPO-1A strontium shipment was made in the dry condition, i.e., with the interstitial liquid siphoned out, in order to afford more free volume to accommodate radiolytic gas production. Similar dry shipment has been proposed for a second generation Decalso strontium cask and for the improved Decalso cesium cask. The effect of heating loaded Decalso on the subsequent elution of strontium and cesium was accordingly determined. With both cesium and strontium, temperatures higher than about 100 C resulted in seriously decreased recoveries. The fraction eluted decreased from ca. 98 percent for 100 C to ca. 55 percent for 200 C and to less than 20 percent for 300 to 400 C heat treatments. The shape of the recovery curve closely paralleled the thermogravimetric weight loss curve, which showed decomposition beginning at about 110 C and a constant weight above about 400 C.

Bulk Fission Product Packaging - Studies of bulk packaging of fission products (strontium-90, promethium-147, cerium-144) continued with completion of development of the precipitator vessel, wash filter, and induction heating coils for product prolysis. Completed studies of strontium peroxide cake washing in full scale equipment show sodium removal factors of 2.5 per 5 liter water wash of 50,000 strontium-90 curie equivalent peroxide cakes. Strontium losses to the initial filtrate and three subsequent washes totaled 6 percent in non-radioactive tests.

Drawings of the canister loading station and capping station are 75 and 50 percent complete, respectively, and specifications for remote welding equipment and heavy duty manipulators have been prepared.

Tests of a clamp type cooling device for protecting canister seal and welding surfaces from oxidation during pyrolysis of fission product intermediates were successfully completed.

Shipping Cask Closures - A stainless steel "Bell Ring" gasket intended for secondary closures on fission product shipping casks and bulk canisters tested at 500 psig and 500 C with helium leakage rates of less than $10^{-6}$ cc/second.

## ANALYTICAL AND INSTRUMENTAL CHEMISTRY

### Scintillating Glasses

A sample of the British cerium-activated glass was received several months ago. Recently, three samples of a laminated cerium-activated Vycor glass were obtained from Corning. All four samples have been ground and polished and tested for alpha response using a dry Pu standard disk. The British glass was found to be substantially identical in quantum efficiency to the chemically similar Naval Research Laboratories (Ginther) glass previously tested, and showed similar resolution. The thin-film Vycor showed slightly improved efficiency over that of the thicker specimen previously tested, but not as much as anticipated. One of the samples is being ground to 0.01 inch thick (scintillating layer) and will be compared to the

thicker samples in relative alpha to beta response. These tests will conclude th studies on glass scintillators as alpha detectors.

Improved Electrodeposition of Trace Plutonium

Radioassay of plutonium in 100 micromicrogram quantity was improved by development of an electroplating technique which is quantitative. The electroplated metal was confined to an eighth-in. diameter surface (suitable for 7 mm crystal detectors made of silicon with traces of silica) by sealing a 9 gauge platinum wire cathode in thermal-setting resin. The rotating cathode provided agitation during electroplating. Electrodeposition required two hours, after which the deposited plutonium was removed by cutting off an eight-inch segment of the cathode and, thereby, exposing plating surface for another sample.

Measurement of Fission Products in Irradiated $UO_2$

Fission product to uranium ratios were measured in some 40 samples of irradiated uranium dioxide. The samples consisted of microgram amounts of dioxide fixed upon cellophane tape. Direct gamma-ray spectrometry yielded qualitative results. Quantitative work required chemical separation. The gum on the tape was dissolved with a solution of equal parts benzene and ether by means of ultrasonic generator agitation. Appreciable cesium dissolved in the mixture whereas the other materials were simply released from the tape. The cesium was stripped into water with acid, the phases were separated, and the particles were centrifuged and dissolved in boiling 6 N nitric acid - 0.1 N hydrofluoric acid. Cerium, ruthenium, zirconium and niobium were determined from direct gamma ray spectrometry counting. Cesium was determined by tetraphenyl-boron extraction and gamma counting. Since samples were so small, uranium was determined with a fluorophotometer. Plutonium-239 was calculated from total alpha measurement.

Trace Copper Measurement by Voltage Scanning Coulometry

Measuring trace quantities of copper by voltage scanning coulometry is not hampered by macro amounts of extraneous ions which generally interfere with colorimetric methods. One microgram of copper was measured directly in a hydrofluoric acid - nitric acid zircaloy solution containing nearly 200 g of metal per liter. Precision was ±5 percent and detection limit was 0.1 microgram, which compare equally with those from colorimetric work. Actual copper content of the zircaloy was 10 to 15 ppm. Also, copper down to 16 ppb was measured directly in PRTR water. The method consisted of reduction to copper metal at -0.30 volt, copper amalgamation in the mercury pool cell, replacement of molar sulfuric acid electrolyte with fresh acid, oxidation of copper at +0.15 volt, and measurement of copper by scanning from +0.15 volt to -0.35 volt.

Measurement of Fluorescein in the Columbia River

Direct measurement down to 1 ppb fluorescein was made possible by using a Farrand spectroflurimeter. Silica turbidity up to 25 ppm was tolerable. The method was used to analyze successfully 36 river samples involved in a recent river dilution and dispersion test.

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## EQUIPMENT AND MATERIALS

### Hydraulic Equipment

A special submerged, canned motor pump for use in in-tank clarification of Purex waste supernates has been received and placed on water test prior to evaluation with a hydroclone for suspended sludge removal.

A second submerged, Hastelloy-C canned motor pump (a canyon service candidate) has been operated uneventfully for 1,550 hours in water.

Difficulties with Hot Semiworks and 234-5 canned motor pumps have been traced to vibration loosening of bearing adjustment flanges and to improper matching of bearing-journal taper. In the latter instance, taper jigs have been fabricated and will be used to standardize all bearing tapers. Control of bearing adjustment flanges has been achieved by set screw locking of bearing adjustment bolts.

### Materials of Construction for Plutonium Electrolysis Cell

Testing of candidate materials for the plutonium fused salt electrolysis cells continued. The following are highlights of these studies:

1. A silicon nitride cell was found to react with and darken 60 percent $BaCl_2$ - 40 percent KCl salt at 800 C. The cell was subsequently soaked in four separate salt solutions of the above composition. The reaction darkened the salt less each time. The porosity was reduced from approximately 30 percent to 15 percent by this procedure.

2. When an electrolytic cell was set up using aluminum as the cathode, carbon as the anode and 60 percent $BaCl_2$ - 40 percent KCl at 800 C as the electrolyte, a black, solid residue collected on the anode shorting the cell out. Only a trace of titanium and barium was found in the residue.

### Effects of Cold Working on the Corrosion of 304-L in 65 w/o Nitric Acid

Samples of 304-L stainless steel were annealed (1975 F for one-half hour, water quenched) and then cold worked to values of 10, 20, 30, 40, 50 and 60 percent reduction in cross sectional area. These samples, plus a control sample not cold worked, were exposed to boiling 65 w/o nitric acid. No significant differences in corrosion rates have been observed during 200 hours' exposure to date. The exposures are being continued.

### Corrosion of Titanium in $HNO_3$ - HF Systems

In 6 M $HNO_3$ - 0.01 M HF, A-55 titanium corrosion rates are reduced significantly as Al/F mole ratios are increased up to four but no further decrease occurs as the mole ratio is further increased to 10. Minimum corrosion rates observed in this series was between one and two mils/mo. In boiling synthetic Purex 1WW (6 M $HNO_3$) containing 0.025 M HF, A-55 titanium corrosion rates were 0.1 mil/mo. at zero aluminum and ca. 0.05 mil/mo at Al/F mole ratios of 1, 2 and 4. When chromium was omitted from the above Purex 1WW, A-55 corrosion rates at Al/F mole ratios from zero to four were all less than 0.2 mil/mo. Corrosion rates decreased with increasing Al/F mole ratio and were the same (0.05 mil/mo) at Al/F of four

whether or not the solution contained chromium. Titanium samples were exposed to boiling 1WW (6 M $HNO_3$ and containing 0.025 M HF) solutions with chromium omitted, iron omitted, chromium and iron omitted, sulfuric acid omitted, and sulfate omitted. Corrosion rates of less than one mil/mo were observed in the Cr-free, $H_2SO_4$-free and $SO_4^=$ free solutions; two mils/mo in the Fe-free solution, and 10 mils/mo in the Fe and Cr-free solution. Phosphoric acid appears to have a strong inhibiting effect on the corrosion of titanium in 6 M $HNO_3$ - 0.025 M HF. First exposure period rates of less than 0.02 mils/mo were observed at a $H_3PO_4$/HF mole ratio of four.

## Corrosion Under Submerged Combustion Conditions

Studies are currently underway to determine the corrosion of 1020 carbon steel and the attack on concrete to be anticipated in in-tank submerged combustion evaporation of Purex organic wash waste. Synthetic organic wash waste (2 M total carbonate) was maintained at 100 C and sparged with $CO_2$ at 200 cc/min. per four liters of waste. Mild steel specimens were exposed to liquid, interface and vapor phases. Concrete test blocks are suspended in the vapor phase. Condensation on these blocks is estimated at 10 ml/hr, sq.ft. During 840 hours' operation of the equipment the pH of the solution dropped from an initial value of 11.0 to 8.9. Maximum mild steel corrosion rates as determined by weight loss were 0.004 and 0.06 mil/mo. for liquid and vapor phase, respectively. A few broad shallow pits (ca. 0.5 mil deep) were noted on these specimens. Interface specimens were not preferentially attacked. The test is being continued with the solution butted to three molar total carbonate. The concrete blocks will be examined at the end of the test.

Several short-term (24-78 hour) corrosion tests have been made with 1020 mild steel in $Na_2CO_3$-$NaHCO_3$-$NaNO_3$ systems simulating the Purex organic wash wastes. Results were very erratic. Whether or not attack occurred seemed to depend mainly on the surface condition of the test specimens. Attack always occurred on specimens activated by momentary exposure to a strong mineral acid. Specimens corrosion tested a few minutes to a few hours after belt grinding were sometimes attacked. None of four specimens tested in the scaled, as-received condition was attacked.

## PROCESS CONTROL DEVELOPMENT

## Recuplex Solvent Extraction Control Studies

Instrumentation necessary for testing the basic concepts of the proposed Recuplex solvent extraction efficiency and capacity control systems was installed and operated on the C-column test facility.

The efficiency control system involves concentration control at a given point in the column by feedback of the concentration controller output to the flow ratio determining mechanism.

The capacity control system operates to give the maximum magnitude of flows which will keep the column operating at a chosen level of dispersed phase holdup. In the test facility the column density is used as an inferential measure of dispersed phase holdup. The column density controller output determines the magnitudes of the flows.

Preliminary tests indicate that both efficiency and capacity control can be achieved in the manner described above. The control system remained stable and performed as expected upon introducing stepwise changes in column density and concentration controller set points.

Instrument Evaluation - New Plutonium Reclamation Facility

Tests using a prototype CAF feed tank are being conducted on the following instruments: (a) a pipe line density monitor, (b) liquid level capacitance probe, (c) D-P cell liquid level indicator, and (d) D-P cells combined for monitoring specific gravity. Results of the tests to date are as follows:

(a) Pipe line density monitor - for the second time during these tests a leak developed in the stainless steel plumet device when nitric acid was introduced to the system. The fault appears to be in the welding of the plumet end pieces. The vendor is attempting to correct this defect.

(b) Liquid level capacitance probe - response and linearity of the probe is good but requires a calibration to account for the dielectric constant of the tank contents.

(c) D-P cell liquid level indicator - worked as expected; response and linearity excellent.

(d) D-P cells specific gravity indicator - one of two D-P cells as used in measuring specific gravity oscillated badly. However, these oscillators could be dampened by putting a valve in the pneumatic line connecting the two cells. The specific gravity readings are nearly linear over the tested range 1.00 to 1.50 units.

C-Column Studies

The first block of 20 exploratory runs has been completed. No additional exploratory runs are scheduled until a detailed analysis of this first block of runs is completed. The test facility is currently being used for testing instruments and control devices for the New Plutonium Reclamation Facility.

The Absorptiometer Data Logger has been used to analyze the samples taken from eight runs made with the C-column test facility. Based on the time elapsed in analyzing these runs, it appears that the 24 two-phase samples taken during a typical C-column run can be analyzed for uranium in both phases, acid in the aqueous phase, and the total volume of each of the phases (hence volumetric fraction of organic) within a routine 8-hour day using the Absorptiometer Data Logger.

Modification of pH Glass Electrode

Laboratory studies are in progress towards modification of a glass electrode to achieve a longer life in high radiation fields. The modification provides for additional electrolyte capacity, and a safety relief valve to prevent undue pressure buildup. A palladium annulus reference electrode is also being modified to increase electrolyte storage capacity, and will also include a pressure relief valve. These modified electrodes will be irradiated until failure to obtain an estimate of their expected life.

Pot Calciner Instrumentation

During the pilot plant run described earlier under "Batch Calcination," (page C-3) a probe to detect the solution level in the pot was tested. The probe consists of a 20-inch long, 1/8-inch diameter, stainless steel sheathed, chromel-alumel thermocouple heated with an AC current. The thermocouple DC millivolt output was recorded. The higher heat dissipation rate from the probe to the solution (relative to steam) causes the probe to cool and the millivolt output to decrease when solution covers the probe.

Splashing of the boiling solution on the probe caused it to react as if it were submerged. Positioning of the probe 6 to 8 inches above the liquid surface was necessary to minimize this effect. During the run with a simulated waste solution, solids deposited on the probe. The sensitivity of the probe decreased markedly as the solids continued to build-up. Testing of a shorter probe is planned.

## REACTOR DEVELOPMENT - 04 PROGRAM

## PLUTONIUM RECYCLE PROGRAM

### Salt Cycle Process

Plutonium Oxidation States in Molten Chloride Salts - Studies of the plutonium (III)/(IV) ratios resulting from treatment of plutonium(III) with chlorine or hydrogen chloride in chloride melts are currently made by bringing the system to equilibrium, then rapidly freezing the melt, dissolving it, and analyzing the resulting aqueous solution for plutonium(III) and for total plutonium. The results obtained to date for systems in which the salt - one percent plutonium system has been sparged with chlorine gas for one-half to three hours, then frozen under a chlorine blanket, are consistent with the expected greater stability of plutonium(IV) at lower temperatures. For example, about two-thirds of the plutonium was present as plutonium(IV) in the aqueous solution which resulted when the above sequence was applied to $PbCl_2$-2KCl at 570 C. A similar sequence when applied to NaCl-KCl at 750 C showed less than 2 percent of the plutonium present as species other than plutonium(III).

Unfortunately, this experimental approach is not capable of distinguishing between plutonium(IV) which existed in the melt at temperature and plutonium(IV) which was formed by reaction of plutonium(III) with chlorine as the melt was chilled, or with trapped chlorine as the frozen salt was dissolved in the aqueous solution. Accordingly, a firm interpretation of these data and a valid determination of plutonium oxidation state in melts at temperature must await the forthcoming installation of a spectrophotometer capable of handling plutonium-bearing molten salts.

Plutonium and Rare Earth Behavior - Efforts have continued to improve plutonium-rare earth separation in the $UO_2$-$PuO_2$ electrolytic codeposition step. Using promethium-147 as a representative rare earth, and studying codeposition from the KCl-NaCl system at 750 C, no improvement in separation was achieved by using various blends of oxygen with chlorine or hydrogen chloride as a sparge gas in place of moist air. It was noted that plutonium codeposition does not occur significantly with dry oxygen-chlorine sparge mixtures as long as the chlorine content is greater than about 2.5 percent.

The importance of close control of the moisture content of the atmosphere over the melt was emphasized by observation of seasonal variations in plutonium decontamination factors in the plutonium-uranium partition step. It was noted that an average plutonium D.F. of about 130 was achieved (in the KCl-NaCl system) during late April when the relative humidity of laboratory air was 40 percent. Two partition experiments performed in June at 75 percent relative humidity resulted in plutonium D.F.'s of only 12.5 and 20.

Studies of $KCl-PbCl_2$ Systems - What appeared to be single crystals of $\overline{UO_2}$, weighing up to about four grams, were produced during the month by electrolytic deposition from the $KCl-PbCl_2$ system. The melt contained initially 25 weight percent uranium as $UO_2Cl_2$ and was dried thoroughly before $\overline{UO_2}$ deposition, with a chlorine sparge and by anodic treatment. The number of crystals permitted to grow was limited by a quartz shroud surrounding the cathode. The shroud was perforated by five 1 mm diameter holes. A chlorine atmosphere was maintained during the 96-hour crystal growth period. Time-lapse infra-red film studies have been made of some of these crystal growths, but the films have not yet been completely analyzed and results will be reported later.

Studies of $KCl-MgCl_2$ Systems - Several more depositions of $\overline{UO_2}$ from the 1:1 $KCl-MgCl_2$ system, at about 500 C, have been carried out. Thus far, the results have been less promising than those obtained in the $KCl-PbCl_2$ system. Crystal quality has not been as good, and several melts have inexplicably turned black. An attempt to raise the uranium(VI) concentration of a melt during a run by the addition of $UO_2Cl_2.H_2O$ was unsuccessful, the added water causing severe crystal branching and general product degradation.

$AlCl_3$-KCl System - Early estimates (cf. HW-62012C, p. 17) of equilibrium constants applicable to the $AlCl_3-KCl-UCl_3$ system were made from equilibrium partition data for uranium between this molten salt system and molten aluminum metal. In the absence of experimental data on the activity coefficient of uranium in molten aluminum metal, these estimates were made on the basis of the (highly suspect) assumption that dilute uranium in molten aluminum constituted an ideal solution. Recently, activity data for the Al-U system published by Johnson and Cafsso at Argonne National Laboratory have permitted recalculation of the equilibrium constants for the following reactions:

$$Cl^- + Al_2Cl_6 \overset{K_1}{\rightleftharpoons} Al_2Cl_7^-$$

$$3Cl^- + UCl_3 \overset{K_2}{\rightleftharpoons} UCl_6^{\equiv}$$

$$Cl^- + Al_2Cl_7^- \overset{K_4}{\rightleftharpoons} 2AlCl_4^-$$

The values based on an activity coefficient of $1.4 \times 10^{-3}$ for uranium in aluminum resulted in values of $1.3 \times 10^8$, $8.9 \times 10^4$, and $2.0 \times 10^3$ for $K_1$, $K_2$ and $K_4$, respectively. The values based on unit activity coefficient were $3.2 \times 10^{14}$, $3.2 \times 10^5$, and $1 \times 10^4$, the largest difference occurring in $K_1$. This is expected since some of the driving force for the uranium reduction reaction ascribed to complexing of $AlCl_3$ is actually provided by the lowering of the activity of uranium metal in molten aluminum.

A paper covering this work is in preparation.

Engineering Development - Three batches of electrolytic $\overline{UO_2}$, weighing 61, 116 and 82 pounds, were produced from a nominally 80 liter $PbCl_2$-2.5 KCl salt bath. In each run $U_3O_8$ was dissolved to a concentration of 15 - 20 weight percent uranium by sparging with chlorine at 700 C. The subsequent electrolyses were carried out at an average deposition rate of 2.5 pounds of $\overline{UO_2}$ per hour at 580 C with an air atmosphere. The current efficiency was about 82 percent, and the cell resistance varied less than 10 percent during the course of the runs.

A dendritic deposit of $\overline{UO_2}$ was obtained, which was easily removed by immersion in water. The $\overline{UO_2}$ granules were then formed into a packed bed and leached for six hours at 70 C with a recirculating solution of 0.1 M di-(2 hydroxyethyl) amino-acetic acid chelating agent at pH 5 to remove $PbCl_2$. After a final water rinse, analyses of the 1st batch showed 600 ppm lead and less than 50 ppm potassium (limit of analytical technique), which indicates that lead removal is still an unsolved problem.

The O/U ratio of the first batch was 2.049. This rather high value may be due to incomplete drying of the melt, the presence of an air atmosphere above the salt bath, or oxidation of the $\overline{UO_2}$ during the electrode removal operation.

## RADIOACTIVE RESIDUE FIXATION

### Mineral Reactions

A recently introduced form of phenolic cation exchange resin, Bio-Rex 40, was found to have a 30 percent greater cesium capacity than Duolite C-3 in experiments with Purex neutralized high-level waste. The solutions were adjusted to 2.8 M $OH^-$ before capacity determinations were made. For this system the cesium selectivity factor ($K_d$ x $Na^+$) for Bio-Rex 40 is 1164, for Duolite C-3 is 900, and for clinoptilolite is 240.

Experiments were performed to study the relationship between particle size and H.E.T.P. for columns of Duolite C-3 resin receiving Purex neutralized high-level waste. By reducing particle size from >0.833 mm to <0.104 mm it was possible to reduce H.E.T.P. from 5.4 to 0.083 cm in laboratory columns. The columns provided a residence time of 3.0 min. The results indicate that residence time in a plant-scale column could be reduced from between one and two hours to between one and five minutes by a reduction in particle size.

### Condensate Streams

Micro Pilot Plant Run 18 which is evaluating the decontamination ability of a bed of clinoptilolite in the hydrogen form is still in operation, having treated over 3500 liters (14,000 column volumes) of radioactive condensate waste with an over-all gross beta decontamination factor of more than 20. The Purex Tank Farm condensate feed is treated in the experimental steam stripper to remove organic and ammonia, acidified with nitric acid to a pH of 3 and passed through activated carbon for removal of residual organic prior to being passed through the mineral column. Cesium, cerium, zirconium and niobium radioisotopes are removed to below their $MPC_w$. Strontium isotopes are being partially removed, but their concentration in the column effluent appears greater than their $MPC_w$. Ruthenium is not effectively removed by the mineral bed. Use of an anion resin on which copper metal has been deposited (regenerated Duolite S10) was effective in removing 50 percent of the ruthenium from the mineral bed effluent, but was not able to remove the radioisotope to belo[redacted] $MPC_w$.

[redacted]

Fission Product Glasses

Two additional strontium-containing glasses were prepared, based on beryllium fluoride as the glass former. These contained 67 and 50 percent $SrF_2$, respectively, with the balance a mixture of $BeF_2$ and $AlF_3$. Melting point of the higher strontium glass was relatively low (<900 C). That of the other was 925 C. Solubility of these glasses was about two percent on a four-hour exposure to boiling water.

## BIOLOGY AND MEDICINE - 06 PROGRAM

## TERRESTRIAL ECOLOGY - EARTH SCIENCES

### Geology and Hydrology

In the application of the "Steady Flow in Soils" computer program to ground water flow problems occasional instability is encountered. This condition is responsible for oscillation as the program over-corrects in the iterative solution of the non-linear equation, resulting in excessive computation time. A study was made of methods to prevent and control this instability. Two methods were found that may be utilized. The first requires alteration of the order of calculation through the matrix, the calculation commencing at the point of maximum instability and proceeding outward toward the boundaries. The second method utilizes an under-relaxation factor, which tends to damp the oscillation. A determination was made of the optimum under-relaxation factor based on the number of iterations required. For the steady flow program the optimum under-relaxation factor was found to be 0.75. The two methods developed appear capable of controlling the oscillation problems that have thus far been encountered.

Field experiments were initiated to study utilization of a commercial well packer for measuring permeabilities in soil near a well. The interpretation of the experimental data to calculate permeability requires solution of the three-dimensional flow equation within the boundary conditions imposed by the packer experiment. Both analytical and numerical solution methods are being investigated.

Five of the sixteen wells on Project CAE-921 are complete. About 30 percent of the estimated total footage is now drilled although about 60 percent of the time for project completion is past. The slow progress continues to delay other work dependent on it for information.

Well 699-53-55 encountered basalt at a depth of 304 feet rather than at 150 feet as predicted. The well was completed at 455 feet. Comparison of the log of the well to the log of well 299-E33-12 in 200 East Area and to the stratigraphy of Gable Mountain disclosed that at least one basalt flow is missing and probably eroded. Sediments lying above basalt in well 699-53-55 are probably in part equivalent to Ellensburg interbeds rather than Ringold sediments. Basalt interflow zones, sometimes including interbeds, are confined but permeable aquifers at Hanford. Hence, ground water movement into or out of the basalt series may be possible there, depending on the potentiometric heads.

The bearing and extent of the erosional channel and the known structures are being studied to determine the full significance of the anomaly. Ground and airborne magnetometer surveys are being reinterpreted.

## Soil Chemistry and Geochemistry

The cesium capacity in the absence of competing sodium was determined to be 135 meq/100g for clinoptilolite, 250 meq/100g for Decalso, and 50 meq/100g for Linde 4A zeolite. The capacities were determined from the 50 percent breakthrough points of column experiments utilizing sodium-base zeolite and 0.01 N $Cs^+$ solutions. The effect of sodium concentration on the cesium capacity of Decalso and clinoptilolite was determined in similar experiments, using 0.01 N $Cs^+$ solutions containing different amounts of sodium. The cesium capacity of Decalso is greater than that of clinoptilolite at sodium concentrations less than about 0.05 N. At higher sodium concentrations the greater cesium selectivity of clinoptilolite causes a reversal of this position and clinoptilolite has a greater cesium capacity than Decalso.

## Field Apparatus Development

The vertical well current flowmeter was completed and laboratory-calibrated. In trials with the previously mentioned well logging line hoist, it was determined that a higher voltage power supply would be needed to drive the unit through the cable furnished with the well logging line hoist. Currently the new power supply is being assembled to permit use of the vertical well current flowmeter with the well logging hoist.

Additional tests of the well packer were performed to establish its versatility and limitations in measuring piezometric head differences. Some difficulty with packer inflation over a period of several days was traced to particulate material lodged in the check valve seat. Other than this the equipment has operated entirely satisfactorily. Only small piezometric head differences were measured in a well which has an indicated vertical flow of 200 cc/min.

## Silicon Diode Detectors

The Ortec solid state diodes have been found to be superior to the Frisch grid ion chambers for certain special applications. A 3.5 mm diode and low-noise pre-amplifier system designed for analytical applications at the Purex plant was successfully used for alpha energy analysis of samples measuring 15 rep/hr. This high tolerance for beta activity exceeds that of the Frisch grid ion chamber by a factor of about $10^3$. The detector also has value for low level sources. The background of a 7 mm diode is 0.3 counts/1000m/170 kev, compared to 40 for the Frisch grid ion chamber, a reduction of about $10^2$. The only disadvantage of the solid state diode is its low counting efficiency, especially with any but small area sources. The efficiencies of several diodes for two of the smaller source sizes are tabulated below:

| Diode Dia. (mm) | Counting Efficiency - (Percent) 1/8" dia. Source | 1/4" dia. Source |
|---|---|---|
| 3.5 | 12 | 2.5 |
| 7 | 30 | 10 |
| 14 | 40 | 30 |

Columbia River Sediment Studies

Although much of the bottom of the Columbia River contains very little sediment, some sediment cores 22 inches long have been obtained from the pool behind McNary Dam. These cores were quickly frozen to minimize radioisotope movement and analyzed in the laboratory. The long-lived isotopes Mn-54, Zn-65, Co-60 and Cs-177 were measurable throughout the length of the core. One of the cores showed a minimum of activity at a depth of about 17 inches, which indicates a widely varying rate of deposition of radioisotopes. Radioisotope ratio measurements indicate that the core represents the accumulation of about four years. More cores will be taken at greater depths to help determine the rates of build-up and radioisotope content.

## ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Radioisotopes as Particles and Volatiles

Further study of the equation for thermal deposition of particles in a conduit derived earlier, and discussed in last month's report (HW-70658C), revealed a group of dimensionless terms which could be replaced by the Fanning friction factor. The resulting expression for particulate deposition is materially simplified. An equation was derived for the mean temperature in the duct and thus avoided the need to approximate this parameter. It was noted, however, that the approximation did not seriously affect the result of the calculation of thermal deposition.

The vapor condensation aerosol generator recently fabricated was used to generate aerosols of stearic acid, ammonium chloride, and triphenyl phosphate. Size distributions of the aerosols thus generated were wider than that anticipated and which will be needed in subsequent tests on particle deposition.

Radiation Protection Studies

In the current studies of radiation protection of erythrocytes, it has been assumed that the initial site of cell damage is the cell membrane. An experiment was designed and carried out to test this assumption. Since erioglaucine does protect the cell from hemolysis and yet appeared not to penetrate into the cell, actual measurements of erioglaucine in the cell contents were made. The concentration of erioglaucine in the cell was less than one percent of the concentration outside the cell, a value too low to offer the protection observed unless the cell membrane is the site of initial damage and protection.

W. H. Reas

Manager
Chemical Research and Development

WH Reas:cf

# BIOLOGY LABORATORY

## A. ORGANIZATION AND PERSONNEL

Dr. Frank P. Hungate, Manager, Plant Nutrition and Microbiology, started a one year leave of absence to accept an assignment with the IAEA in Athens, Greece. R. T. O'Brien will be Acting Manager during his absence until February 28, 1962, at which time R. L. Uhler will assume the duties until Hungate's return next fall.

## B. TECHNICAL ACTIVITIES

### FISSIONABLE MATERIALS - 02 PROGRAM

#### Effect of Reactor Effluent on Aquatic Organisms

Columnaris

The study of the effect of fish population density on the incidence of columnaris infection continued to show that this disease tended to be less of a problem when the fish were less crowded. Four different initial populations of fish were held in troughs supplied with regular Columbia River water. To date those with the greater populations of 900 and 450 have experienced the greatest mortalities of 4.7 and 4.4 per cent, respectively. The lesser populations of 150 and 50 have experienced no mortality to date. (Infection arises from columnaris endemic to the river and present in the water supply.)

Fish samples from the Yakima River and Hanford Slough were negative for columnaris. However, minnows from the Hanford Slough which were placed in laboratory troughs promptly came down with the disease. The incidence of infection among larger fish in the 146 building ponds is higher this year.

#### Population Dynamics - Waterfowl

Observations of gulls banded at Hanford have been reported from Vancouver, British Columbia. Indications are that a major portion of the young gulls produced on the Hanford Reservation migrate northwest and then westward to the Pacific Coast. Significant numbers of ban returns were also received from southern California.

### BIOLOGY AND MEDICINE - 06 PROGRAM

#### Strontium

Two miniature swine were added to the chronic toxicity study at a daily feeding level of 625 μc (five times the present highest level of 125 μc/day). It is expected that this level will produce hematopoietic damage in a relatively short time.

Analysis of the data from the experiments on $Ca^{40}$, $Ca^{45}$ and $Sr^{85}$ binding in serum is nearly complete. The results obtained supported the earlier experimental findings in that not all of the serum calcium was exchangeable with in vitro-added $Ca^{45}$. In addition, there was a definite pH effect upon the

relative ultrafiltrabilities ($\frac{\text{nuclide/ml ultrafiltrate}}{\text{nuclide/ml serum}}$) of the nuclides. With a serum pH of 6.8 the ultrafiltrability of in vitro-added $Ca^{45}$ was 1 to 1.3 times that for serum calcium as compared to values of 1.3 to 1.5 times serum calcium for $Sr^{85}$. At a pH of 7.7 the values for ultrafiltrable $Ca^{45}$ and $Sr^{85}$ were 1.2 to 1.5 and 1.8 to 1.9 times serum calcium, respectively.

Additions of $CaCl_2$ to the serum did not have an appreciable effect upon the above relationships whether the $CaCl_2$ was added 24 hours before or immediately after the $Sr^{85}$ and $Ca^{45}$. However, additions of $CaCl_2$ at each of the three pH levels used resulted in a lower per cent ultrafiltrability for each of the nuclides. In relation to this, the concentrations of inorganic phosphate in the ultrafiltrates were appreciably lowered by additions of $CaCl_2$. At the serum pH values of 7.3 and 7.7, the concentrations of calcium and inorganic phosphate in the ultrafiltrates could be approximated using solubility products for $CaHPO_4$ and $Ca(PO_4)_2$ derived from the data. Considering the electrolyte content of serum, these values of $3 \pm 1 \times 10^{-7}$ and $4 \pm 2 \times 10^{-26}$ for the respective products $[Ca^{++}][HPO_4^{=}]$ and $[Ca^{++}][PO_4^{=}]^2$ compared well with those reported by other investigators. At the serum pH of 6.8 the product for $CaHPO_4$ was reasonably satisfied but the concentrations of calcium and inorganic phosphate were too low to result in formation of $Ca_2(PO_4)_2$. These data suggest that the formation of calcium phosphate complexes in the blood of living animals may serve in addition to blood protein in regulation of the ionic calcium and phosphate levels.

Studies are in progress to determine the effect of varying levels of the alkaline earths in the perfusion fluid upon in vivo absorption of $Sr^{85}$ and $Ca^{45}$ from the small intestine of the rat. Earlier results which indicated a greater effect of Ca on $Ca^{45}$ absorption than on $Sr^{85}$ absorption were confirmed. Thus, the ratio of $Sr^{85}/Ca^{45}$ absorbed increases as the level of added Ca is increased from 0 to 25 mM. The effect of added strontium is less than that of Ca. This is true in the case of both $Sr^{85}$ and $Ca^{45}$. Relative effects are the same for both isotopes so that the ratio of $Sr^{85}$ to $Ca^{45}$ absorbed does not change with strontium level over the range of 0 to 25 mM. Preliminary indications are that the effect of magnesium will be different from that of either calcium or strontium.

Iodine

The amount of $I^{131}$ excreted by swine in urine and feces is being determined. The following concentrations were observed about 20 hours after the daily feeding of $I^{131}$:

| | Feces (wet wt.) | Urine |
|---|---|---|
| Swine | $4.9 \times 10^{-4}$ μc/g | $3.6 \times 10^{-4}$ μc/ml |
| Sheep | $14 \times 10^{-4}$ μc/g | $4.0 \times 10^{-4}$ μc/ml |

Ruminants, as previously reported, excrete a large proportion of the radioiodine via the feces. Swine, like man and many other monogastric animals, excrete most of the $I^{131}$ via the urine. This is not readily evident from the above chart unless one realizes that swine excrete, on a weight basis, about five times as much urine as feces.

## Neptunium

Some data are now available on the effect of valence state on gastrointestinal absorption of $Np^{237}$ in the rat. Solutions thought to contain predominantly Np(IV), Np(V), and Np(VI) were absorbed to the extent of .3, 1.1, and 2.3 per cent, respectively. In all cases citrate was present in order to enhance solubility. Valence state was deduced from previous chemical treatment and not confirmed by analysis. Further studies in the absence of citrate and at much lower mass levels will be conducted employing $Np^{239}$.

## Plutonium

Considerable difference is observed in the response of swine to intradermal injections of plutonium. On a given pig, however, it is possible to differentiate during the most reactive phase (i.e., the second month) between the 5 μc, 1 μc and 0.2 μc sites.

In an attempt to evaluate our in vivo counting methods, pig skin was injected at measured depths with measured amounts of plutonium. The skin was then removed, monitored, submitted to Internal Dosimetry for in vivo counting and was analyzed radiochemically. The Biology in vivo counting method was fairly effective up to a depth of 4 mm, which is the depth used in our intradermal studies. At depths of 8 mm or more, neither in vivo method was accurate, although that used by Internal Dosimetry was considerably more effective than Biology's.

Further data were obtained on dogs killed 30 days after inhalation of plutonium nitrate. In all three dogs tested the lung contained 64 to 72 per cent of the body burden, the liver 9 to 17 per cent, and the skeleton 15 to 20 per cent. Less than 1 per cent of the total deposited dose was excreted in urine. During the fourth week after exposure daily urinary excretion amounted to about 0.01 per cent of the body burden. Three other dogs were injected intravenously with solutions of plutonium nitrate to compare distribution and excretion with data obtained in the inhalation study.

All 27 dogs alive 21 months after inhalation of $Pu^{239}O_2$ were given thorough physical examinations. Only a few showed abnormal respiratory rates, but all have low blood lymphocyte levels.

It has been found possible to prepare a plutonium solution in such a form that approximately 90 per cent of an intravenous dose is deposited in the liver of rats. This plutonium, presumably of a colloidal nature, is not appreciably affected by subsequent DTPA treatment (less than 5 per cent removed). There is, however, some translocation to bone.

## Radiation Effects on Cells

The mitotic cycle of the pea root meristem has been resolved as follows: pre DNA synthesis three hours, DNA synthesis 4.5 hours, post DNA synthesis 2.25 hours and 2.25 hours for mitosis. Entrance into mitosis is inhibited by 800 r and partially inhibited by 400 r.

## Radiation Effects on Insects

Results from X raying different life cycle stages of Tribolium indicate that the doses required to induce sterility and lethality widely diverge at the white pupal stage. The sterilizing dose is consistently below that inducing lethality.

A gross morphological abnormality was found in an immature Tribolium pupa. Genetic tests were performed to determine if it was an inheritable mutation. Results showed it was not.

## Microbiological Studies

Studies on the mechanism of action of X rays on the yeast cell membrane indicate that permeability changes are all or none. That is, each cell has a threshold which much be exceeded before the membrane becomes permeable allowing cell contents to leak out. This is similar to effects seen with mercury-treated cells. Since mercury reacts specifically with membrane SH groups, it is suggested that X rays act on the same sites.

## Plant Ecology

Cesium-137 values in dried milk products from ten milk sampling stations in the northwestern United States were grouped according to biologic landscape units and tested statistically to determine whether these units are useful in interpreting the geographic distribution of $Cs^{137}$ in dried milk.

The results indicate significant differences between the milk sampling stations in coniferous forest, praire grassland and sagebrush vegetation zones. The differences on $Cs^{137}$ content is attributed largely to the precipitation features of these vegetation zones.

## Project Chariot

Collections were made of tundra vegetation and samples of caribou flesh, bone, antler, organs and stomach contents for radiochemical analyses of fallout products.

Permanent plots were established in a lichen community grazed by caribou. Analyses were made of the standing crop on species, weight, canopy coverage, and grazing utilization. These plots will provide a basis for future measurement of productivity.

Analyses of water from ponds and streams showed a marked difference in the chemical properties of the water from one pond (Pond 1) compared to others in the Cape Thompson area. Iron, magnesium and sulfate values were from 2 to 23 times higher in this pond compared to the others. Studies are in progress to determine if there are differences in the plant and animal populations associated with these water chemistry differences.

R. C. Thompson

BIOLOGY LABORATORY

RC Thompson:es

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C. Lectures

a. Papers Presented at Formal Meetings

R. O. McClellan, "Biological effects of $Sr^{90}$ in miniature swine," August 22, 1961, American Veterinarian Medical Association Convention, Detroit, Michigan.

b. Seminars (Off-Site and Local)

University of Washington Summer Institute held in 100-F Area, August 8-9, 1961:

E. Jane Coleman - "Autoradiography"
R. T. O'Brien - "Permeability changes or catalase"
R. O. McClellan - "Large animal research"
W. J. Bair - "Radioactive Particle Inhalation Studies"
P. A. Olson - "Effluents and river fish"
J. E. Ballou - "Typical experiment on internal emitter"
R. C. Thompson - "Problems of internal emitters

AEC Health Physics Fellowship Program - 300 Area - August 1961

W. J. Bair - 8/7/61 - "Inhalation problems"
F. P. Hungate - 8/14/61 - "Genetic effects"
R. C. Thompson - 8/21/61 - "Internal emitters"

Hanford Seminar for Science Teachers - 300 Area - August 28-30, 1961

W. J. Bair - "Inhalation studies of internal emitters"
R. C. Thompson - "Brief history and trends of research at Hanford"
J. E. Ballou - "Small animal studies with internal emitters"
W. H. Rickard - "Ecological problems"
J. Van't Hof - "Methodology for the study of radiation effects at the cellular level"
L. A. George - "The effects of whole body or localized radiation exposure of animals"

Others:
L. A. George - "Biological effects of radiation," 8/9/61, participants in First-Line Management Program, HAPO, 700 Area.
F. P. Hungate - "Calcium-strontium uptake in plants," 8/3-4/61, Oregon State College, Corvallis, Oregon.

c. Seminars (Biology)

Dr. W. S. S. Jee, August 15, 1961 - from the University of Utah - "Bone Autoradiography"

d. Miscellaneous

R. E. Nakatani, August 4, 1961 - "Fish of the Columbia River" - YMCA Day Camp, Columbia Park.

D. Publications

a. HW Documents

Bair, W. J. and D. H. Willard, "Plutonium inhalation studies. III. Effect of particle size and total dose on retention and translocation," Document HW-68645, March 1961.

b. Open Literature

Bair, W. J., "Deposition, retention, translocation and excretion of radioactive particles," in Inhaled Particles and Vapours, Pergamon Press, pp. 192-208, (Proceedings of Symposium held in Oxford, England, April 1960) (1961).

Willard, D. H. and W. J. Bair, "Behavior of $I^{131}$ following its inhalation as a vapor and as a particle," Acta Radiologica 55, 487-496 (1961).

Hackett, Patricia L., L. A. George, C. M. Barnes, and L. K. Bustad, "Changes in blood constituents in sheep after thyroidectomy," Am. J. Physiol. 200, 1011-1012 (1961).

# OPERATIONS RESEARCH AND SYNTHESIS OPERATION
# MONTHLY REPORT - AUGUST, 1961

## ORGANIZATION AND PERSONNEL

Dr. J. B. Goebel joined the Operation on August 4, 1961, as a mathematician and has been assigned to the Experimental Statistics function.

Mr. R. L. Buschbom went on leave of absence on August 31, 1961, to start work on a master's degree in Biometrics at the University of California.

## OPERATIONS RESEARCH ACTIVITIES

### Input - Output Model

Learning curves for the irradiation process and for HAPO as a whole have been developed. The question concerning the effect of additional facilities on the operational learning curve has been resolved. The relative importance of (1) adding facilities, (2) consolidating overhead, and (3) reducing operating cost in existing facilities has been studied with regards to their effect on cost learning. The addition of facilities has a major effect on this curve through improved cost efficiency in new facilities.

### HAPO Criteria Study

The third draft was completed and is being reviewed.

## OPERATIONS ANALYSIS STUDIES

### Fuel Element Performance

A report relating in detail the polynomial method of describing fuel element distortion was issued. This method is now being used routinely, and provisions are being made to re-calculate much of the past data.

An investigation was made of the effects of using only the first failure of a multiple failure lot in rupture analyses. The various uses to which rupture data are being put were considered, and recommendations were made of actions to take with regards to data from multiple failure lots in these situations.

Two questions were considered in connection with evaluating the rupture performance of the overbore fuel element: (1) the existence of sufficient overbore channels to demonstrate integrity of the fuel element with rupture free performance prior to a certain date, and (2) how best to utilize existing channels in this regard.

Assistance is being given in the design of a proposed high temperature, high pressure autoclave test to determine autoclave conditions which will better remove potential ruptures. Several important side benefits are expected to be derived from such a test.

Process Tube Corrosion

Assistance is being provided in connection with the process tube leak problem, where the leaks are caused by internal corrosion. Existing probolog schedules call for an excessive amount of probologging in order to insure that potential leakers are removed. Attempts will be made to derive an equally effective schedule which requires less probologging.

Information Systems Studies

Debugging and testing activities of the Z-Plant computer continued in preparation for the operational test.

At a meeting of AEC and EDPO representatives with representatives of the General Electric Computer Department, the questions of the operational date of the computer and the time at which the lease agreement was to start were satisfactorily negotiated.

Reliability Studies

At the request of a member of Irradiation Processing Department, work was begun on a reliability analysis of various instances of trip logic of the kind generally known as "majority gate" logic.

Diffusion Studies

Comparison tests are being conducted on two different IBM-7090 Programs, which have been written to obtain numerical solutions to transient-state nonlinear diffusion problems. Preliminary results indicate that both methods exhibit excellent stability characteristics, but that they differ markedly in their convergence rate depending upon the type of boundary conditions imposed by the problem.

Inventory Studies

A meeting was held to answer some further questions concerning the implementation of inventory sampling.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Data are being analyzed to obtain an estimate of the canning conditions leading to optimum quality of the eight-inch I and E fuel elements. The

cuboctahedron design employed in this test covers the same sets of conditions previously used for four-inch and six-inch fuel elements. Between test comparisons will also be made.

Several sets of calibration data relating film density to fuel element cladding thickness were fit. These were based on different film exposure times. The best curve for predictive purposes was then selected, where this choice depends on the residual error and the parameters of the model.

Consulting services were provided in connection with selecting an appropriate sampling plan. Fixed sample size plans were compared with sequential plans.

Irradiation Processing Department

Three alternate sequential sampling plans were computed for use in the sampling of splines. This was in response to a request to determine how large a sample is required to be defect-free before a lot can be considered acceptable.

Work continued on the problem of constructing a stochastic model of within-pile neutron flux in the presence of neutron sinks. The model, when constructed, will serve to aid in the minimum cost within-pile detection of

[redacted]

Somewhat incomplete failure data for jumpers used in the separations processes indicated that they probably can be described by the Weibull distribution. A memo was prepared presenting this distribution, indicating how to estimate its parameters, once the data are more complete, and pointing out how to interpret the results.

Calculations to demonstrate conformity to specifications were completed for parts shipped during the second quarter of CY-1961. The delay was due to instrument difficulties in measuring isotopic content.

An investigation was made of the relationship between part density and impurity content, and between normal shrink and impurity content for special

in the 284-E and 284-W Powerhouses. Results indicated that one type of coal had a significantly lower burning efficiency than the other types, but only when burned in the 284-W Powerhouse. There was no indication of significant differences in efficiency among the remaining types of coal. Further investigation indicates that the difference probably arises from differences in design of two of the boilers in 284-W.

Work continued on the problem of providing a queueing theory model of motor vehicle usage in the 200 Areas.

Analytical and consulting services continued in connection with the development of a tape controlled guiding mechanism for the Gorton lathe.

Contract and Accounting

Several meetings were held with representatives of Business Systems Development Operation to discuss the development of a linear programming model of the fuel element fabrication and scheduling process.

## STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

### 2000 Program

### Fuels Development

Consultations were held on methods of taking and analyzing data which would serve to characterize the cross sectional and axial warp of long fuel elements before and after irradiation.

### Chemical Development

An attempt is being made to develop an efficient and reliable routine which will obtain the solutions to a set of nonlinear algebraic equations. The problem is a repetitive one, the answers serving to characterize the distribution and form of the various elements involved in a specific chemical process.

The statistical evaluation of various recording instrument calibration experiments continued. A more sophisticated form of the temperature correction function for the mid-column photometer was estimated from experimental data. This function includes the effect of an incremental change in standard water temperature. The calibration function for the rotometer, which expresses flow rate as a function of solution density, bob position as measured by a voltage ratio, and the air system zero pressure flow setting was estimated from suitable experimental data using the NELLY nonlinear least squares routine.

Preliminary analysis of the absorptiometer calibration experiment data was begu[redacted]erence cell data are being analyzed to determine the degree of

instrument drift during the course of the three-day experiment. The magnitude of this drift will govern the method of correcting sample cell voltages to a nominal level using an as yet undetermined time average of the reference cell values. Several discussions were held concerning the estimation of the unknown parameters in the differential equation system, which expresses the mass transfer of uranium in the column as a function of vertical position and time.

Reactor Effluents Studies

The past work on this program is being reviewed in anticipation of meetings with Chemical Research personnel to discuss additional assistance to the program.

4000 Program

Swelling Studies

Void fraction and void density estimates were calculated on the IBM-7090 for all fission gas pore size distributions currently available. BIMD analysis of variance routines are being used to investigate the effect of burnup, axial position, annealing temperature and annealing time on the void fraction and the void density for each distribution. Analysis is in progress to determine the functional form of pore size distributions with hopes of expressing the effect of the above mentioned variables in terms of shifts of appropriate distributional parameters which have physical significance.

Plutonium Recycle

Statistical analysis was completed of the OD fluorescent penetrant nondestructive test data and the final results of the analysis conveyed to interested persons.

6000 Program

Biology

Work continued on the problem of constructing a mathematical model of the response of Tribolium confusum, and Tribolium castaneum to low level irradiation.

A statistical analysis was made to investigate the existence of an association between rainfall and cesium content in milk and vegetation zones. The hypothesis of zone effects in both rainfall and milk sampling data was tested and further analysis also carried out to determine if a direct association could be proved.

Geochemical Research

An attempt is being made to obtain the solution to a multiregion potential problem. The problem arose during the design of an experiment to measure the permeability of a particular subsurface stratum.

General

Radiation Protection

The calibration equation previously studied represents the average data for gamma shielded and gamma open window readings very well through the range 15 mr - 5000 mr. It is less satisfactory for beta readings.

The film badge pencil data for a sample of HAPO people have been transcribed onto IBM cards, and initial screening experiments and correlation studies are currently in process. The exact direction and degree of future analysis will depend on the outcome of these runs.

Atmospheric Diffusion Studies

A review was initiated of the methods of statistical analysis used in the diffusion experiments data to obtain downwind cross section profiles and meteorological parameters expressing the diffusion and deposition as a function of distance from the source. A time average model expressing the total amount of material passing a given position downwind should correlate more closely with experimental data than an instantaneous Fickian diffusion model modified for ground perturbations. Appropriate mathematical development is underway to construct such a model.

Instrumentation

Statistical analysis of data from the Schaevitz system calibration study conducted by Instrument Research and Development Operation was completed. Calibration curves with their appropriate confidence intervals were determined for the Schaevitz system on three different scales. Statistical methods used in the analysis were outlined to personnel of Instrument Research and Development Operation so that in the future data for similar calibration studies can be submitted directly to Data Processing.

Precision and accuracy study of a quantitative colorimetric method for boron analysis was completed. In addition to the precision and accuracy of the method, the heterogeneity in the boron content of the samples submitted for analysis was estimated.

Division of Research Programs

Work continued on the correction of program data in the IRA master file. A procedure was devised and the logic of a computer program written out for the quantitative reduction of a set of time dependent multichannel energy spectra.

Instrument Research and Development

Work on the IBM-7090 program to compute the longivity of neutron flux monitors as a function of their isotopic constituents is nearing completion and is soon to be turned over to Instrument Research and Development Operation for their use [redacted]n studies.

Coatings and Corrosion

A test was designed to evaluate the effects of using slight amounts of chromic acid in the autoclave as a corrosion inhibitor. Various autoclave times and temperatures will be utilized in the test.

Methods Development

Further modifications were made in NELLY, the HLO version of the Los Alamos nonlinear least squares routine discussed in Los Alamos document LA-2367. The modifications allow for the use of the monotone convergence option and the quadratic gradient option in conjunction with the restriction of parameter signs option. A second modification involves a change in the stopping rule from one based on distance moved in the parameter space to the degree to which the normal equations are satisfied.

The complete series of BIMD statistical routines have arrived from Western Data Processing Center and a number of these have been transcribed from magnetic tape to cards. To date, a screening routine and two analysis of variance routines are operational on the IBM-7090.

Work continued on the bibliography of statistical techniques for the reduction of composite distributions. In addition to searching on-site literature, a number of off-site requests for specific periodicals have been made, and copies of the relevant ones attached to the bibliography. Material is being organized for ready reference to specific kinds of composite distributions which arise in connection with Hanford problems.

Manager
OPERATIONS RESEARCH AND SYNTHESIS

CA Bennett:dgl

# PROGRAMMING OPERATION
# AUGUST, 1961

## I. REACTOR DEVELOPMENT - 04 PROGRAM

### PLUTONIUM RECYCLE PROGRAM AND SPECIFIC FUEL CYCLE ANALYSIS

At the expense of all other plutonium recycle studies, an accelerated program was undertaken in which plutonium values were computed for a variety of reactor cases and economic conditions. Although the data are still regarded as very preliminary and an estimated six months will be required in order to check and explain the results, a preliminary report was sent to Washington, D. C., on August 11, and discussions were held with personnel from the Divisions of Reactor Development and Operations Analysis in Washington on August 27-28, 1961.

A summary of the most pertinent observations from the report is as follows:

1. Reduction of the amount of U-238 in fuel elements allows better use of Pu-240 and elevates plutonium values, possibly to $20/gram fissile in thermal reactors.

2. Plutonium values vary with reactor type and fueling strategy to such an extent that a single value is hard to establish for a given isotopic plutonium composition. Of five prototype reactor studies (PWR, Gas-Cooled, BWR, $D_2O$, and Organic) at full U-238 concentrations the values varied from $14 to $8/gram fissile, in the order listed. Variation of U-238 concentration raises these values and appears to reduce the variance between reactors.

3. Phoenix fuels will have high values over and beyond central station power uses.

4. Reactor zoning tends to eliminate adverse effects on plutonium value caused by any penalties involved with plutonium toxicity.

5. Change in price of fully-enriched uranium has been shown to be the major impact of altered uranium price schedules on plutonium values.

6. Plutonium-242 detracts from plutonium values and simple formulation of a negative term for this effect appears possible.

7. The thorium and U-238 systems are remarkably parallel in isotopic sequence and over-all neutron balance. The resulting value differences are not as great as casual analysis indicates. Two major aspects bringing the values of U-233 and plutonium together are the high plutonium cross sections which enhance U-238-plutonium values and the relatively long half life and high cross section of protactinium-233 (precursor of U-233) which detracts from the value of Th-232-U-233 systems. Crossing the progeny of the two systems may be the best method of maximizing the values of each, as previously reported under Combined Fuel Cycles.

Of the foregoing results, the alteration of U-238 concentration in fuels with plutonium enrichment is possibly the most important point. It appears that plutonium is penalized when substituted for U-235 enrichment in an optimized U-235-U-238 fueled reactor without readjustment of the U-238 concentration to account for the special properties of plutonium. It follows then, that most of the plutonium values quoted to date by various analysis groups are low because such studies do not appreciably alter the concentration of U-238, even though the fissile enrichment level in U-238 is adjusted. To maximize the productivity of plutonium enrichment, the U-238 concentration usually must be reduced to bring about optimum neutron absorption levels in Pu-240 and U-238. Reduction in U-238 concentration also allows fuller utilization of the high absorption cross section of the plutonium isotopes. Analysis of the concentration effect requires an extensive increase in computation, but appears mandatory as incomplete data developed to date indicate that plutonium values of $20/gram fissile may result. Another possible advantage of reduced U-238 concentration in fuels may result from allowing greater versatility of fuel element make up and design which would reflect in further productivity increase.

Of the available computed HLO data, the best comparative set of plutonium values is being developed with the CHAIN MELEAGER code. This code involves "linking" or "chaining" appropriate codes so that they can be called into the computer's rapid access memory from standby magnetic tapes as needed. The chain consists of the following major programs:

1. MELEAGER - to supply the physics data.
2. QUICK - to supply the cost data by operating on MELEAGER results.
3. MINIMIZER - to determine the minimum fuel cost.
4. PUVE - to establish the plutonium value resulting from an appropriate recycle sequence.

The computer operating sequence starts with uranium enrichment of the reactor; and the plutonium ashes from this are used to enrich the next cycle (with supplementary U-235 enrichment, as needed) and so on with further cycles until enough statistics can be developed to solve for the plutonium values. Each cycle is chosen at optimum conditions for a set of estimated plutonium prices. The solution (PUVE) determines the plutonium value for the plutonium fuel going into the reactor and for the plutonium removed from the reactor. Due to the isotopic composition changes with irradiation, these ash values are generally not equal. The plutonium values resulting from PUVE are then compared with the estimated values originally assigned for each step in the CHAIN MELEAGER so that minimum cost points could be selected. If sufficient difference exists, new plutonium value estimates are prepared and the chain sequence is rerun until adequate convergence is achieved. Of the data run to date, only one such

iteration was made. Iteration of the rest of the cases is awaiting other data checks to minimize the number of reruns that may be required. Initial results are presented for the following five generalized reactor types:

APWR - Advanced Pressurized Water Reactor (As described in TID-8502.)

BWR - Boiling Water Reactor (A generalized description.)

OMR - Organic Moderated Reactor (As described in TID-8501.)

$D_2O$ - Deuterium Oxide Moderated (With zirconium tubes - a general type.)

Gas Cooled - Gas Cooled Graphite Reactor (General type patterned after "Bradwell".)

Plutonium values are listed for the plutonium composition that results from various cumulative exposures with U-238 measured in megawatt days per ton of U-238. This tabulation is used because exact matching of plutonium compositions for the various reactors is not possible. Table I lists the plutonium values for batch cycles in the various reactors with the plutonium compositions selected in descending order of relative Pu-239 concentration for each of three cumulative exposures: 15,000; 30,000; and 60,000 megawatt days per ton. Plutonium compositions as a function of exposure match the best for the APWR I, BWR I, and $D_2O$ II runs. Note, also, that the plutonium values for these are between \$11.00 and \$13.60 per gram fissile as nitrate. The Gas Cooled reactor yields the highest values and the Organic reactor the lowest values. APWR II is a rerun of APWR I using the resulting APWR I results as plutonium value estimates in APWR II. The difference in results is significant and all cases should be iterated. This was not done in the short time available in order to increase the scope of the evaluations for the five reactor types as follows:

| | | Applied AEC Use Charge %/yr | |
|---|---|---|---|
| APWR I | - Batch | 4.75 | |
| APWR II | - Batch | 4.75 | (Iteration I) |
| APWR III | - Batch | 12.5 | |
| APWR IV | - Batch | 4.75 | (Delta* Pu FEFJ = \$45/lb of U) |
| BWR I | - Batch | 4.75 | |
| BWR | - Graded | 4.75 | |

* Delta Pu FEFJ = Fuel element fabricating and jacketing costs for plutonium enriched fuel minus the corresponding costs for uranium enriched fuels.

| | | Applied AEC Use Charge %/yr | |
|---|---|---|---|
| $D_2O$ I | - Batch | 12.5 | |
| $D_2O$ II | - Batch | 4.75 | |
| $D_2O$ | - Graded | 4.75 | |
| Organic | - Batch | 4.75 | |
| Gas Cooled I | - Batch | 4.75 | |
| Gas Cooled II | - Batch | 4.75 | (Reduced moderator; i.e., tight lattice.) |

Table II shows that increasing the fuel use charge from 4.75 to 12.5 percent decreases plutonium values somewhat. These values, of course, are not iterated with better estimates from PUVE, and other analyses where this has been done show less variation with the interest rate. Increases in fuel cost with higher interest rates is its greatest effect, as shown at the bottom of Table II. Of more impact to plutonium values is the effect of batch and graded fuel cycles that is shown for the BWR and $D_2O$ machines in Table III. In this instance, a definite reduction in plutonium value is observed. Note, also, that the fuel cost for graded cycles is less than for the batch cycles for these reactors. The validity of the results cannot be supported by consistent argument at this time. Additional study of the differences between batch and graded must be made. One major difference is the reduction of enrichment level with batch cycles which softens the neutron spectra and thereby reduces the plutonium cross sections. It is suspected that results using optimized U-238 densities for each step will bring the plutonium values together for batch and graded cycles in the same nuclear reactor.

As plutonium recycle is continued, the isotopic density of Pu-239, 240, and 241 reaches a psuedo equilibrium value relatively soon (30-50,000 megawatt days per ton cumulative) Pu-242 continues to grow in and does not reach equilibrium until fantastic cumulative exposures are achieved as Pu-242 has a relatively low nuclear cross section. Pu-242 is a parasite as far as the fuel cycle is concerned and, as such, detracts from the plutonium value. It was possible, therefore, to correlate the value of recycled plutonium batches with negative contributions for Pu-242.

## TABLE I

### COMPUTED PLUTONIUM VALUES USING MELEAGER CHAIN CODE FOR PROTOTYPICAL REACTORS

| Cumulative Exposure[1] of Recycled Fuel MWD/Ton | Composition of Plutonium in the Reactors at a Specific Exposure (Weight Percent) | | | | Plutonium Values for Indicated Reactors with 4.75% Use Charge (Monetary Value = $/Gram Fissile) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 239 | 240 | 241 | 242 | Organic | APWR I | BWR I | $D_2O$ II | Gas Cooled II | Gas Cooled I | APWR II[2] |
| 15,000 | 79.0 | 10.0 | 10.0 | 1.0 | 9.70 | | | | | | |
| | 69.5 | 18.5 | 10.0 | 2.0 | | 13.60 | | | | | 13.80 |
| | 69.0 | 17.0 | 11.0 | 3.0 | | | 12.60 | | | | |
| | 64.0 | 22.0 | 10.0 | 4.0 | | | | 13.40 | | | |
| | 53.0 | 30.0 | 11.5 | 5.0 | | | | | 14.50 | | |
| | 48.0 | 39.0 | 9.0 | 4.0 | | | | | | 13.00 | |
| 30,000 | 73.5 | 9.5 | 14.0 | 3.0 | 9.00 | | | | | | |
| | 61.5 | 17.5 | 15.0 | 6.0 | | | 12.30 | | | | |
| | 60.0 | 21.0 | 14.0 | 6.0 | | 13.20 | | | | | 13.70 |
| | 54.0 | 25.0 | 12.5 | 8.5 | | | | 13.10 | | | |
| | 44.5 | 30.0 | 13.5 | 12.0 | | | | | 12.40 | | |
| | 35.5 | 43.0 | 10.0 | 11.5 | | | | | | 14.00 | |
| 60,000 | 71.0 | 8.0 | 16.0 | 5.0 | 7.70 | | | | | | |
| | 56.5 | 15.5 | 16.5 | 11.5 | | | 11.10 | | | | |
| | 52.0 | 21.0 | 15.0 | 12.0 | | 11.90 | | | | | 13.30 |
| | 46.5 | 24.5 | 13.0 | 16.0 | | | | 11.90 | | | |
| | 37.0 | 27.0 | 13.0 | 23.0 | | | | | 11.30 | | |
| | 28.0 | 40.0 | 10.0 | 22.0 | | | | | | 13.60 | |
| Fuel Cost in Mills/KWhe for Above Cases = | | | | | 2.70 | 2.38 | 2.05 | 1.90 | 3.06 | 3.44 | 2.41 |

(1) Plutonium values at the same cumulative exposures were determined from actual data plots of chain results.

(2) APWR II is a rerun of APWR I using the plutonium values for I as estimates of value for APWR II. The plutonium compositions are nearly identical.

## TABLE II

### COMPUTED PLUTONIUM VALUES USING MELEAGER CHAIN CODE FOR BATCH CYCLES IN APWR AND BWR PROTOTYPES FOR DIFFERENT AEC USE CHARGES

| Cumulative Exposure MWD/T | Composition of Plutonium in the Reactors at a Specific Exposure[1] (Weight Percent) 239 | 240 | 241 | 242 | Plutonium Values for Indicated Reactors with Different Use Charges (Plutonium Monetary Value = $/Gram Fissile) 12.5% Use Charge[2] APWR III | $D_2O$ I | 4.5% Use Charge APWR I | $D_2O$ II |
|---|---|---|---|---|---|---|---|---|
| 15,000 | 69.0 | 19.0 | 10.0 | 2.0 | 12.6 | | 13.60 | |
| | 63.0 | 23.0 | 10.0 | 4.0 | | 11.5 | | 13.40 |
| 30,000 | 59.0 | 21.5 | 13.5 | 6.0 | 12.4 | | 13.20 | |
| | 53.5 | 25.5 | 12.5 | 8.5 | | 11.2 | | 13.10 |
| 60,000 | 51.0 | 21.5 | 15.0 | 12.5 | 10.6 | | 11.90 | |
| | 46.5 | 24.5 | 16.5 | 12.5 | | 10.4 | | 11.90 |
| Fuel Cost Mills/KWhe for Above Cases | | | | | 3.11 | 2.20 | 2.38 | 1.90 |

(1) Plutonium compositions are identical as a function of fuel exposure for each reactor type.

(2) 12.5% Use Charge simulates private fuel ownership.

## TABLE III

### COMPUTED PLUTONIUM VALUES USING MELEAGER CHAIN CODE FOR BATCH AND GRADED CYCLES IN PROTOTYPICAL, BWR AND $D_2O$ REACTORS

| Cumulative Exposure MWD/T | Composition of Plutonium in the Reactors at a Specific Exposure (Weight Percent) | | | | Plutonium Values for Indicated Reactors with a 4.75% Use Charge (Monetary Value = $/Gram Fissile) | | | |
|---|---|---|---|---|---|---|---|---|
| | 239 | 240 | 241 | 242 | BWR I | BWR Grade | $D_2O$ Batch | $D_2O$ Graded |
| 15,000 | 69.0 | 17.0 | 11.0 | 3.0 | 12.6 | | | |
| | 64.0 | 22.0 | 10.0 | 4.0 | | | 13.4 | |
| | 61.5 | 20.5 | 13.0 | 5.0 | | 10.5 | | |
| | 59.0 | 26.0 | 11.0 | 4.0 | | | | 10.1 |
| 30,000 | 61.5 | 17.5 | 15.0 | 6.0 | 12.3 | | | |
| | 56.0 | 19.5 | 15.5 | 9.0 | | | 13.1 | |
| | 54.0 | 25.0 | 12.5 | 8.5 | | 9.2 | | |
| | 48.5 | 27.0 | 12.5 | 12.0 | | | | 9.1 |
| 60,000 | 56.5 | 15.5 | 16.5 | 11.5 | 11.1 | | | |
| | 51.5 | 17.5 | 16.5 | 14.5 | | | 11.9 | |
| | 46.5 | 24.5 | 13.0 | 16.0 | | 8.6 | | |
| | 42.5 | 25.5 | 12.0 | 20.0 | | | | 8.3 |
| Fuel Cost Mills/KWhe for Above Cases = | | | | | 2.05 | 1.55 | 1.90 | 1.26 |

The predicted values from the fitted equations show surprising agreement with those from the machine calculations, as shown below for the APWR II and Gas Cooled II which represents the least and greatest error of fit:

| Reactor | Step | Value From Fitted Equation ($/g $Pu_{tot}$) | Value From CHAIN MELEAGER ($/g $Pu_{tot}$) |
|---|---|---|---|
| APWR II | 1 | 10.76 | 10.94 |
| | 2 | 10.01 | 9.92 |
| | 3 | 9.31 | 9.29 |
| | 4 | 8.72 | 8.78 |
| | 5 | 8.27 | 8.19 |
| Gas Cooled II | 1 | 7.76 | 10.02 |
| | 2 | 6.85 | 7.19 |
| | 3 | 6.23 | 6.20 |
| | 4 | 5.74 | 5.73 |
| | 5 | 5.37 | 5.35 |

The results for Step 1 show the greatest difference (especially for the Gas Cooled II results). This is thought to chiefly result from a nonequilibrium-240 situation. Therefore, these equations should not be used for plutonium batches that result from exposures much below 15-20,000 megawatt days per ton, i.e., before establishment of a psuedo equilibrium condition for Pu-240.

The general form of the fitted equations is as follows:

$$\$/g\ Pu_{tot} = K - A(\text{wt. fraction } 242)^n$$

In some cases the value of A showed considerable variance and it was necessary to introduce an exponent for the Pu-242 other than 1.0, to secure values for K and A which were approximately constant.

The set of resultant equations for most of the cases covered by the CHAIN MELEAGER and reported in Tables I, II, and III are as follows:

APWR II $\$/g\ Pu_{tot} = 11.15 - 18.60(\text{wt. fraction } 242)$
APWR IV $\$/g\ Pu_{tot} = 11.15 - 18.60(\text{wt. fraction } 242)$
APWR III $\$/g\ Pu_{tot} = 10.50 - 26.50(\text{wt. fraction } 242)$

BWR I $\$/g\ Pu_{tot} = 10.76 - 37.70(\text{wt. fraction } 242)^{1.2}$

Organic $\$/g\ Pu_{tot} = 9.15 - 76.00(\text{wt. fraction } 242)^{1.15}$

$D_2O$ I $\$/g\ Pu_{tot} = 8.80 - 16.40(\text{wt. fraction } 242)$
$D_2O$ II $\$/g\ Pu_{tot} = 10.70 - 23.25(\text{wt. fraction } 242)$

Gas Cooled II \$/g $Pu_{tot}$ = 8.25 -11.50(wt. fraction 242)(Poorer fit)

BWR Graded \$/g $Pu_{tot}$ = 7.52 -15.50(wt. fraction 242)$^{1.2}$

$D_2O$ Graded \$/g $Pu_{tot}$ = 7.33 -18.00(wt. fraction 242)$^{1.5}$

There are a number of other statistical methods of correlating the data being investigated - many of which will be more informative than the method just shown. Among these is an effort to establish unit values for each plutonium isotope present and, in addition, a term dependent upon the nuclear reactor characteristics which apparently will involve the degree of moderation and the effective moderator temperature.

ANNUAL REPORT

The Plutonium Recycle Program Annual Report for fiscal year 1961 has been assembled and will be issued on September 15, 1961.

## II. OTHER ACTIVITIES

### 1. Radioisotope Production

The incremental cost of neutrons produced in a large reactor was examined for use in the manufacture of special radioisotopes by irradiation. When costs for burnup, fabrication, processing, and use charges were considered for low enrichment fuels, the cost of neutrons was found to be close to \$4,000/gram. This then gives a cost of about \$17/gram of special isotope assuming an atomic weight near 235. This cost is small in comparison with other costs associated with isotope preparation such as the cost of the target material and the special fabrication and processing necessary for these unusual materials.

### 2. Drinking Water Standards

The new Public Health Service Drinking Water Standards as published in the Federal Register include radioactive materials for the first time. Particularly unfortunate is the establishment of a limit based on the concentration of gross beta emitters in drinking water. The gross beta level has long been utilized as an alternative to detailed radiochemical analysis and evaluation as recommended by the NCRP. Use of the concentration of gross beta emitters as a limit poses several problems, primarily because the difference in hazard of various radionuclides is not taken into account and because of the difficulty in measurement and interpretation of measurements.

Although the drinking water in Pasco exceeds the proposed limit for gross beta emitters, 1,000 μμc/l, the dose to the GI tract (critical organ for this mixture of radionuclides) is only about 80 mrem/year compared to a permissible limit of 1,500 mrem/year.

3. Miscellaneous

C. A. Rohrmann presented a lecture on "Special Radioisotopes as Power Sources" for the Ninth Annual Naval Research Seminar at the Sand Point Naval Air Station, Seattle, Washington, August 14, 1961. The audience comprised about eighty Naval Research Reserve personnel from the Thirteenth Naval District.

A report, "Arsenic and Its Radioisotopes in the Environs," was prepared by R. L. Junkins for presentation at the First Symposium on Radioecology, September 10-15, 1961, at Colorado State University.

W. K. Woods

Manager,
Programming

WK Woods:jm

# RADIATION PROTECTION OPERATION
# REPORT FOR THE MONTH OF AUGUST, 1961

## A. ORGANIZATION AND PERSONNEL

Virginia A. Warford was transferred from Internal Dosimetry to the Laboratory Auxiliaries Operation on August 7. Geraldine P. Staats was transferred from Construction Engineering and Utilities Operation to Composite Dose Studies and Records on August 14, replacing Maryann L. Sheldon who resigned from the Company on August 18. Two summer employees, Harold N. Hauser and Calvin E. Gentle, completed their temporary assignments with the Company and resigned effective August 23 and August 30, respectively. James E. Atterberry was transferred from Internal Dosimetry to the Chemical Processing Department effective August 28. Myrtle S. Ghent was deactivated effective July 18 due to personal illness. The work force now totals 134.

## B. ACTIVITIES

### Occupational Exposure Experience

There were four new cases of plutonium deposition confirmed during the month; thus, the total on record is 271, of which 197 are currently employed.

A CPD process operator received a plutonium deposition estimated as 2 percent of the maximum permissible body burden as the result of a contaminated minor injury received at the 234-5 Building on May 31, 1961. Examination of the injury at the Whole Body Counter at that time showed about $2 \times 10^{-3}$ μc plutonium and no medical action was taken.

Biological sample results confirmed that a CPD process operator received a minor deposition of plutonium as the result of the spread of contamination that occurred while he was working in the PR room of the Purex facility last month. The deposition is estimated as less than one percent of the permissible body burden. Another CPD process operator received a plutonium deposition extimated as less than one percent of the maximum permissible body burden as the result of a contaminated minor injury received at the 234-5 Building last month. Examination at the Whole Body Counter indicated that about $3 \times 10^{-3}$ μc of plutonium remained at the injury site after medical excision.

Widespread plutonium oxide contamination occurred during a hood removal operation at the 234-5 Building by construction forces when a cloth tape contamination barrier was inadvertently pulled off the bottom of the hood. Six construction personnel and one GE employee received extensive skin and protective clothing contamination with nasal smears to 1500 c/m. Spot sample analysis for one construction employee who received head, face, and neck contamination greater than 40,000 d/m indicated a deposition in the range of 10 percent of the permissible body burden. According to previous discussions, Industrial Medicine was informed and medical treatment consisting of an expectorant and an intravenous injection of one gram of calcium DTPA was performed. On the basis of initial biological

sample results following the treatment and assuming a conservative factor for the increase in the excretion rate effected by the DTPA, deposition was estimated as less than 5 percent of the maximum permissible body burden. Bioassay was also initiated for the other personnel involved.

Two CPD engineers received whole body exposures in excess of the Hanford operational control when they were exposed to uncontrolled dose rates up to 500 r/hour. The exposure occurred when the men entered a trench to inspect welds on two lines leading to a newly constructed waste crib for the Purex facility. Premature and unauthorized usage of the lines led to the uncontrolled exposure. Evaluation of the film badge dosimeters and analysis of the dosimetry involved indicated that the whole body dose was between 1.7 r and 2.1 r for one employee and between 2.1 r and 2.8 r for the second individual. Previous exposure for this calendar year was negligible for both men.

Routine processing and analysis of the film badge dosimeter for a CPD laboratory technician at the 234-5 Building indicated a dose of 2.1 r for the four-week period. Although a thorough investigation failed to reveal a satisfactory explanation for the exposure, examination of the film indicated that the film density resulted from exposure to penetrating gamma radiation.

The third strontium separation started July 21 at the Hot Semiworks and continued for six days. Air contamination, previously a problem in A sample gallery, was a problem in the B sample gallery on this run. An eight-hour 12,000 cubic foot air sample, taken in the greenhouse in B sample gallery, had a dose rate of 20 rads/hour. The concentration was estimated at $2 \times 10^{-6}$ μc FP/cc. An additiona. cap was placed on a sample riser in the greenhouse to reduce the possibility of a blow-back from the vessel into the greenhouse. The use of an automatic sampler, which sampled every thirty minutes, was discontinued. Contaminated lead bricks were replaced. These remedial actions apparently alleviated the cause of air contamination. Another routine survey, this time in A pipeway, discovered contamination to 40 rads/hour on the floor under steam line number 69. The initial decontamination in dose rates up to 2 rads/hour, including 200 mr/hour, was mildly successful in reducing the contamination to 2.6 rads/hour. A strainer on the steam line was replaced. A plastic washer removed from the line read 300 rads/hour at one inch.

During a power failure on July 30, the deluge sprinkler system in the Critical Mass Facility (209-E Building) reactor room was activated by a pneumatic-controlled valve. Samples of the water standing on the floor indicated the alpha activity concentration was on the order of twice the MPC for plutonium in water. After the room was drained and mopped, alpha activity was detected on the shoe covers and rubbers. Subsequent surveys revealed that the sprinkler water seeped into the fuel pump hood located on the north wall of the reactor room. This water then seeped out between the front panel and the hood frame and dripped into the four inches of water standing on the reactor room floor. The bottom of the hood and the floor below it were contaminated to greater than 40,000 d/m. Visible amounts of fuel had previously leaked from the pump onto the floor of the hood. Hood panel bolts were tightened, the hood exterior and reactor room floor cleaned to nonsmearable and the floor below the hood painted with strippable paint.

The proper valve closing procedure was not followed and resulted in improper routing of 1 WW waste solution from Purex into a transfer line in the 325-A facility. Two employees were exposed to dose rates estimated to be 450 rads/hour for several seconds.

Radiation monitoring efforts at the Plutonium Recycle Test Reactor were largely in support of locating heavy water losses and foreign material in the primary system. Dose rates experienced during removal of two flux monitoring channels included beams up to 230 r/hour and general radiation fields up to 5 r/hour. Tritium air activity in A cell ranged from a maximum of $1 \times 10^{-3}$ μc/cc to less than $5 \times 10^{-6}$ μc/cc. Analysis of samples collected from the effluent stack showed tritium concentrations to $2 \times 10^{-4}$ μc/cc, indicating significant heavy water loss at this source. Twelve bioassay samples of the 232 samples collected for tritium analyses showed a maximum of 7 μc T/liter. This concentration corresponds to a whole body dose of 48 mrem in the following 28 days. On one occasion when the power level was raised from critical to 70 Mw in a short period of time, high air concentrations in the vessel on the order of $10^{-5}$ μc/cc were reflected in the effluent air activity which exceeded the control limit of $5 \times 10^{-5}$ μc/cc for approximately four hours.

The examination of new hires and terminees in the Whole Body Counter is now in place as a part of the routine program.

Environmental Experience

A total of 139 fish comprising twelve species, predominantly whitefish and squawfish, was obtained from routine sampling locations at Priest Rapids, Hanford, Richland, and Burbank. One hundred sixty-eight tissue samples from these fish were prepared and submitted for radiochemical analyses.

Nineteen routine and twenty-three special produce samples were obtained for radiochemical analysis. Routine samples consisted of: milk and pasture grass from Ringold, Riverview, and Benton City areas; ten sets of bovine thyroids; and three samples of Willapa Bay oysters. Special samples consisted of tomatoes, cantaloupes, peaches, beans and wheat from farms in Benton City, Riverview, and Ringold.

Grass in the 300 Area was surveyed for contamination following the detection of a few thousand counts/minute on area lawnmowers. No contamination was detectable on the grass by direct survey. Grass samples were collected for laboratory analysis and no significant amounts of radionuclides were detected during ten-minute counts. Longer counting times indicated the presence in low concentration of a radionuclide which was not identified by the end of the month.

Three routine background aerial survey flights for off-plant locations were made. No significant changes in previous results were noted.

Studies and Improvements

Fluorescein dye was introduced into the Plutonium Recycle Test Reactor aqueous effluent in order to determine the distribution of the waste stream in the river. Visual observation showed that the waste stream stayed in a narrow band along the west bank of the river as far south as Van Giesen Street at Richland. Analytical measurements on the concentration of dye in the river water are not yet complete but they were lower than anticipated due to insufficient dye and too slow a rate of addition. Also, the PRTR experienced an unscheduled shutdown at the time of the test and, therefore, thermal effects on effluent distribution were not observable. River water was sampled on five cross sections between the 300 Area and Pasco. Analytical measurements on dye content were not completed at the end of the month.

A special sample of Columbia River water was shipped to the Southwest Radiological Health Facility, USPH, at Las Vegas, Nevada, at their request. One-half of the sample was retained for radiochemical analysis by the Radiological Analysis Operation for comparative results. The primary purpose was to assist the former group in setting up analytical methods for the determination of radionuclides in river water.

Work was continued on a detailed review of the Columbia River and sanitary water monitoring program. Substantial modifications are being considered.

Forms were received from 105 fishermen contacted by the local Game Protector along the Columbia River. Most contacts were from the Ringold to McNary Dam section. Preliminary tabulation of results was started.

The potential impact of the aqueous effluent from the PRTR on the Columbia River was reviewed in relation to $MPC_w$'s listed in 10 CFR 20.

Work was continued on the comprehensive compilation of data relating to the Columbia River requested by the AEC.

An analysis was made of the consequences of accidental release of 1.5 liters of 1 BP solution (Purex) during shipment to Oak Ridge. It was concluded that ordinary care and precautions normally required for the shipment of radioactive materials via common carriers would be sufficient.

Basic equations were developed for acute exposures to the GI-tract from accidental release of radioactive materials. When completed this work will eliminate the necessity of converting concentrations of particular radionuclides to percent of MPC's and then to dose.

Work was continued on relating exposure to predicted areas of contamination following accidental releases of radioactive materials from stacks of various heights, for three wind speeds under "neutral" and "unstable" atmospheric conditions.

The air flows through stack gas sampling equipment at Purex, Redox, and the 327 facilities were recalibrated during the month as a result of recent inconsistenci

in stack emission results at Redox. The static scrubber system at Redox indicated a 35 percent change from previous calibration data. The 327 Building equipment showed a decrease of 40 percent from the original values. No significant calibration differences were noted for other systems.

Sampling studies were continued on the Redox stack 50-foot level. Due to difficulties with the steam system, a study was initiated to determine the feasibility of replacing the system with either an air jet or vacuum pump system.

Revisions were made in the proposed floor plan of the Fuel Recycle Pilot Plant (FRPP). These revisions have resulted in a good separation between radioactive and non-radioactive areas while maintaining good traffic patterns. Discussions concerning the location of the first and second filters for the cells are continuing.

Consideration was given to the exhaust air monitoring requirements for a thorium handling facility. Modifications to the 306 Building to provide thorium handling capabilities are being considered. Use of systems similar to the 234-5 Building exhaust air monitors are being considered.

A holder was provided for use of the uranium oxide radiator with the K-fluorescent X-ray. This radiator provides 100 Kev K-fluorescent X-rays. A lanthanum radiator, which provides, theoretically, 35 Kev K-fluorescent X-rays, was cast and mounted for routine use. Preliminary data obtained with the multi-channel analyzer indicate that the energy peak of the lanthanum radiator is about 35 Kev. A tungsten sheet 5 mils in thickness was ordered to replace the present defective tungsten radiator. Studies of the 59 Kev K-fluorescent X-rays show that the tin filters which have been used to minimize low energy X-ray scattering with certain radiators are generating a low energy K-fluorescence at about 23 Kev. Methods to provide more mono-energetic radiations are being reviewed.

The pinhole lenses used with the pinhole camera were modified to provide a wide angle field of view for both the optical and the radiation picture. The use of fresh KK X-ray film significantly improved the radiation pictures. Sheets of duPont 508 film, 5" x 7" in size, were ordered to provide increased radiation sensitivity. Inquiries regarding the use of the pinhole camera for the study of irradiated fuel elements were received.

The prototype Hanford personnel dosimeters were received from the vendor, Product Engineering Company. Certain on-plant assembly procedures are in progress. The workmanship and general construction features of the prototypes are good.

Fabrication of the film X-ray coding machine to provide X-ray film identification for nonroutine personnel dosimeters is now in progress. Completion of the machine at the 328 Technical Shops is scheduled for October 15.

Debugging of the automatic film densitometer continued through the month. Alignment of the mechanical parts is complete. A re-adjustment of the number

matrix components has been made to assure correct payroll number interpretation by the densitometer. Initial runs with the automatic densitometer indicated that 15 mr of radium gamma radiation can be easily detected. For radium gamma radiation, the 95 percent confidence limit for a dose of 15 mr is ± 5 mr; for doses between 30 mr to 300 mr, this limit is ± 10 mr.

Five additional moderators for the moderated foil criticality dosimeters were received from the vendor. Radiographs of these moderators indicate that they were free from voids in the paraffin filling and were acceptable. The vendor was advised to proceed and complete the current order which will provide 300 units for placement throughout the Hanford plant. A report detailing the development, performance, and evaluation of the moderator foil criticality dosimeter is nearing completion.

Performance tests of various gas fillings of small $BF_3$ tubes were completed. A gas filling of 18.5 cm of $BF_3$ and 6.5 cm of Argon gas provided the desired characteristics for use with the Hanford portable $BF_3$ monitoring instrument. Three of the small tubes are being fabricated at Hanford for study. A double moderator of reduced size is being built for use with these smaller tubes. A weight reduction of about 50 percent in the double moderator is expected to result with no sacrifice in the performance of the instrument. Weight reduction is possible through the use of a smaller detector tube. The smaller detector tube also provides increased dose range for the $BF_3$ type instruments.

Radium gamma exposure to silicon diodes under study as possible fast neutron dosimeters resulted in no detectable change in the forward resistance for doses up to 500 r. Higher exposures have not been completed. Calibration curves for neutron doses from 100 mrads to 1300 mrads were obtained utilizing the plutonium fluoride neutron source. These calibration curves indicate that the response of the 0.075-inch silicon diode was higher at a given current through the diode than was the response from a 0.100-inch diode. The change in the forward resistance for the 0.075-inch diode was about twice that observed for the 0.100-inch diode for a 100 mrad dose.

Preliminary investigations to measure the change in thermoelectric power semiconductor materials following fast neutron exposure was planned. Semiconductor materials such as silicon and germanium or special alloys such as $Bi_2Te_3$ and $Sb_2Te_3$ will be investigated. The measurement of thermoelectric power is simple and can be easily carried out with equipment readily available.

The annual physical inventory of normal uranium assigned to the Calibrations facility was performed on August 2. All uranium except that cemented in the film calibration jig was weighed in the presence of a GE accountability representative. The total uranium on hand was 24,222.3 grams. This weight was within 5 grams of the total weight declared during 1960, and the inventory results were considered acceptable. The annual physical inventory of portable instrument and assigned equipment was also completed during the month. All assigned equipment was witnessed and accounted for. GM number 277 which had been missing since November 28, 1960, was located near end of the inventory period.

Investigation into the cause of two criticality alarms at the 326 Building on August 27 revealed that the instrument was set to alarm at 25 mr/hour instead of the recommended 1 r/hour. Recalibration of the equipment showed full-scale readings 50 percent in error from the previous calibration. The reasons for the setting of the alarm being at a point one-twentieth of that recommended were not uncovered.

Charts and drawings showing the location of criticality detectors, criticality alarms, threshold neutron detectors, and criticality film badge kits have been prepared for all facilities at Hanford. A copy will be distributed to each member of the Radiological Emergency Team and one copy will be placed in each box containing high-range dose rate meters and self-reading dosimeters.

A revised Columbia River Emergency Plan was prepared for review and comments.

A final draft of the emergency procedures for the threshold neutron detector system was distributed for comment.

C. VISITORS

The following visitors met with various members of the Radiation Protection staff during the month:

Dave Wagstaff, Oregon State Board of Health, Salem, Oregon
E. C. Tsivoglou)
M. W. Lammering)
C. Henderson ) US Public Health Service - Cincinnati, Ohio, and Portland,
J. L. Agee ) Oregon
D. Hoffman )
Vittorio Prodi, Balogna University, Italy (IAEA Fellowship Student at Argonne National Laboratory)
John Horan, AEC, Idaho Operations Office, Idaho Falls, Idaho
Dave Wallace) US Public Health Service (assigned to Washington State
Jack Wallace) Board of Health)
A. T. Neale )
G. Hansen )
E. Asselstine) Washington State Pollution Control Commission - Olympia and
C. Ogden ) Yakima, Washington
T. Clemetson )
K. E. Story )
O. E. Reid )
F. W. Rymer ) Tennessee Valley Authority
A. N. Qualls)
A. R. Walker)
C. G. Amato, American Machine and Foundry Atomics, New York City, New York

## D. EMPLOYEE RELATIONS

Two suggestions were submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to thirty-four. Four suggestions were rejected with no adoptions. Ten suggestions submitted by RPO personnel are pending evaluation.

There were four medical treatment injuries during the month for a frequency of 1.88. No security violations occurred during the month of August.

All Job Hazard Breakdown's are being revised and updated throughout the Operation. New Job Hazard Breakdown's were prepared for several new types of operation such as the biological monitoring work in Environmental Monitoring.

Radiation Protection training included orientation on specific aspects of radiation protection to: new and visiting employees, members of Analytical Laboratories Operation, visitors from the Tennessee Valley Authority, HAPO patrolmen, and to the members of the first-line management class.

The Radiation Protection Operation display was presented at the Benton-Franklin County Fair August 25-27 to an estimated audience of 3,500 people. The display was also presented at the Southeastern Washington Fair in Walla Walla August 31 through September 3.

The 1961 AEC Radiological Physics Fellowship Program was concluded on August 24. A total of ten students participated in this year's ten-week summer training session. Nine of the participating students are returning to the University of Washington on extensions of their fellowships for completion of M.S. degrees. One student employed by the New York State Health Department is returning to his former position.

## E. SIGNIFICANT REPORTS

HW-70689 - "Analysis of Radiological Data for the Month of July, 1961" by R. F. Foster.

HW-70706 - "Some Radioactive Materials Measured in Various Waters in the United States - A Literature Search" by J. K. Soldat.

HW-70930 - "Monthly Report - August 1961, Radiation Monitoring Operation" by A. J. Stevens.

A paper entitled "A Method of Linearizing Thermistor Thermometer Data in Calorimetry" by H. V. Larson and I. T. Myers was presented at the International Calorimetry Conference that was held at Ottowa, Canada, on August 14-17.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-July 1961 - Mid-August 1961)

| Sample Type and Location | Activity Type | Monthly Average | Units |
|---|---|---|---|
| **Drinking Water** | | | |
| 100-F Area | Isotopic | 0.3 | % $MPC_w$-GI* |
| Separation Areas | Gross Beta | $2.4 \times 10^{-7}$ | µc/cc |
| Pasco | Isotopic | 3.5 | % $MPC_w$-GI** |
| Kennewick | Isotopic | 1.2 | % $MPC_w$-GI** |
| Richland | Gross Beta | $< 3.0 \times 10^{-8}$ | µc/cc |
| **Columbia River Water** | | | |
| Above 100-B Area | Gross Beta | $< 3.0 \times 10^{-8}$ | µc/cc |
| 100-F Area | Isotopic | 1.2 | % $MPC_w$-GI* |
| Hanford | Isotopic | 0.8 | % $MPC_w$-GI* |
| Pasco | Isotopic | 6.2 | % $MPC_w$-GI** |
| McNary Dam | Gross Beta | No Sample | |
| Vancouver, Washington | Isotopic | 0.3 | % $MPC_w$-GI** |
| **Atmosphere** | | | |
| $I^{131}$ Separations Areas | $I^{131}$ | $3.3 \times 10^{-13}$ | µc/cc |
| $I^{131}$ Separations Stacks | $I^{131}$ | 1.0 | Combined curies/day |
| Active Particles - Project | -- | 2.6 | ptle/100 $m^3$ |
| Active Particles - Environs | -- | 0.08 | ptle/100 $m^3$ |
| **Vegetation** (Control limit for vegetation is $10^{-5}$ µc $I^{131}$/g) | | | |
| Separations Areas | $I^{131}$ | $< 1.5 \times 10^{-6}$ | µc/g |
| Residential | $I^{131}$ | $< 1.5 \times 10^{-6}$ | µc/g |

* The % $MPC_w$ is the percent of the maximum permissible limit for occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

** The % $MPC_w$-GI is the percent of the maximum permissible concentrations for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

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## PERSONNEL DOSIMETRY AND RADIOLOGICAL RECORDS

### External Exposures Above Permissible Limits

| | August | 1961 to Date |
|---|---|---|
| Whole Body Penetrating | 0 | 0 |
| Whole Body Skin | 0 | 1 |
| Extremity | 0 | 0 |

### Hanford Pocket Dosimeters

| | | |
|---|---|---|
| Dosimeters Processed | 2,848 | 33,858 |
| Paired Results - 100-280 mr | 28 | 380 |
| Paired Results - Over 280 mr | 0 | 16 |
| Lost Results | 0 | 0 |

### Hanford Beta-Gamma Film Badge Dosimeters

| | | |
|---|---|---|
| Film Processed | 10,664 | 81,569 |
| Results - 100-300 mrads | 918 | 7,454 |
| Results - 300-500 mrads | 190 | 939 |
| Results - Over 500 mrads | 32 | 182 |
| Lost Results | 54 | 246 |
| Average Dose Per Film Packet - mrad (ow) | 6.38 | 8.44 |
| - mr (s) | 26.88 | 21.81 |

### Hanford Neutron Film Badge Dosimeters

#### Slow Neutron

| | | |
|---|---|---|
| Film Processed | 0 | 11,562 |
| Results - 50-100 mrem | 0 | 0 |
| Results - 100-300 mrem | 0 | 0 |
| Results - Over 300 mrem | 0 | 0 |
| Lost Results | 0 | 58 |

#### Fast Neutron

| | | |
|---|---|---|
| Film Processed | 0 | 2,745 |
| Results - 50-100 mrem | 0 | 367 |
| Results - 100-300 mrem | 0 | 106 |
| Results - Over 300 mrem | 0 | 0 |
| Lost Results | 0 | 58 |

### Hand Checks

| | | |
|---|---|---|
| Checks Taken - Alpha | 33,478 | 270,249 |
| - Beta-gamma | 52,967 | 415,090 |

### Skin Contamination

| | | |
|---|---|---|
| Plutonium | 48 | 243 |
| Fission Products | 41 | 388 |
| Uranium | 10 | 46 |

| Whole Body Counter | Male | Female | August | 1961 to Date |
|---|---|---|---|---|
| GE Employees | | | | |
| Routine | 66 | 2 | 68 | 468 |
| Special | 3 | 0 | 3 | 48 |
| Terminal | 15 | 2 | 17 | 19 |
| Non-employees | 13 | 0 | 13 | 63 |
| Pre-employment | 20 | 2 | 22 | 22 |
| | 117 | 6 | 123 | 620 |

Bioassay

| | August | 1961 to Date |
|---|---|---|
| Confirmed Plutonium Deposition Cases | 4 | 8* |
| Plutonium - Samples Assayed | 344 | 4,225 |
| - Results Above $2.2 \times 10^{-8}$ µc Pu/Sample | 12 | 109 |
| Fission Product - Samples Assayed | 459 | 4,837 |
| - Results Above $3.1 \times 10^{-5}$ µc FP/Sample | 5 | 13 |
| Uranium - Samples Assayed | 149 | 2,077 |
| Biological - Samples Assayed | 0 | 196 |

Uranium Analyses

| | Following Exposure Units of $10^{-9}$ µc U/cc | | | Following Period of No Exposure Units of $10^{-9}$ µc U/cc | | |
|---|---|---|---|---|---|---|
| Sample Description | Maximum | Average | Number Samples | Maximum | Average | Number Samples |
| Fuels Preparation | 9.0 | 3.6 | 37 | 12.0 | 3.7 | 37 |
| Fuels Preparation** | 0 | 0 | 0 | 0 | 0 | 0 |
| Hanford Laboratories | 12.2 | 4.3 | 16 | 23.5 | 6.4 | 13 |
| Hanford Laboratories** | 0 | 0 | 0 | 0 | 0 | 0 |
| Chemical Processing | 20.1 | 5.6 | 21 | 35.5 | 7.3 | 21 |
| Chemical Processing** | 2.5 | 2.5 | 1 | 3.7 | 3.1 | 2 |
| Special Incidents | 5.8 | 5.8 | 1 | 0 | 0 | 0 |
| Random | 0 | 0 | 0 | 0 | 0 | 0 |

| Tritium Samples | Maximum | Average | Count | August Total |
|---|---|---|---|---|
| Urine Samples | | | | |
| Routine | 7.0 µc/l | 1.77 µc/l | 273 | |
| Samples Above 5.0 µc/l | | | 13 | |
| Samples < 1 µc/l | | | 119 | |
| | | | | 273 |
| $D_2O$ Samples | | | | |
| Moderator | 92.2 µc/ml | 75.7 µc/ml | 4 | |
| Primary | 22.8 µc/ml | 19.8 µc/ml | 4 | |
| Reflector | 75.3 µc/ml | 64.1 µc/ml | 4 | |
| | | | | 12 |
| Water Samples | 160.5 µc/ml | 43.1 µc/ml | 126 | 126 |

* The total number of plutonium deposition cases which have occurred at Hanford is now 271, of which 197 are currently employed.

** Samples taken prior to and after a specific job during work week.

| Calibrations | Number of Units Calibrated | |
|---|---|---|
| | August | 1961 to Date |
| Portable Instruments | | |
| CP Meter | 1,019 | 7,334 |
| Juno | 270 | 1,971 |
| GM | 568 | 4,241 |
| Other | 204 | 1,349 |
| Audits | 111 | 831 |
| | 2,172 | 15,726 |
| Personnel Meters | | |
| Badge Film | 1,740 | 11,865 |

[redacted]

# LABORATORY AUXILIARIES OPERATION
# MONTHLY REPORT - AUGUST, 1961

## GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 2.29 for the month and 2.89 for the year-to-date.

## TECHNICAL SHOPS OPERATION

Total productive time for the period was 24,960 hours. This includes 17,478 hours performed in the Technical Shops, 4,161 hours assigned to Minor Construction, 22 hours assigned to other project shops and 3,299 hours assigned to off-site vendors. Total shop backlog is 20,364 hours, of which 60% is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 5.3% (1230 hours) of the total available hours.

Distribution of time was as follows:

| | Man-hours | % of Total |
|---|---|---|
| Fuels Preparation Department | 5,995 | 23.85 |
| Irradiation Processing Department | 1,920 | 7.63 |
| Chemical Processing Department | 474 | 1.90 |
| Hanford Laboratories Operation | 16,704 | 66.45 |
| Construction Engineering & Utilities | 43 | .17 |

Requests for emergency service decreased to a level requiring a 5.3% overtime ratio, compared to 6.3% for the previous period.

At the close of the reporting period, there were two open requisitions for Machinists. Qualified candidates have been interviewed and are in process.

There were six medical treatment injuries, which is considered normal for this type of operation.

## CONSTRUCTION OPERATION

There were 62 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $181,976. One hundred and twelve new orders, 6 supplements and adjustments for underruns amounted to $111,659. Expenditures during the month on HLO work were $100,071. Total J. A. Jones backlog at month's end was $193,564.

Summary

| | HL | | CE&U | |
|---|---|---|---|---|
| | No. | Unexpended Balance | No. | Unexpended Balance |
| Orders outstanding beginning of month | 51 | $ 174,709 | 1 | $ 7,267 |
| Issued during the month (Inc.Sup. & Adj.) | 118 | 101,359 | 1 | 10,300 |
| J. A. Jones Expenditures during month (Inc. C. O. Costs) | | 93,124 | | 6,947 |
| Balance at month's end | 63 | 182,944 | 1 | 10,620 |
| Orders closed during month | 100 | 152,413 | - | -- |

## FACILITIES ENGINEERING OPERATION

### Projects

At month's end Facilities Engineering Operation was representing the Company on 17 projects having total authorized funds in the amount of $2,435,000. The total estimated cost of these projects is $7,708,300.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end 17

Number of new projects at month's end 1
CAH-836 Coolant Systems Development Laboratory

Projects completed in August 0

New project proposals submitted to AEC in August 0

New projects awaiting AEC approval: 4
CGH-918 Second Whole Body Counter Facility
CAH-917 Field Service Center
CGH-922 Burst Test Facility for Irradiated Zr Tubes
CAH-932 300 Area Retention Waste Systems Expansion

Project proposals complete or nearing completion are as follows:
Modifications to the H-1 Loop - 105-H Building
H-2 Basic Film and Corrosion Loop - 105-H Building

The attached report details project status.

## Engineering Services

| Title | Status |
|---|---|
| Pressure Vessel and Piping Systems - Engineering & Inspection Service | Code engineering service work is being performed on PRTR Systems, Breakaway Corrosion Loop, and Equipment Projects. A draft of the proposed manual of procedures for the acquisition and use of pressure systems was issued for comments. |
| "Split-Half" Machine for Critical Mass Studies | Design essentially complete. |
| Control and Safety Rods for Tamper Tank (Critical Mass) | Development work is being continued. |
| 10KW Tube Dryer - 314 Building | Design complete. Installation 25% complete. |
| Process Tube Monitor - 309 Building | Design started. |
| HLO Electrical & Signal Systems | Buildings are routinely metered and records maintained. A lighting level survey is being made in all buildings. Signal systems are being standardized. |
| Monorail Trolley - 326 Building | New insulated electrical conductors are being installed on trolley as a safety precaution. |
| Power Transfer Switch - 306 Bldg. | A new switch is being installed for transferring electrical loads during emergency power periods. |
| Air Conditioning Unit - 326 Bldg. | Heat generated by new equipment in room 21-A requires supplemental cooling. Design complete. |

## Drafting and Design Services

The work load in the 3706 Building drafting room and in the 327 Building is steady with some overtime required. Work loads in 306, 314, 308, and 1707-D Buildings are steady with little or no overtime required.

The equivalent of 147 design drawings were completed this month.

## Plant Maintenance Operation

### Analysis of Costs

Costs for July of $115,530 are about as predicted. This year, the improvement maintenance program started quickly with an activity about twice previous period.

### Improvement Maintenance

| Item | |
|---|---|
| Relocation and Alterations | $ 1,278 |
| Repainting | 4,378 |
| Electrical Modifications | 0 |
| Piping Modifications | 0 |
| Heat & Vent Modifications | 1,411 |
| | $ 7,067 |

### Waste Disposal and Decontamination Service

Waste disposal and decontamination work performed during the month is as follows:

| | July | June |
|---|---|---|
| Concrete barrels | 16 | 16 |
| Loadluggers - hot waste | 3 | 4 |
| Milk pails | 40 | 25 |
| Gattling gun | 2 | 2 |
| Crib Waste | 305,000 gal. | 310,000 gal. |

### Plant Engineering and Miscellaneous

Approximately 17,000 square feet of prints were reproduced during the month.

The total estimated value of the twelve requisitions issued during the month was $80,000. This procurement is primarily for approved HL projects.

A row of offices on the second floor of the 325 Building is being treated to reduce the noise level caused by building machinery.

The contingency maintenance work of research equipment moves is progressing in 326, 306 and 231-Z Buildings.

Plant Engineering and Miscellaneous (Cont'd.)

Decontamination Chamber of 327 Building is being removed.

Construction forces are complete with modification of room 316 in 325 Building.

A work order has been issued to Plant Forces for changes to room 123 and 123-A of 328 Building.

Exhaust fans are to be installed in the shop of 328 Building.

Plans have been made for replacement of contaminated ductwork from room 324 in the 325 Building. A work order has been issued to replace the ductwork with P.V.C.

Painting of the exterior of 328 Building has been contracted. Painting continued in 329 Building.

## TECHNICAL INFORMATION OPERATION

Approval was received from the AEC on a number of classification revisions proposed by HAPO on poison splines. A Classification Information bulletin was distributed containing the new instructions together with information on classifying research and development work on $BeO-UO_2$ fuels.

Comments on the first draft of the "General" section of the new local classification guide have been received from HAPO components. The section will now be readied for HOO approval.

A proposal to declassify design descriptions and specifications for certain reactor maintenance tools, heretofore classified, was submitted to HOO. Two documents were included to illustrate the types of information which should be unclassified.

Backlog of formal R&D reports at month's end was 33, including 5 reports being typed. Unfortunately the addition last month of another clerk in Technical Publications has not enabled us to reduce the backlog because of time lost by vacations. Rapid elimination of the backlog appears to be our principal problem, and steps will be taken to do this.

The microfilming of the documents in the Classified Files (Operation "Mop-Up") is proceeding smoothly. To date 167 file drawers have been emptied, 2477 copies have been pulled for filming, and 36 boxes of documents unsuitable for microfilming have been retired to the Records Center. A total of 36,064 documents have been microfilmed to date.

As a result of a joint effort, in which General Electric participated, three courses in Librarianship will be presented this winter at the University of Washington Center for Graduate Study. The courses will be taught by Maryde Orr, of the Technical Information staff.

The Operation had two visitors from off-site during the month. They were John P. Binnington, from Brookhaven Technical Information Division, and James H. Kennedy, from the Information Division of the University of California Radiation Laboratory. They were principally interested in our machine applications.

Work Volume Statistics

| | July | August |
|---|---|---|
| **Document Distribution and Files** | | |
| Documents routed and discharged (copies) | 14,850 | 16,195 |
| Documents issued (copies) | 13,049 | 17,908 |
| Documents sent off-site (copies) | 6,281 | 8,116 |
| Document reserves filled (copies) | 504 | 423 |
| Documents picked up and delivered | 15,749 | 17,524 |
| **Document Accountability** | | |
| Holders of classified documents whose files were inventoried | 217 | 279 |
| Documents inventoried in Files (copies) | -- | -- |
| Documents destroyed or retired (copies) | 4,346 | 3,493 |
| Documents revised (copies) | 658 | 894 |
| Documents pulled and documents filed (copies) | 11,543 | 15,241 |
| Documents reclassified | 45 | 442 |
| Documents microfilmed | 2,985 | 2,542 |
| Accountable copies of SECRET and DOCUMENTED | 191,832 | 194,444 |
| **Reference and Publication** | | |
| Books cataloged (new titles) | 99 | 104 |
| Books added to the collection (volumes) | 275 | 209 |
| Ready reference questions answered by professional staff | 170 | 140 |
| Literature searches by professional staff | 65 | 71 |
| Reports abstracted (titles) | 227 | 229 |
| Formal reports prepared (titles) | 18 | 18 |
| Off-site requests for HAPO reports (copies) | 328 | 303 |
| Reports released to CAP (titles) | 27 | 36 |

## Library Acquisitions and Circulation

| | July | August |
|---|---|---|
| Books ordered (volumes) | 372 | 425 |
| Periodicals ordered | 64 | 97 |
| Books circulated (volumes) | 1,300 | 1,694 |
| Periodicals circulated (issues) | 3,151 | 3,273 |
| Inter-Library loans | 97 | 83 |
| Films borrowed or rented | 7 | 4 |
| Industrial film showings | 46 | 49 |
| Bound periodicals added to the collection | 80 | 87 |
| Bound periodicals discarded | 177 | 18 |

## Library Collection

| | Main Library | W-10 Library | 108-F Library | Ind.Med. | Total |
|---|---|---|---|---|---|
| No. of books | 32,080 | 8,681 | 1,837 | 2,061 | 44,659 |
| No. of bound periodicals | 14,912 | 17 | 1,924 | 23 | 16,876 |
| | 46,992 | 8,698 | 3,761 | 2,084 | 61,535 |

## Classification and Declassification

| | July | August |
|---|---|---|
| Documents, invluding drawings and photographs reviewed for downgrading or declassification | 49 | 67 |
| Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification | 25 | 38 |
| Documents submitted to Declassification Branch, Oak Ridge | 2 | 3 |

J. L. Boyd
Manager
Laboratory Auxiliaries

JL Boyd:jw

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872

DATE 8-31-61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-822 | Pressurized Gas Cooled Facility | 4141 Opera 5 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 1,120,000 | DESIGN $ 40,000 / CONST. $ 1,080,000 | AEC $ 0 / GE $ 1,120,000 | COST & COMM TO 8-20-61 / ESTIMATED TOTAL COST | $ 887,814 (GE / $ 1,120,000 |

| STARTING DATES | | | ESTD. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 8-19-59 | CONST. 10-17-60 | DATE AUTHORIZED 2-3-61 / DIR. COMP. DATE 9-30-61 | DESIGN 4-29-60 | CONST. 9-30-61 |

ENGINEER

REDO - DP Schively

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | 100 | 10( |
| TITLE I | | | |
| GE-TIT. II | 100 | 100 | 10( |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 99 | 9 |
| PF | | | |
| CPFF | 17 | 95 | 9 |
| FP | 7 | 100 | 10( |
| Govt. Eq. 76 | | 99 | 9 |

SCOPE, PURPOSE, STATUS & PROGRESS

Addition of DC stopping power to main blowers & miscellaneous electrical work in progress.

Estimates are being obtained for the installation of a trap between the NaK heater and in-reactor section.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-842 | Critical Reactivity Measuring Facility | 58-e-15 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 360,000 | DESIGN $ 45,000 / CONST. $ 315,000 | AEC $ 148,000 / GE $ 212,000 | COST & COMM. TO 8-20-61 / ESTIMATED TOTAL COST | $ 169,398 / $ 360,000 |

| STARTING DATES | | | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 11-17-59 | CONST. 10-3-60 | DATE AUTHORIZED / DIR. COMP. DATE 8-15-61 | DESIGN 2-1-61 | CONST. 8-15-61 |

ENGINEER

REDO - WS Kelly

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 100 | 72 |
| PF | | | |
| CPFF | 57 | 100 | 53 |
| FP | 43 | 100 | 100 |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

A revised project proposal requesting an extension of the scheduled completion date is being circulated for approval. A new schedule will be submitted when it is approved.

Piping and electrical installation was continued.

1230267

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-70872

DATE 8-31-61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-857 | Physical & Mechanical Properties Testing Cell - 327 Bldg. | 0290 |

| AUTHORIZED FUNDS | DESIGN $ | AEC $ | COST & COMM. TO | $ |
|---|---|---|---|---|
| $ 75,000 | 75,000 | GE $ 75,000 | 8-20-61 | 74,945 |
| | CONST. $ | | ESTIMATED TOTAL COST | $ 460,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 11-2-59 | 10-1-59 | DESIGN | 3-1-61 |
| CONST. | 5-15-62 | DIR. COMP. DATE | CONST. | 12-15-62 |

ENGINEER

FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | 540 |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTU |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 100 | 100 | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in the 327 Bldg.

The proposal is being reviewed prior to submission to the AEC for approval.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-858 | High Level Utility Cell - 327 Building | 0290 |

| AUTHORIZED FUNDS | DESIGN $ | AEC $ | COST & COMM. TO | $ |
|---|---|---|---|---|
| $ 400,000 | 50,000 | GE $ 400,000 | 8-20-61 | 267,418 |
| | CONST. $ 350,000 | | ESTIMATED TOTAL COST | $ 400,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 11-2-59 | 10-1-59 | DESIGN | 3-1-61 |
| CONST. | 5-15-61 | DIR. COMP. DATE 2-28-62 | CONST. | 2-28-62 |

ENGINEER

FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | 3 | 140 |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | 35 |
| DESIGN ENGINEERING OPERATION | | 716 |
| GE FIELD ENGINEERING | .2 | 6 |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTU |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 95 | 100 | 100 |
| AE-TIT. II | | | |
| Vendor | 5 | 100 | 100 |
| CONST. | 100 | 10 | 12 |
| PF | | | |
| CPFF | | 10 | 12 |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to prepare specimens from irradiated materials for use in determining their physical and mechanical properties and involves the installation of a cell in 327 Building.

Procurement is progressing satisfactorily.

1230268

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872 II

DATE 8-31-61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-866 | Shielded Analytical Laboratory - 325-B Building | 61-a-1 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 700,000 | DESIGN $ 60,000 / CONST. $ 640,000 | AEC $ 546,500 / GE $ 153,000 | COST & COMM. TO 8-20-61 / ESTIMATED TOTAL COST | $ 28,110 (GE) / $ 700,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 9-5-59 | 5-31-60 | DESIGN | 11-15-60 |
| CONST. | 6-28-61 | DIR. COMP. DATE 6-30-62 | CONST. | 6-30-62 |

ENGINEER

FEO - RW Dascenzo

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | 11 | 218 |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | 0 | 3 |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 10 | 100 | 100 |
| AE-TIT. II | 90 | 100 | 100 |
| | | | |
| CONST. | 100 | 9 | 6 |
| PF | 3 | 1 | 1 |
| CPFF | 2 | 0 | 0 |
| FP | 95 | 9 | 6 |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow greater capacity for analytical work involving today's more highly radioactive solutions and consists of adding a shielded laboratory to the 325 Building.

Existing concrete basement stairway was broken out. Wall footing concrete has been poured. Electrical grounding grid for the Bldg. was placed. Basement drain was installed.

Contractor is installing wall and cell pier forms and reinforcing steel.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAE-867 | Fuel Element Rupture Test Loop | 58-e-15 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 1,500,000 | DESIGN $ 130,000 / CONST. $ 1,370,000 | AEC $ 770,000 / GE $ 730,000 | COST & COMM. TO 8-20-61 / ESTIMATED TOTAL COST | $ 502,859 (GE) / $ 1,500,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 8-1-60 | | DESIGN | 3-15-61 |
| CONST. | 11-2-60 | DIR. COMP. DATE 10-31-61 | CONST. | 10-31-61 |

ENGINEER

REDO - PC Walkup

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | 400 |
| COST PLUS FIXED FEE | 10 | 430 |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 91 | 100 | 100 |
| AE-TIT. II | 9 | 100 | 100 |
| | | | |
| CONST. | 100 | 69 | 20 |
| PF | 2 | 0 | 0 |
| CPFF | 57 | 95 | 17 |
| FP (1) | 10 | 100 | 100 |
| (2) | 31 | 60 | 0 |

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Co.

Bids received. Apparent low bidder is Lewis Hopkins Const. Co. at $345,000.

Revised project proposal, extending completion date, has been approved and revised. Construction schedule has been submitted.

1230269

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872 I

DATE 8-31-61

PROJ.NO. CAH-870

TITLE Facility for Recovery of Radioactive Materials - 325 Bldg.

FUNDING 60-a-1

AUTHORIZED FUNDS $ 486,000

DESIGN $ 46,000 | CONST. $ 440,000

AEC $ 446,000 | GE $ 40,000

COST & COMM. TO 8-20-61 $ 463-344

ESTIMATED TOTAL COST $ 486,000

STARTING DATES: DESIGN 11-20-59 | CONST. 5-6-60

DATE AUTHORIZED 3-22-60 | DIR. COMP. DATE 6-1-61

EST'D. COMPL. DATES: DESIGN 3-1-60 | CONST. 5-31-61

ENGINEER

FEO - RW Dascenzo

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT.II | 10 | 100 | 100 |
| AE-TIT.II | 90 | 100 | 100 |
| | | | |
| CONST. | 100 | 100 | 100 |
| PF | 1 | 100 | 100 |
| CPFF | | | |
| FP | 99 | 100 | 100 |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for recovery of specific radioisotopes from wastes, and involves an addition to the 325 Building.

This project is complete and will no longer be reported

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PROJ. NO. CAH-888

TITLE Biology Laboratory Improvements

FUNDING 60-h-1

AUTHORIZED FUNDS $ 420,000

DESIGN $ 44,000 | CONST $376,000

AEC $ 400,000 | GE $ 20,000

COST & COMM. TO 7-30-61 $ 355,234

ESTIMATED TOTAL COST $ 420,000

STARTING DATES: DESIGN 8-8-60 | CONST. 7-10-61

DATE AUTHORIZED 9-2-60 | DIR. COMP. DATE 3-31-62

EST'D. COMPL. DATES: DESIGN 3-31-61 | CONST 6-15-62

ENGINEER

FEO - JT Lloyd

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | 0 | 392 |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | NS | 100 |
| TITLE I | | | |
| GE-TIT.II | 17 | NS | 100 |
| AE-TIT.II | 83 | NS | 100 |
| | | | |
| CONST. | 100 | | |
| PF | | 17 | 10 |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides additional space for biological research supporting services, and involves an addition to the 108-F Building.

Proceeding with compaction of earth fill under first floor. Started laying prejointed transite pipe below first floor level. Excavated for radiation room walls. Drilling holes for Phillips shields in present building beams for tie in of new structure has been completed. Electrical grounding mat has been installed. No immediate delay is expected due to pipefitters strike since underground work has been completed and pipe chasses can be blocked out in presently planned concrete pours.

1230270

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872

DATE 8-31-61

| PROJ.NO. | TITLE | FUNDING |
|---|---|---|
| CAH-896 | Stress Rupture Test Facility | 60-1 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 90,000 | DESIGN $ 7,500 / CONST. $ 82,500 | AEC $ 78,500 / GE $ 11,500 | COST & COMM. TO 8-20-61 | $ 11,486 (GE) |
| | | | ESTIMATED TOTAL COST | $ 90,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 7-29-60 | 3-6-61 | DESIGN 12-1-60 | |
| | CONST. 3-20-61 | DIR. COMP. DATE 10-15-61 | CONST. 12-15-61 | |

ENGINEER

FEO - H Radow

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | 1 | 360 |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 100 | 100 | 100 |
| AE-TIT. II | | | |
| | | 92 | 80 |
| CONST. | 100 | | |
| PF | 2 | 0 | 0 |
| CPFF | | | |
| FP | 98 | 96 | 82 |

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

The construction phase of the job is essentially complete; however, overall completion has lagged badly because of lack of receipt and installation of equipment. The Contractor has requested an extension of the contract completion date and this is being negotiated with the AEC. Delinquent delivery of the instrument panel by Minneapolis-Honeywell and the reaction vessel by American Instrument Company are currently delaying project progress.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-901 | Structural Material Irradiation Test Equipment - ETR | 8-15-61 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 125,000 | DESIGN $ 12,000 / CONST. $ 113,000 | AEC $ / GE $ 125,000 | COST & COMM. TO 8-20-61 | $ 82,803 |
| | | | ESTIMATED TOTAL COST | $ 125,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 9-15-60 | 9-2-60 | DESIGN 3-31-61 | |
| | CONST. 6-26-61 | DIR. COMP. DATE 10-15-61 | CONST. 10-15-61 | |

ENGINEER

FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | 5 | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 100 | 100 | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 63 | 90 |
| PF | 100 | 63 | 90 |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides for the installation of equipment at the ETR for which changes in the physical properties of reactor structural materials subjected to in-reactor conditions can be determined.

Installation is complete except for modifications of instrumentation, to provide improved control and monitoring of loop conditions.

1230711

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872

DATE 8-31-61

| PROJ.NO. | TITLE | FUNDING |
|---|---|---|
| CGH-902 | Uranium Scrap Burning Facility | 61-j |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ 36,000 | DESIGN $ 5,000 / CONST. $ 31,000 | AEC $ 27,500 / GE $ 7,500 | COST & COMM. TO 8-20-61 / ESTIMATED TOTAL COST | $ 5,751 (GE) / $ 36,000 | |

| STARTING DATES | | | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 5-15-61 / CONST. 10-1-61 | DATE AUTHORIZED 12-15-60* / DIR. COMP. DATE 10-15-61 | | DESIGN 7-25-61 / CONST. 1-1-62 | |

ENGINEER

FEO - RK Waldman

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 0 | 0 |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a means of making uranium scrap material safer for storage and off-plant shipment by converting this scrap to a stable uranium oxide. The facility will be adjacent to the 333 Building.

*Accepted by the General Electric Company 5-17-61.

Cost Estimate 836 and 836 supplement # has been submitted to the AEC. A letter requesting approval of funds to J. A. Jones Co. has been submitted to the Commission.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-914 | Rattlesnake Springs Radioecology Facility | 61-j |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ 90,000 | DESIGN $ 3,400* / CONST. $ 86,600 | AEC $ 71,700 / GE $ 18,300 | COST & COMM. TO 8-20-61 / ESTIMATED TOTAL COST | $ 14,420 (GE) / $ 90,000 | |

| STARTING DATES | | | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 3-1-61 / CONST. 7-12-61 | DATE AUTHORIZED 12-22-60 / DIR. COMP. DATE 10-31-61 | | DESIGN 6-15-61 / CONST. 12-1-61 | |

ENGINEER

FEO - OM Lyso

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | 238 |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | NS* | 100 |
| TITLE I | | | |
| GE-TIT. II | | | 100 |
| AE-TIT. II | 100 | NS* | 100 |
| | | | |
| CONST. | 100 | 43 | 52 |
| PF | | | |
| CPFF | 7 | 0 | 0 |
| FP | 93 | 46 | 56 |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow performance of radioecological studies under local environmental conditions. It consists of constructing field facilities for this purpose. Approval signatures for project drawings and specifications were obtained 5-31-61.

*Bovay Engineers. Contractor work started 7-12-71

Mechanical spillways have been installed in both dams. Pond excavation has been completed.

The well has been drilled and accepted. Work is in progress on the fence installation, sewer piping and power line.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872

DATE 8-31-61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-916 | Fuels Recycle Pilot Plant | Funds Avail to Comm. |

| AUTHORIZED FUNDS | DESIGN $ | AEC $ | COST & COMM. TO | |
|---|---|---|---|---|
| $ 100,000 | 100,000 | | 7-30-61 | $ 100,000 |
| | CONST. $ | GE $ 100,000 | ESTIMATED TOTAL COST | $ 5,000,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 3-1-61* | 2-17-61 | DESIGN | 3-1-62 |
| | CONST. 5-1-62 | DIR. COMP. DATE | CONST. | 11-1-63 |

ENGINEER

FEO - RW Dascenzo

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | NS | |
| TITLE I | | 100NS | 100 |
| GE-TIT. II | | NS | 3 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | NS | |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

The revised project proposal for detail funds has been approved by HOO-AEC and has been forwarded to Washington D. C. AEC for approval.

Mechanical design is developing wall plug-in cubicles for equipment in the Hot Pilot Cells.

Ventilation design is working on studies for in-cell filters and costs of possible refrigeration cooling in the administrative area.

Comments have been received on a revised floor plan.

*Date Title I design started.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-917 | Field Service Center - Atmospheric Physics | 61-j |

| AUTHORIZED FUNDS | DESIGN $ | AEC $ | COST & COMM. TO | |
|---|---|---|---|---|
| $ | | | | $ |
| | CONST. $ | GE $ | ESTIMATED TOTAL COST | $ 154,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 11-15-61* | | DESIGN | 2-15-62* |
| | CONST. 3-15-62 | DIR. COMP. DATE | CONST. | 8-1-62* |

ENGINEER

FEO - JT Lloyd

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | | |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities necessary to conduct atmospheric physics research and development programs.

*Based on AEC authorization by 10-1-61.

A letter of recommendation to proceed in accordance with the G. E. proposal for phase I and II is being prepared by the responsible local AEC Division. A thorough study has been made by the AEC to determine if space is or will be available to meet this project requirements. It was found that no space can be allocated for this purpose.

Also a cost estimate prepared by the AEC indicates the project cost to move into an existing building would exceed the estimate prepared by G. E. Also this cost would be as great as the project cost for phase I and II in the project proposal.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872

DATE 8-31-61

| PROJ.NO. | TITLE | FUNDING |
|---|---|---|
| CAH-918 | Second Whole Body Counter Cell--747 Bldg. | 62-k |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ | DESIGN $ | AEC $ | COST & COMM. TO | $ |
| | CONST. $ | GE $ | ESTIMATED TOTAL COST | $ 110,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 9-15-61 | | DESIGN 1-15-62 | |
| | CONST. 5-15-62 | DIR. COMP. DATE | CONST. 2-15-63 | |

ENGINEER

FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | | |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

Project Proposal Revision was submitted to the Commission on July 5, 1961. The Review Board deferred it indefinitely on July 13. It has been indicated that correspondence will be submitted by the Commission suggesting other lines of approach to strengthen the justification for this project.

No correspondence was received by 8-29-61.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-921 | Geological & Hydrological Wells - FY-61 | 61-j |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 79,000 | DESIGN $ 1,000 | AEC $ 69,500 | COST & COMM. TO 8-20-61 | $ 62,143 |
| | CONST. $ 78,000 | GE $ 9,500 | ESTIMATED TOTAL COST | $ 79,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 4-15-61 | 3-21-61 | DESIGN 5-15-61 | |
| | CONST. 5-22-61 | DIR. COMP. DATE 12-31-61 | CONST 12-31-61 | |

ENGINEER

FEO - HE Ralph

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | 8 | 480 |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | 100 | 0 | 0 |
| GE-TIT. II | | 75 | 75 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 58 | 36 |
| PF | 0 | | |
| CPFF | 3 | NS | 75 |
| FP | 97 | 58 | 35 |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

Contractor is operating 2 rigs, each on a two 10 hour shift basis. Approximately 2000 ft. of hole has been completed.

Contractor is 22% behind schedule at the present. However, he is reducing the backlog due to the 2 shift basis.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70372

DATE 8-31-61

| PROJ.NO. | TITLE | FUNDING |
|---|---|---|
| CGH-922 | Burst Test Facility for Irradiated Zirconium Tubes | 62-k |

| AUTHORIZED FUNDS | DESIGN $ | AEC $ | COST & COMM. TO | $ |
|---|---|---|---|---|
| $ | CONST. $ | GE $ | ESTIMATED TOTAL COST | $ 228,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 11-15-61* | DATE AUTHORIZED | DESIGN | 5-15-62* |
| CONST. | | DIR. COMP. DATE | CONST. | 12-1-62* |

ENGINEER

FEO - H Radow

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | | |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to permit deliberate destructive testing of irradiated zirconium tubing. This will provide operating and tube life data not now available because of the limited operating history of Zircaloy-2 pressure tubing in reactors.

The project proposal was forwarded by HOO-AEC to AEC, Washington, with recommendation for authorization.

*Based on AEC authorization 11-1-61.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAE-919 | Air Conditioning - 314 Building | |

| AUTHORIZED FUNDS | DESIGN $ 3,750 | AEC $ 28,650 | COST & COMM. TO 8-20-61 | $ 4,863 (GE) |
|---|---|---|---|---|
| $ 35,000 | CONST. $ 28,650 | GE $ 6,350 | ESTIMATED TOTAL COST | $ 35,000 |

| STARTING DATES | | DATE AUTHORIZED | 4-18-61 | EST'D. COMPL. DATES | DESIGN | 7-5-61 |
|---|---|---|---|---|---|---|
| | CONST. 6-15-61 | DIR. COMP. DATE | 9-15-61 | | CONST. | 11-1-61 |

ENGINEER

FEO - OM Lyso

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | 170 |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | NS | 100 |
| TITLE I | | | |
| GE-TIT. II | | NS | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 93 | 65 |
| PF | | | |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will supplement existing cooling units, thus providing cooling air supply commensurate with heat load and outdoor temperatures.

Directive AEC-188, dated March 8, 1961, authorized the project and assigned management to the AEC. Work Authority was issued 4-18-61, to the G.E. Company.

Two units are in operation. #3 unit installation is 75% complete. Relocation of an existing unit and installation of unit #4 remains to be done. The pipefitters walkout has stopped progress on this project. It is not now expected that the work will be completed by the directive completion date.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 7087_ ..

DATE 8-31-61

| PROJ.NO. | TITLE | FUNDING |
|---|---|---|
| CGH-923 | Spectroscopy Laboratory | 0290 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 95,000 | DESIGN $ 4,500 / CONST. $ 90,000 | AEC $ / GE $ 95,000 | COST & COMM. TO 8-20-61 / ESTIMATED TOTAL COST | $ 88,775 / $ 95,000 |

| STARTING DATES | | | ESTD. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 3-21-61 / CONST. 5-15-61 | DATE AUTHORIZED 3-9-61 / DIR. COMP. DATE 11-15-61 | | DESIGN 5-24-61 / CONST 11-15-61 | |

ENGINEER

FEO - RC Ingersoll

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | 196 |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | 14 |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | | 100 | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 100 | 98 |
| PF | | | |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for specialized spectroscopy work.

The NMR equipment has been connected and the vendor's field engineer was on site 8-23, 8-24 and 8-25 for checkout and adjustment. Relocation of EPR equipment remains. EPR equipment is operating and relocation depends on R&D schedules.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-924 | 200 KW Induction Heating System - 306 Building | 0290 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 31,000 | DESIGN $ 3,200 / CONST. $ 27,800 | AEC $ 24,650 / GE $ 6,350 | COST & COMM. TO 8-20-61 / ESTIMATED TOTAL COST | $ 5,730 (GE) / $ 31,000 |

| STARTING DATES | | | ESTD. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 5-1-61 / CONST. 10-1-61 | DATE AUTHORIZED 3-27-61 / DIR. COMP. DATE 2-28-62 | | DESIGN 7-1-61 / CONST 1-1-62 | |

ENGINEER

FEO - RC Ingersoll

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | NS | 30 |
| TITLE I | | | |
| GE-TIT. II | | NS | 30 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 0 | 0 |
| PF | | | |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a source of power for induction heating for R&D work in the 306 Building.

Bids on the work stations and voltage regulator have been received and reviewed by GE&CO Design. An order will be placed as soon as bid information is clarified.

# SEMI-MONTHLY PROJECT STATUS REPORT

HW- 70872

GENERAL ELECTRIC CO. — Hanford Laboratories

DATE 8-31-61

| PROJ.NO. | TITLE | FUNDING |
|---|---|---|
| CAH-927 | Additions to the 271-CR Building Waste Treatment Demonstration Facility | 61-j |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 80,000 | DESIGN $ 4,000 / CONST. $ 76,000 | AEC $ 17,500 / GE $ 62,500 | COST & COMM. TO 8-20-61 | $ 11,423 (GE) |
| | | | ESTIMATED TOTAL COST | $ 80,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 6-15-61 | | DESIGN 10-16-61 | |
| | CONST. 9-16-61 | DIR. COMP. DATE 3-31-62 | CONST. 3-31-62 | |

ENGINEER

FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | 3 | 50* |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

*Correction

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 77 | 75 |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | 100 | 77 | 75 |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides facilities for pilot plant development of decontamination processes for intermediate level chemical processing plant waste for safe discharge to the plant environs.

Design difficulties prevented realization of the intended completion to comment stage by 8-15-61.

Drawings and specifications are expected to be complete by 9-1-61.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-932 | 300 Area Retention Waste System Expansion | 62-k |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ | DESIGN $ / CONST. $ | AEC $ / GE $ | COST & COMM. TO | $ |
| | | | ESTIMATED TOTAL COST | $ 70,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 10-15-61* | | DESIGN 1-1-62* | |
| | CONST. 2-1-62 * | DIR. COMP. DATE | CONST. 6-1-62* | |

ENGINEER

FEO - OM Lyso

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | | |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will increase the basin capacity commensurate with the increased volumes handled. This will permit transfer to crib waste of contaminated waste if required, and still permit adequate sampling time for the normal flow.

The project proposal was submitted to HOO-AEC for authorization on 5-5-61. Review of this project was deferred by the HOO-AEC Review Board.

*Based on AEC authorization by 9-15-61.

1230277

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70872

DATE 8-31-61

PROJ.NO. CGH-935 | TITLE: Metals Storage Bldg. | FUNDING: 61-j

AUTHORIZED FUNDS: $ 22,300 | DESIGN $ 500 | CONST. $ 21,800 | AEC $ | GE $ 22,300

COST & COMM. TO 8-20-61 $ 21,265

ESTIMATED TOTAL COST $ 22,300

STARTING DATES: DESIGN 1-2-61, CONST. 6-22-61 | DATE AUTHORIZED 6-16-61 | DIR. COMP. DATE 10-31-61

EST'D. COMPL. DATES: DESIGN 2-10-61, CONST. 10-31-61

ENGINEER: FEO - DS Jackson

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | 60 |
| ARCHITECT-ENGINEER | 1.5 | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | NS | 100 |
| TITLE I | | | |
| GE-TIT. II | 100 | NS | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | NS | 65 |
| PF | | | |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a building adjacent to the 328 Building in which fabrication materials and components can be stored for use by the Technical Shops.

Construction of footings, foundation walls, floor slab, and concrete block walls is completed. Structural steel roof supports are completed and steel roof decking is being installed.

PROJ. NO. CAH-936 | TITLE: Coolant Systems Development Laboratory | FUNDING: 62-k

AUTHORIZED FUNDS: $ 12,000 | DESIGN $ | CONST. $ | AEC $ | GE $

COST & COMM. TO 8-20-61 $ 12,000

ESTIMATED TOTAL COST $ 93,000

STARTING DATES: DESIGN 9-11-61, CONST. 4-10-62 | DATE AUTHORIZED 8-9-61 | DIR. COMP. DATE

EST'D. COMPL. DATES: DESIGN 2-11-62, CONST. 10-10-62

ENGINEER: FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUA |
|---|---|---|---|
| DESIGN | 100 | NS | |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides facilities for the conduct of corrosion and decontamination studies for nuclear reactor coolant systems, by the addition of a 2700 sq. ft. laboratory facility on the west side of the 1706 KE Building.

Design criteria are complete. Design is expected to start 9-1-61.

1230278

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 70672

DATE 8-31-61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-937 | Safety Improvements to 231-Z Bldg. | 61-j |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ 45,000 | DESIGN $ 5,500 | AEC $ | COST & COMM. TO 8-20-61 | $ 15,646 |
| | CONST. $ 39,500 | GE $ 45,000 | ESTIMATED TOTAL COST | $ 45,000 |

| STARTING DATES | | | | EST'D. COMPL. DATES | | PERCENT COMPLETE | | |
|---|---|---|---|---|---|---|---|---|
| | DESIGN 7-12-61 | DATE AUTHORIZED | 6-29-61 | | DESIGN 9-29-61 | | WT'D. | SCHED. | ACTUAL |
| | CONST. 7-10-61 | DIR. COMP. DATE | 5-15-62 | | CONST. 5-15-62 | DESIGN | 100 | NS | |
| | | | | | | TITLE I | | | |
| | | | | | | GE-TIT. II | | NS | 100 |
| | | | | | | AE-TIT. II | | | |
| | | | | | | | | | |
| | | | | | | CONST. | 100 | 12 | 2 |
| | | | | | | PF | | | |
| | | | | | | CPFF | | | |
| | | | | | | FP | | | |

ENGINEER

FEO - JT Lloyd

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides supplemental ventilation and installation of a fire detection system in the 231-A Bldg.

Design by CE&UO is underway. Comment prints are being made.

Design drawings have been completed and approved. The purchase specification for ventilation equipment has been approved and presented to construction for purchase.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| | | |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ | DESIGN $ | AEC $ | COST & COMM. TO | $ |
| | CONST. $ | GE $ | ESTIMATED TOTAL COST | $ |

| STARTING DATES | | | | EST'D. COMPL. DATES | | PERCENT COMPLETE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | DESIGN | DATE AUTHORIZED | | | DESIGN | | WT'D. | SCHED. | ACTUAL |
| | CONST. | DIR. COMP. DATE | | | CONST. | DESIGN | 100 | | |
| | | | | | | TITLE I | | | |
| | | | | | | GE-TIT. II | | | |
| | | | | | | AE-TIT. II | | | |
| | | | | | | | | | |
| | | | | | | CONST. | 100 | | |
| | | | | | | PF | | | |
| | | | | | | CPFF | | | |
| | | | | | | FP | | | |

ENGINEER

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

SCOPE, PURPOSE, STATUS & PROGRESS

1230279

# PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

## MONTHLY REPORT

### EMPLOYMENT (Professional)

Advanced Degree - Eight Ph.D. applicants visited HAPO for professional employment interviews. Seven offers were extended (all HL); six acceptances and six rejections were received (all HL). Current open offers total six. Twenty-two Ph.D. acceptances were obtained during the recruiting year ending August 31. Of these twenty-two, seven were Company transfers, five were open market and ten were campus candidates.

Technical Graduate Program - One Technical Graduate was placed on permanent assignment. Seven new members were added to the program rolls and three terminated. Current program members total 89.

### EMPLOYMENT (Non-Professional)

Twenty-six requisitions were filled during the month with a total of twenty active requisitions remaining to be filled.

### HEALTH, SAFETY AND SECURITY

The document HW-69476, "Guide to Procurement and Use of Pressure Equipment," was issued to all HAPO personnel concerned with such equipment in furtherance of operational safeguards.

### PERSONNEL DEVELOPMENT

Current A-Course enrollment is twenty-three consisting of thirteen E&SP members, one technical graduate, and nine permanent HAPO employees.

O. E. Boston, Manager
Professional Placement
and Relations Practices

OEB:lmh

## TABLE II PROFESSIONAL PERSONNEL PLACEMENT

### A. Technical Recruiting Activity - HAPO - September 1, 1960 to date

| | Cases Considered | Visits to Richland: Invited | Visited | To Visit | Offers: Offered | Accepted | Open | On the Roll |
|---|---|---|---|---|---|---|---|---|
| PhD | 571 | 178 | 86 | 20 | 66 | 22 | 5 | 12 |
| Exp. BS/MS | 601 | 110 | 80 | - | 111 | 60 | 9 | 45 |
| Prog.BS/MS | 400 | - | - | - | 174 | 67 | - | 53 |

### B. Technical Recruiting Activity - HL - September 1, 1960 to date

| | Cases Considered | Visits to Richland: Invited | Visited | To Visit | Offers: Offered | Accepted | Open | On the Roll |
|---|---|---|---|---|---|---|---|---|
| PhD | 571 | 178 | 86 | 20 | 59 | 19 | 4 | 10 |
| Exp. BS/MS | 333 | 53 | 35 | - | 34 | 17 | 3 | 14 |

In addition to the above activity, 14 exempt employees have transferred into HL from other HAPO departments and 14 technical graduates have accepted off-program placement in HL to date.

C - Technical Graduate Program
Month ending August 31, 1961

| | |
|---|---|
| Number Personnel on Assignment | 89 |
| (HAPO Tech Grad Program ..... 73 | |
| (Engineering & Science Program ..... 16 | |

Distribution of Assignments by Departments

| | |
|---|---|
| IPD | 33 |
| HL | 38 |
| CPD | 11 |
| FPD | 5 |
| C&AO | 1 |
| CE&UO | 1 |

Distribution of Assignments by Function

| | |
|---|---|
| Research & Development or Engineering | 63 |
| Other | 26 |

# FINANCIAL OPERATION MONTHLY REPORT
# AUGUST 1961

## Personnel

J. W. Worden, Specialist - PRTR Cost Accounting, was transferred to CE&UO Finance during August. S. C. Thomson, Business Training Recruit, was transferred to Contract and Accounting Operation and J. G. Plese, a Business Training Recruit, was transferred from CPD Finance to HLO Finance.

## Activities

### GENERAL ACCOUNTING OPERATION

Following is the status of approval letters which are in process:

| Number | Title | Status |
|---|---|---|
| AT-52 | Expanded Use of Whole Body Counter | Resubmitted to Commission for approval on 6/29/61. |
| AT-104 | Fission Products Dispersal Handbook | Still being considered by AEC (submitted 3/17/61). |
| AT-105 | Symposium on the Biology of Transuranic Elements | AEC Washington is considering. |
| AT-187 | Proposal for University of Washington Library School Student Practice Work in Technical Information Operation | Submitted to AEC 8/31/61. |
| AT-188 | National Committee on Radiation Protection and Measurements | Submitted to Contract and Accounting 8/31/61. |

The following actions under Agreement AT-6 took place during the month:

Physics Computer Code Consultation with APED
- Submitted to GE by HOO-AEC 8/14/61
- Agreement by HLO 8/16/61

Borated Graphite Shielding Material Neutron Irradiation
- Submitted to GE by HOO-AEC 8/11/61
- Agreement by HLO 8/14/61

Radiometallurgical X-ray Work for Union Carbide Nuclear Company - APED
- Submitted to GE by HOO-AEC 8/1/61
- Agreement by HLO 8/2/61

Preparations are in process for the annual witnessed physical inventory of reactor and other special materials to be conducted on September 27, 28, and 29, 1961.

Reconciliation of the physical inventory findings of movable cataloged equipment in custody of Laboratory Auxiliaries and portable health instruments in the custody of Radiation Protection is complete. A report of results will be issued in September. Inventory of equipment in custody of the Laboratory Equipment Pool is still in progress.

Project unitization report was issued during the month on Project CAH-744, Metallurgical Development Facility, 306 Building, $2,665,654.

Preliminary unitization work was performed during the month on the following projects and equipment tagged.

CGH-785 In Reactor Studies Equipment - 105-KW Building.

CGH-834 Modification and Additions to High Pressure Heat Transfer Apparatus - 189-D Building.

CGH-907 Strontium-90 Interim Program.

CGH-923 Spectroscopy Laboratory - 325 Building.

CAH-870 Facility for Recovery of Radioactive Material - 325 Building.

CAH-914 Rattlesnake Springs Radioecology Facility.

Unitization reports will be issued on Projects CGH-785, CGH-907 and CAH-870 following receipt of a Financial Closing Statement.

Preliminary unitization work is currently in progress on Project CA-681, Hanford Equipment in the ETR - Arco. Tentative plans are to visit Arco during September to physically inventory project purchased equipment and establish controlled units of property. The project costs ($1,028,708) are currently in Plant and Equipment unclassified.

Five chapters of the Property Management Manual were revised and distributed to manual holders. Revisions update the Manual and set forth HLO procedures for the removal of Government property off-site in connection with lectures or talks and authorization for approval of such passes utilizing the one trip property pass form.

Forty-eight items valued at $31,333 were received at the Laboratory Equipment and Material Pool during the month. Five items valued at $2,775 were loaned or transferred in lieu of placement of requisitions and two items valued at $2,079 were withdrawn by custodians. There are currently 818 items valued at $326,392 in the Pool of which 119 items valued at $15,513 are uncataloged type items and 80 items valued at $44,694 are being held for the convenience of others.

A minor revision was made to the Travel and Living Expense Manual concerning travel by private auto on company business for personal reasons.

Three new forms were designed during the month for the R&D components.

Three suggestions were received for evaluation. Two were rejected and the third will be accepted. It is currently being routed to other HAPO components for possible application.

Action as indicated occurred on the following projects during the month:

New Money Authorized HLO

| | | |
|---|---|---|
| CAH-936 | Coolant Systems Development Laboratory | $12 000 |

Construction Completion and Cost Closing Statements Issued

CAH-885 Geological and Hydrological Wells - FY 1960
(AEM report issued in June 1961)

CA-747 Plutonium Fabrication Pilot Plant
(AEM report issued in February 1961)

COST ACCOUNTING OPERATION

A Target Budget for FY 1962 operating costs were prepared in August by each HAPO component at the request of the General Manager - HAPO. Based on the Target Budget, Hanford Laboratories will receive $103,000 less from the HAPO Service Assessment Pool than originally budgeted. The first departmental allocation of funds for FY 1962 was authorized by the General Manager - HAPO during August. The most significant change from the proposed allocation previously recommended by Contract Accounting was an increase in 02 Program equipment funds from $1,600,000 to $1,800,000.

The August control budget for Hanford Laboratories reflects amounts included in the HAPO Target Budget. Changes from the July control budget are (1) a reduction from $300,000 to $180,000 in funds for Strontium-90 Purification sponsored by CPD and (2) minor adjustments in off-site special requests and other accounts. In addition, funds for the following research and development programs were reallocated internally:

Advance Concept Studies
Specific Fuel Cycle Analyses
Isotopic Analyses
Radiochemical Analyses

Sub-section budgets for the R&D components were developed and included in the August financial statements.

Hanford Laboratories' FY 1962 capital equipment funds were allocated to the sections and submitted to management for review and comments. The allocations were included in financial statements issued during August.

A current list of Hanford Laboratories' General Plant Projects and capital work order requirements for FY 1962 was prepared and forwarded to Contract Accounting to assist in establishing a departmental allocation of HAPO funds.

The annual report concerning personnel recruitment costs for FY 1961 was prepared at the request of AEC and submitted to Contract Accounting for HAPO consolidation. In summary, Hanford Laboratories generated 1,172 interviews with 281 offers and 149 acceptances. Salaries, travel, relocation expenses, and other expenses related to the recruiting function amounted to $175,000 in FY 1961.

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One special request was established during the month as follows:

| Accounting Code | Activity |
|---|---|
| .1U | On-site consultation with APED on S Code work. Estimated cost - $1,200 |

Permission was requested and granted by HOO-AEC for Kaiser to perform the pickling and autoclaving of the PRTR process tube spares.

The FY 1962 Building and Utilities budget and individual building liquidation rates of the Biology Operation were calculated and established. The assignment was completed with the assistance of the Biology landlord.

Standard rates were established for billing salaries of section and sub-section managers and specialists to off-site special requests. Section status at $100 per day and sub-section status at $75 per day will be used for billing purposes.

The annual review of outstanding routine work orders in Hanford Laboratories has been completed with the operating components. Required cancellations, code revisions, and reissuing have been done.

W Wade
Manager - Finance
September 12, 1961

## 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 |
|---|---|
| D. F. Carroll | A Nuclear Fuel Material, HW-70626, August 3, 1961. |
| B. B. Brenden | HWIR-1416, Gaging Tubes and Channels for Straightness |
| L. K. Mudge and F. A. Scott | Methods for Preparation of Uranium Dioxide Powders for Ceramic Fuel Elements (HW-70729) |
| F. A. Scott | Method of Preparing Dense Self-Supporting Uranium Dioxide Ceramics (HW-70730) |
| K. J. Schneider | A Radiantly Heated Spray Concentrator |