# HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

## MAY, 1961

JUNE 15, 1961



HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

GENERAL ELECTRIC

## LEGAL NOTICE





AEC-GE RICHLAND, WASH.

[redacted]
DECLASSIFIED

HW-69822

This document consists of 175 pages. [redacted] ries

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

78987

DECLASSIFIED
By Authority of CG-PR-2 (PR24)
DS Lewis 8/6/92
DS Krsnew 8/11/92
PM Eck 8-12-92

Compiled by
Operation Managers

June 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

CLASSIFICATION REVIEW
DECLASSIFICATION
UNCHANGED
By RH
Date 5-23
U.S. AEC Division of Classification

[redacted]

PRELIMINARY REPORT

This report was prepared only for use within General Electric Company in the course of work under Atomic Energy Commission Contract AT(45-1) - 1350. Any views or opinions expressed in the report are those of the author only.

| Route To: | P. R. No. | Location | Route Date | Signature and Date |
|---|---|---|---|---|
| | | | | |
| | | | | |

1252486

[redacted]
DECLASSIFIED

## DISTRIBUTION

| Copy Number | |
|---|---|
| 1 | W. E. Johnson |
| 2 | H. M. Parker |
| 3 | F. W. Albaugh |
| 4 | C. A. Bennett |
| 5 | O. E. Boston |
| 6 | J. L. Boyd |
| 7 | L. P. Bupp |
| 8 | F. E. Crever, GEAPD |
| 9 | I. H. Dearnley |
| 10 | W. E. Foust |
| 11 | P. F. Gast |
| 12 | A. R. Keene |
| 13 | H. A. Kornberg |
| 14 | W. Sale |
| 15 | R. E. Tomlinson |
| 16 | F. W. Woodfield |
| 17 | H. P. Shaw - V. R. Cooper |
| 18 - 21 | Atomic Energy Commission, Hanford Operations Office<br>Attn: J. E. Travis |
| 22 - 24 | G. F. Quinn, Director, Division of Production<br>Washington 25, D. C. |
| 25 | Savannah River Operations Office, Aiken, South Carolina |
| 26 | 300 Files |
| 27 | Record Center |

# TABLE OF CONTENTS

TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE May 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 | 125 | 113 | 238 | 125 | 116 | 241 | 0 | 2 | 0 | 5 |
| Reactor & Fuels Research & Development | 193 | 181 | 374 | 193 | 181 | 374 | 0 | 0 | 0 | 0 |
| Physics & Instrument Research & Development | 88 | 62 | 150 | 87 | 62 | 149 | 1 | 0 | 0 | 0 |
| Biology Operation | 34 | 47 | 81 | 33 | 46 | 79 | 1 | 1 | 0 | 0 |
| Operation Res. & Syn. | 16 | 4 | 20 | 16 | 4 | 20 | 0 | 0 | 0 | 0 |
| Radiation Protection | 39 | 100 | 139 | 39 | 98 | 137 | 0 | 3 | 0 | 1 |
| Laboratory Auxiliaries | 50 | 184 | 234 | 50 | 182 | 232 | 0 | 7 | 0 | 5 |
| Financial | 20 | 14 | 34 | 20 | 14 | 34 | 0 | 1 | 0 | 1 |
| Prof. Placment & R. P. | 51 | 11 | 62 | 59 | 11 | 70 | 3 | 0 | 11 | 0 |
| Programming | 15 | 3 | 18 | 15 | 4 | 19 | 0 | 0 | 0 | 1 |
| General | 2 | 4 | 6 | 2 | 4 | 6 | 0 | 0 | 0 | 0 |
| Totals | 633 | 723 | 1356 | 639 | 722 | 1361 | 5 | 14 | 11 | 13 |
| Totals excluding internal Transfers. | 633 | 723 | 1356 | 639 | 722 | 1361 | 5 | 9 | 0 | 8 |

## BUDGETS AND COSTS

May operating costs totaled $2,218,000; fiscal year-to-date costs are $23,407,000 or 88% of the $26,664,000 budget.

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

| (Dollars in Thousands) | Cost | | | | |
|---|---|---|---|---|---|
| | Current Month | Last Month | FY To Date | Budget | % Spent |
| HLO Programs | | | | | |
| 02 Program | $ 65 | $ 70 | $ 575 | $ 661 | 87% |
| 04 Program | 706 | 917 | 8 694 | 9 835 | 88 |
| 05 Program | 60 | 71 | 720 | 806 | 89 |
| 06 Program | 231 | 180 | 2 105 | 2 402 | 88 |
| | 1 062 | 1 238 | 12 094 | 13 704 | 88 |
| IPD Sponsored | 232 | 190 | 2 820 | 3 170 | 89 |
| CPD Sponsored | 161 | 160 | 1 804 | 1 994 | 90 |
| | $1 455 | $1 588 | $16 718 | $18 868 | 89% |

## RESEARCH AND DEVELOPMENT

### 1. Reactor and Fuels

Construction continued on the PRTR complex. The Maintenance and Mockup Facility is estimated at 92% completed versus 100% scheduled. The Critical Facility building is estimated at 99.3% complete versus 100% scheduled as of April 20, 1961. The PRTR and PFPP paving and landscaping contract is proceeding on schedule, and the gas loop construction is 83% completed versus 95% scheduled.

Work has commenced on a reduced capacity water plant to meet the immediate PRTR secondary coolant water and rupture loop coolant water requirements. The previously designed water plant structure has been revised to include only two export pumps and correspondingly modified auxiliary equipment.

PRTR startup proceeded into the power test phase. At the beginning of the report period ion exchange resin and other foreign material was found to be lodged in PRTR fuel bundle crevices and otherwise dispersed through the primary coolant system. After cleanup, power tests were initiated. The reactor operated at power levels up to 15 MW, accumulating approximately 53 MWD of core exposure before shutdown on May 18. On May 7, fission product activity was detected in the containment vessel air and in the primary coolant. It is not yet clear whether this activity came from

a fuel rupture or from "tramp" uranium contamination. After the shutdown of May 18, chloride and fluoride contamination of the primary coolant was discovered. Investigation of the extent of corrosion damage, correction of this damage, and inquiry into its origin are in progress.

The mechanical seals and neoprene seals in all three primary pumps were replaced during the month. All three pumps had overheated during operation at primary system temperature of 415 F, causing seal damage. It was concluded that the helium evolved during cooling at the primary seal and during depressurization at the secondary seal was a larger volume than that of which the seals could purge themselves. Modifications have been made to furnish cold $D_2O$ injection to each primary pump and to protect the system in case of future overheating.

During the period of PRTR power operation it was found that xenon effects are about as previously calculated. Also, PRTR shielding was found to be satisfactory except for some neutron streaming through large penetrations in the bottom shield. Cadmium wrapping has been added to reduce the potential for neutron activation of stainless steel components. Further measurements are planned at higher power levels to check these early results.

A calculational study of the reactivity effect of loss of PRTR primary coolant as a function of coolant and moderator purity is being performed. Results to date indicate that for loss of up to ten percent degraded (with light water) coolant, there will be no positive reactivity effect for moderator degradations of ten percent or less.

An addition of a third channel to the log N flux monitoring system was begun. Triplication of the log N system should improve reactor time operating efficiency by reducing the number of spurious safety circuit trips.

Research on $PuO_2$ and on the $UO_2$-$PuO_2$ system indicates the possibility of two forms of $Pu_2O_3$, the possibility of eutectoid decomposition of $PuO_{1.82}$, and complications in the $UO_2$-$PuO_2$ system.

Two injection cast plutonium-aluminum alloy capsules have successfully completed irradiation tests in the MTR.

Arc fused $UO_2$ evolved five times as much gas after swaging as the unswaged material. Tests are being made to determine the source of the evolved gas since the specimen had been exposed to the air for two months.

Extensive sub-grain structure was newly observed on polished and etched columnar grains of $UO_2$ produced during irradiation of swaged or vibrationally compacted $UO_2$, vibrationally compacted electrodeposited $UO_2$, and sintered $UO_2$ pellets. Collections of void along these sub-grain boundaries is further evidence of fission product relocation which continues

to be revealed by additional autoradiographs of cut and ground transverse faces of irradiated $UO_2$ fuel rods.

Special PRTR Mark I swaged $UO_2$ fuel elements with thermocouples embedded along the axes of fuel rods have operated satisfactorily during power operation conducted to date.

Irradiation of a three-foot long nested tubular fuel element containing vibrationally compacted high energy impact formed $UO_2$ continues without unusual incident in the ETR 6x9 loop at an estimated maximum surface heat flux of 300,000 BTU/hr-ft$^2$. About 330 MWD/T exposure has been accumulated. A tubular Zircaloy-clad vibrationally compacted $UO_2$ test element (HAPO-6) recently discharged from KER-1 after accumulating approximately 150 MWD/T shows no externally visible change.

The first significant irradiation of hot swaged $UO_2$ (4-rod cluster) is in progress in the MTR. An $UO_2$ - 10 w/o $ThO_2$ mixture was vibrationally compacted to 86% TD (90% compaction efficiency) in 1.120" OD x 0.030" wall stainless steel tube, 12" long. The element will be irradiated in the MTR.

The irradiation of KSE-3 single tube metallic fuel elements to exposures of 2000 MWD/T have, in general, been successful. The braze closure has displayed no shortcomings.

In the investigation of the metal inert gas welding process for final closure of NPR fuel elements, the apparatus has been automated. The entire cycle, exclusive of positioning the fuel, takes slightly more than three seconds to complete. High quality welds are being produced.

In the development of a modified NPR closure utilizing copper as a bonding medium, difficulty was encountered in producing a continuous bond free of small non-bonded areas. Use of a post-pressing heating cycle with an external retaining ring on the end of the element has now produced bonds free of any detectable discontinuity.

Detailed studies of NPR inner tube extrusions with and without cladding have started to show a fair correlation between the plane of shift and the plane of warp. Wall thickness variations are also being explored to see if they can be related to warp.

The sixth NPR rupture test was conducted in the ETR using a specimen previously irradiated to 400 MWD/T in KER. A slight increase in pressure drop accompanied by increased loop activity caused the test to be terminated in one hour.

An NPR inner tube self-support made with reverse folds in 30-mil thick Zircaloy-2 strip will replace the arched type unless flow tests, discharge

tests, or irradiation tests reveal unforeseen deficiencies. The new design will hold 1000 pounds without crushing or causing a shear load on the spot welds, whereas the old design either crushes or breaks the spot welds at 400 pounds load or less.

A computer program was written for the analysis of fluted cylindrical reactor fuel elements. Cladding deformations and stresses can be estimated for arbitrary shapes and any number of convolutions. A technique for welding end caps in fluted elements has been developed employing electron beam welding.

The operating temperature of Zircaloy-2 creep capsule II-2 is considerably higher than originally anticipated. Contamination of the helium atmosphere within the capsule is suspected to be the cause of a considerable reduction in heat transport within this capsule. A modification has been made in the design of third generation capsules to reduce heat generation and transport problems.

A breakaway type of hydriding in Zircaloy-2 samples has been observed about the time the hydrogen content in the metal reaches the hydrogen solubility limit at the temperature of the corrosion test. The evidence comes from samples having the same surface area but of different thickness exposed at 400 C to a mixture of hydrogen and water vapor.

Fifteen Zircaloy-2 tubes for the overbore test at C Reactor have been produced by a new fabricating process promising over-all metal yield from sponge to finished tube of about 75%. An ultrafine grain structure is developed, making increased amounts of cold work per tube reduction pass possible.

The third thermocouple slug for measuring the temperature drop across crud deposits was successfully charged into KER Loop 1, but ruptured six hours after reactor startup. Visual examination in the basin revealed a circumferential split in the cladding near the end cap and also a longitudinal split over the two holes for thermocouples. A more detailed examination in the Radiometallurgy Laboratory will be made to determine the cause of failure.

The addition of small amounts of iron oxide during the manufacture of graphite alters the dimensional changes during irradiation. During 30 C irradiation the transverse growth of the graphite to which iron oxide had been added was 43% greater than that for graphites without additive. Since graphites which grow at a high rate during room-temperature irradiations normally contract at a low rate at high temperatures, these results suggest that the dimensional stability of graphite at high temperatures may be improved by additives.

Heat transfer experiments were completed to allow a prediction of the fuel temperatures during the shutdown transient following a rupture of the inlet piping to a process tube on a BDF type reactor.

The determinations of maximum heat transfer capabilities of the NPR tube-in-tube fuel elements were continued. Forty-eight additional boiling burnout data points were obtained using an electrically heated test section.

A report was issued covering laboratory investigations of the critical discharge of steam-water mixtures from uniform flow passages. In addition, experimental work was also devoted to a study of the discharge of hot water to the atmosphere through short tubes having sharp entrance edges.

2. Chemical Research and Development

Initiation of large scale, strontium-90 recovery operations at the Hot Semiworks resulted in the accumulation of about 150,000 curies of product. The recovered material met all specifications for radiochemical and inert impurities. In addition, 25,000 curies of strontium-90, obtained from High Level Radiochemistry Facility operations, were absorbed onto the Decalso bed of the HAPO-1A cask for shipment to ORNL. (The cask left HAPO on June 1, 1961.)

Studies were continued on the preparation of strontium-90 bearing glasses. As expected, the solubility of the glasses in boiling water increases with strontium content while the higher melting glasses exhibit lower solubilities.

A procedure has been developed for the scavenging of radionuclides from NPR decontamination wastes. The scavenging agent, manganese dioxide in alkaline solution, was found to remove about 99, 95, 90 and 50 percent of the cerium, strontium, zinc and cobalt radioisotopes, respectively. As reported last month, the treated waste will be disposed to ground in a crib north of Gable Mountain some five miles from the NPR site.

Several minerals which show promise of utility for the decontamination of reactor effluent waters were evaluated on the basis of P-32 absorption. The two most efficient minerals, sodalite and epidote, were found to remove 60 and 47 percent, respectively, of phosphorus-32 in 1000 bed volumes of reactor effluent water.

Samples of water from the Columbia River and its major tributaries are currently being analyzed to determine the source and concentration of parent materials responsible for radioisotope formation when this water is used to cool the Hanford reactors.

The use of a radiant heat spray calciner as a liquid waste concentrator was demonstrated. Low temperature of reactor operation and recycle of hot gases permitted high volume reductions without fouling of heat transfer surfaces.

Batch (pot) calcination of simulated Purex high level waste admixed with borax and phosphoric acid resulted in severe corrosion of the stainless steel pot. Negligible corrosion is experienced in the absence of borax and phosphoric acid.

Basic feasibility of a spray calciner utilizing an internal flame as the heat source, vice radiant heat from the hot wall, was demonstrated.

Stratigraphic studies have shown that the "blue clays" or lower beds of the Ringold formation between Richland and Columbia River mile 348 (site of the proposed dam) are interlaced with extensive gravel trains. Flow patterns of ground water in such aquifiers are anticipated to be complex and may have significance to the movement of underground wastes.

In addition to extensive and broad studies underway to elucidate the basic chemistry of uranium, plutonium and fission products in molten salt systems, it has been found that self-supporting, dense $UO_2$ compacts can be grown electrolytically under a wide range of conditions.

Conditions for the photochemical reduction of uranium(VI) to uranium(IV) were adjusted such that the yield in nitric acid-hydrazine solution was roughly equivalent to that obtained previously in nitric acid-formaldehyde solutions. Hydrazine bearing solutions are desired for Purex plant application (i.e., to obviate the use of ferrous ion as the plutonium reductant).

3. Physics and Instrument Research and Development

Advances were made in the computational programs for reactor physics. The NPR lattice cell was successfully analyzed with the RBU code giving good agreement with experiments and other calculations. Improvements to the input subroutine for HFN, the multi-group neutron diffusion theory code, increase its speed by twenty percent. A new code was developed for use in critical mass calculations for homogeneous systems.

Further HLO-CPD experiments were completed to improve the nuclear safety limits for one step of the 234-5 Building process. The mass limit for a hood was increased a factor of three as the result of in situ measurements of neutron multiplication.

More economical and reliable circuits have been developed for the prototype Fast and Slow Scanning Type Fuel Failure Monitor. The prototype scanner has now rotated continuously for three months with satisfactory operation of the mechanical system and the electrical slip rings.

Improvement of reactor nuclear instrumentation will be aided by design of a ceramic tube cathode follower circuit which has operated reliably at 300 C.

Better analyses of production reactor safety are being obtained with a new nineteen-region reactor analog simulation being used to evaluate the effect of safety rod malfunction on speed of control.

A very small release rate of 100°C $CO_2$ gas into the air has been detected by infrared radiometry. Further work is planned to determine if this method could be used to help locate costly helium gas leaks at the production reactors.

Development of theoretical methods for predicting neutron energy spectra will be aided by evidence of neutron self-shielding in PuAl alloy fuels found in a PCTR experiment.

Improved predictions of fuel isotopic changes during irradiation will be obtained with fuel and moderator neutron temperature data from the PRTR critical tests.

The HLO developed Process/Shroud Tube Annulus Gauge operated satisfactorily during the first inspection of PRTR tubes since the reactor has operated.

In the extended lifetime Neutron Flux Monitor program, attention is being given to the effects of reactor temperature changes on the response of detectors using Pu isotopes.

Mathematical analysis of data obtained with the broadband eddy current nondestructive testing equipment shows a need for more definite experimental data. New circuits have been devised for this purpose.

Sensitivity of the developmental thermal nondestructive test is now sufficient to detect 1/8-inch-diameter defects in coextruded Zircaloy-clad fuel core-to-jacket bonds.

In the study of graphite damage mechanisms, irradiation and measurement difficulties at liquid nitrogen temperature were overcome. Resistance changes were measured with good accuracy and reproducibility.

Three different studies were begun at the whole body counter to provide information on a new scanning technique, the usefulness of a shadow shield, and on backgrounds encountered in counting P-32.

Progress was made in the development of miniature thermoluminescent dosimeters. However, further improvements in gamma energy independence are needed at low gamma energies.

Activities in Air Force supported programs in Atmospheric Physics increased during the month with startup of diffusion experiments at Cape Canaveral, Florida, on May 15, as scheduled. By month end, eleven experiments had been completed, providing dosage measurements to a distance of 1.5 miles from a source near ground level. Data collected during these experiments

will comprise an important addition to the data collected at Hanford for evaluating topographic and regional influences on atmospheric dispersion patterns.

4. Biology

From X-ray sensitivity tests it appears that virulent columnaris strains are diploid, while the non-virulent are haploid. If this very important finding is confirmed, it may comprise good evidence for the improbability of Hanford production being associated with increasing the virulent strain.

Population studies indicate this has been the most successful Canada goose nesting season since comprehensive studies began in 1953.

Ability of yeast to absorb potassium, phosphate, and glucose was found to decrease in $D_2O$.

Roots of plants killed by boiling water or by freezing resulted in greater uptake of calcium than in unharmed plants. Elucidation of fundamental physiological processes in plants may be forthcoming.

Swine being fed $Sr^{90}$ showed more rapid uptake of $Fe^{59}$ into erythrocytes from the serum than did control swine. This may be a new, sensitive indicator of bone damage.

"Paducah dust" exerts most of its hazard through chemical toxicity--presumably uranium. In dogs that inhaled the material, kidneys appeared damaged.

5. Programming

The recently announced AEC price-reduction for uranium (from $39.27 to $23.50/kg U for natural-enrichment $UF_6$ effective July 1, 1961) will reduce total fuel costs for many typical power reactors from about 3 mills/KWhe to about 2.5 mills. The simultaneous effect of increasing the uranium use-charge from 4.0 to 4.75 percent offsets the above reduction only very slightly.

The economics of recycling plutonium through a salt-cycle process is influenced substantially by the relative size of plutonium-enriched zones in the reactor. This factor affects both the reprocessing plant costs and the penalty per gram for fabricating plutonium-bearing fuel. However the burnout costs appear to be relatively insensitive to the sizes of the zones for practical cases.

Last month's study of the potential hazards and estimates of accident liabilities for shipping Cs-137 is being extended to include shipping Sr-90 in various forms.

## TECHNICAL AND OTHER SERVICES

In the accelerated nondestructive testing of NPR pressure tubes, 22-1/2 miles of tubing were tested, counting the multiple inspections of each tube by several test methods. Many indicated defects have been found to be within five mils of the surface where they can be readily removed by surface conditioning.

No new cases of plutonium deposition appeared this month. Totals remain at 267, of which 194 are currently employed.

Emissions of strontium from the Hot Semiworks to the atmosphere totaled 100 mc. No significant personnel exposure occurred. High efficiency stack filters are presently being installed to reduce emissions.

At a periodic Columbia River Advisory Group (CRAG) meeting a recent environmental exposure evaluation of the Hanford vicinity prepared by the U. S. Public Health Service was discussed. Within the framework of their assumptions, the calculated doses are in approximate agreement with the values derived and reported locally. However, the conclusions reached implied a more serious situation than we presently hold.

There are 20 currently active projects having combined authorized funds in the amount of $19,999,000. The total estimated cost of these projects is $25,303,000. Total expenditures through April, 1961, were $15,214,000. Project proposals have been submitted to the Commission requesting authorization of $562,000, total project funds on four projects.

Use of available computer programming techniques has greatly simplified certain analyses of rupture data, thus making it possible to develop many models for the same set of data, where the data are divided into equal power-temperature cells in different ways.

Optimum sizes of supplemental crews were determined for reactor operation following conversion to bumper fuel elements.

A new method of estimating aluminum corrosion penetration during the breakaway stage, which is independent of any assumption about the pre-induction time corrosion mechanism, was used to analyze M-400 and X-8001 alloy corrosion data. The results of the analysis are in agreement with previously formed notions about the effect of heat treating variables except for a peculiar dependence on the method of cooling samples following anneal. Further work is being done on this remaining question.

Statistical analyses of data from an experiment involving irradiation of a population of Mediterranean flour moths was completed and results reported to Biology.

The investigation was completed concerning what inferences could be made as to reactor characteristics and/or exposure levels given a knowledge of Pu isotopic concentration.

## SUPPORTING FUNCTIONS

The FY-1962 estimate of Hanford Laboratories requirements under the "Assistance to Hanford" program was submitted to Contract Accounting in the amount of $65,000.

Special request activity during the month was as follows:

1. Authorization was received from HOO-AEC in the amount of $18,000 to cover costs and commitments on U. S. Air Force purchase order PR J 572 which was originally established for $55,000, but subsequently changed due to termination of the over-all aircraft nuclear propulsion program.

2. Program code was established for the new AEC/AECL Cooperative Program entitled "Non-Destructive Testing of Thin Wall Zircaloy Fuel Sheathing." Expected costs are $8,000 in FY 1961, $110,000 in FY 1962 and $32,000 in FY 1963.

3. Program code was established for the new AEC/AECL Cooperative Program entitled "SAP-SAP Magnetic Force Closure Studies." Expected costs in FY 1961 are $24,000.

Heavy water returned to SROO for rework during May amounted to 4038 kgs. Heavy water generated for return to SROO during May amounted to 1604 kgs. A requistion was placed during the month for 3636 kgs to be delivered in August.

A two-minute news film on the completion of the Critical Mass Laboratory was prepared.

Discussions with small work groups on changes in benefit plans were completed with a total of 49 presentations.

Advanced Degree - Eight Ph. D. candidates visited HAPO for professional employment interviews. Seven offers were extended; three acceptances and nine rejections were received. Current open offers total 11. For the recruiting year, we have achieved 12 Ph. D. acceptances.

BS/MS - Recruiting activity for the Technical Graduate Program included 19 offers, 17 acceptances and 58 rejections. Six offers remain open. For BS/MS experienced personnel, 17 offers were extended, 5 acceptances and 2 rejections were received with ten offers remaining open.

Technical Graduate Program - Nine Technical Graduates were placed on permanent assignment during the month. Four new members were added to the program rolls and two terminated. Current program members total 41.

Two disabling injuries occurred. One employee severed a finger tip with a power shear. Another suffered a broken toe when an empty barrel slipped. There were 32 medical treatment injuries compared to 42 in April.

The incidence of security violations was reduced from eight in April to two in May.

Tuition refunds for the winter quarter of the University of Washington Graduate Center are currently being made. As a matter of interest, Hanford Laboratories has 90 employees, including 6 non-exempt, who are receiving refunds compared with a HAPO total of 163.

The microfilming of Files document holdings in the Records Center was substantially completed early in the month. On May 9, work began on the older documents in the Files vault. The objective of the microfilming program, to make more filing space available in the vault, is now being attained.

The mechanization of the Files issuance, routing, and mailing activities is proceeding as scheduled. The IBM Card-a-type equipment arrived on Plant May 22 and a mockup of the Files installation has been made in the Conference Room of the 705 Building.

R S Paul
for Manager
Hanford Laboratories

HM Parker:RSP:mcs

# REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

## TECHNICAL ACTIVITIES

## A. FISSIONABLE MATERIALS - 2000 PROGRAM

### 1. METALLURGY PROGRAM

#### Corrosion Studies

KER-1 Zircaloy Process Tube. Previously a sample cut from the area of rapid corrosion in the irradiated KER-1 Zircaloy-2 process tube also indicated accelerated corrosion during autoclave exposure to 300 C, pH 10 water (LiOH). A second irradiated sample cut from an area of normal corrosion in this process tube is currently being tested under the same conditions. After seven days of exposure to 300 C, pH 10 water, the weight gain for the irradiated sample cut from the low corrosion zone of the process tube was 11.4 $mg/dm^2$, compared to 15.5 $mg/dm^2$ for the sample from the high corrosion zone and 11.3 $mg/dm^2$ for unirradiated KER-1 samples. It is tentatively concluded that the area of high corrosion occurring during the service history of the tube is related to the local condition of the metal, since it persists under post-irradiation testing.

The Effect of Hydrogen Content on Hydrogen Pickup. A breakaway type of hydriding has been observed at about the time the hydrogen content of the corrosion samples reached the hydrogen solubility limit at the temperature of the corrosion test. Samples of the same surface area but different thicknesses will become saturated with hydrogen at different times while hydriding at the same initial rate. A series of 5, 10, and 30-mil thick Zircaloy-2 samples exposed at 400 C to a mixture of 400 mm $H_2$ and 23 mm $H_2O$. The 5-mil samples showed a sharp increase in hydriding rate between two and three days; the 10-mil samples between 13 and 20 days. Hydrogen contents were about at the 400 C solubility limit when the break occurred in each case. The 30-mil samples are completed, but no data are available.

Erosion-Corrosion of Aluminum Alloys. To study the erosion-corrosion behavior of aluminum alloys X-8001 and 1245, samples were exposed to 300 Area tap water adjusted to pH 6, 7, and 8, by adding either nitric acid or sodium hydroxide flowing at a velocity of 88 ft/sec. The water was heated to 102 C before being passed over the samples for six hours. Corrosion was uniformly smooth along the exposed groove except for alloy X-8001 which showed some jaggedness at pH 8. The corroded groove in X-8001 at pH 8 had a cross-sectional area of 153 $mils^2$ as compared to 83 $mils^2$ for 1245. At pH 7, the corroded groove in X-8001 had a cross-sectional area of 35 $mils^2$ and alloy 1245 showed no measurable corrosion. Both alloys at pH 6 showed no measurable corrosion attack. The above tests are short-term only, but pH adjustment appears fairly critical and alloy 1245 shows some superiority.

Radiometallurgy Laboratory Studies

Metallographic examination of a longitudinal end cap section from a KER single tube irradiated to 2000 MWD/T has been completed. The end closure and the cladding appeared to be in excellent condition. One of the tubes that appeared to have bumps in the internal bore when viewed in the basin was sectioned, but no serious bumping was found (RM-578). Metallographic examination of a section from a second Zr-2 clad inner tube with hot head closures from PT-IP-300A revealed fine cracks in the uranium that were filled with some unknown material. Voids and porosity in the uranium at the cladding interface were also found. The cracks in the uranium did not extend into the cladding (RM-706). Two thermocouple capsules were sectioned to remove metallography, density, and burnup analysis specimens. Metallography revealed that the 1.6% enriched uranium fuel was badly fragmented and the Zr-2 cladding contained multiple longitudinal brittle fractures (RM-559). Two fuel elements were received for examination after rupture indications were noted following discharge from KER. Examination showed that the cladding had parted around the base of one element at the juncture of the fuel and end cap. The failure mechanism appeared the same as in the K-3-12 failure (RM-579). Eight Zr-2 clad swelling specimens were removed from NaK capsules GEH-14-96, 97, 101, and 103. On two of the specimens an end cap had broken completely off during the irradiation. Swelling of the uranium core next to the end caps had split the cladding both longitudinally and circumferentially on the ruptured specimens from capsules 96 and 97 (RM-565). Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

Basic Metallurgy Studies

Electron and Optical Microscopy. Microstructural changes or damage in metals due to fission fragment and neutron bombardment are being studied by electron microscope techniques. High purity, aluminum foils, 0.003" thick, in the annealed and cold worked states, have been thinned and examined after neutron doses of $2 \times 10^{20}$ nvt (thermal). For a given dose, the cold worked aluminum foils contain a greater number of prismatic dislocation loops than the annealed specimens. Comparison of these foils with those irradiated to $1 \times 10^{20}$ nvt (thermal) definitely shows an increase in the number and size of these loops. Since these loops are interpreted as being formed by the collapse of vacancy clusters, where the high vacancy concentration results from the neutron bombardment, migration of vacancies to the collapsed loop and short circuit diffusion around the periphery of each loop by the mechanism advanced by Johnson (Phil. Mag., 5, No. 60, p. 1255, Dec. 1960) may account for the increase in loop size with exposure. Dislocation tangles are less prevalent in highly irradiated specimens, and where these jogged dislocation tangles exist, the number of collapsed vacancy loops is much smaller. Apparently diffusion of vacancies to existing dislocations can occur, and jogging results. Aluminum tensile specimens which have been irradiated will be tested in the electron microscope to determine how dislocations move and interact with the prismatic loops.

In order to more fully understand the reasons for fission track registration in metallic and nonmetallic films and foils subjected to fission fragment bombardment, the following experiment was performed. Two types of collectors, a 200 A thick carbon film and a similar carbon film coated with 20 A of platinum, were positioned one millimeter from an evaporated film of $UO_2$ during irradiation. The source film was of two types: (1) a film of $UO_2$ only, and (2) a film of $UO_2$ coated with a 200 A thick layer of evaporated carbon. After an exposure to $4 \times 10^{18}$ nvt (thermal) in an evacuated capsule, the collector films were examined in the electron microscope. Particles, identified by electron diffraction to be $UO_2$, formed on the collectors only in the case of the uncoated, $UO_2$ sources. The 200 A thick carbon coating on the $UO_2$ source, therefore, prevents $UO_2$ transfer to the collector, such transfer being due to thermal activation of $UO_2$ atoms by fission spikes. Fission damage tracks were readily perceived in the platinum coated carbon collectors. Presence of the $UO_2$ on the collector which was opposite an uncoated source was further substantiated by virtue of the long damage tracks in this collector. Only very short tracks in the collector opposite the carbon coated source are detectable. Considerations of the physical geometry of source and collector during irradiation leads to the conclusion that tracks in the collectors are due to fission fragments which pass through the collector and come to rest in the copper supporting grid. Fission product activity, due to Zr, Nb, Ru, Ba, La, Te, Ce, and Mo in the copper grid have been definitely identified by gamma ray spectrometry. The possibility of studying fission fragment damage in metals as a function of the energy of the fragments is being considered for future work.

A formal report, HW-68919, "Experimental Evidence of Fission Fragment Damage in Some Metals and Nonmetals," has been submitted to Technical Publications.

Notch Sensitivity of Zircaloy-2. Recent failures of Zircaloy-2 clad test elements have shown localized failure with little uniform straining in the remainder of the clad. Sensitivity of Zircaloy-2 to surface irregularities such as a notch or deep striation introduced during forming or handling might be the cause of this unpredicted failure tendency. A series of tests at 280 C is being conducted to determine the effects of such variables as notch depth and shape, specimen geometry, orientation, and strain rate. Preliminary results have been obtained on 0.020" thick flat transverse specimens having a v-shaped notch with a 0.005" base radius. At a notch depth between 0.3 and 0.4 of the specimen thickness, considerable strain occurs at the notch; however, there is about equal probability of failure outside the notch area. An increase of the calculated nominal ultimate strength of the material at the notch occurs as the notch depth fraction is increased. An increasing strain rate also causes an increase in strength. The strain at the base of the notch is observed to result primarily in a reduction of specimen thickness. Strain in the unreduced section generally does little to specimen thickness but causes a marked reduction in the width of the specimen. The hardening effect of the notch may be related to the introduction of a lateral restraint. Strain then can only occur in the thickness of the specimen which has considerably different strength because of the anisotropy of the Zircaloy-2. The

observance of a strain rate effect indicated that work hardening rate is also effective in controlling the failure mode. Work is continuing with an investigation of the effects of notch shape on this strengthening.

Metallic Fuel Development

Fuel Irradiations. The sixth rupture test of NPR-type fuels in the current series was performed at the ETR on April 28, 1961. The defected fuel element used for this test had been previously irradiated to 400 MWD/T in KER Loop 3. The ETR was operated for four hours at full power before the defect cap was sheared off. Twelve minutes after the defect cap was sheared off, the first indication of the failure of the fuel element was an increase (1/4 psi) in the pressure drop across the loop. After 34 minutes, the loop pressure drop had increased by 3/4 psi and four minutes later the delayed neutron monitor and the gamma scintillator began rising. The test was terminated after one hour by shutting down the reactor over a four-minute period. Temperature conditions at the defect during the test were:

| | |
|---|---|
| Local bulk water temperature | - 264 C (507 F) |
| Cladding surface temperature | - 290 C (556 F) |
| Cladding-core interface temperature | - 352 C (666 F) |
| Core center temperature | - 481 C (897 F) |

The radiochemical burnup analyses were completed for two KER tube/tube fuel elements with an average calculated burnup of 3200 MWD/T. The uranium tube/tube element had a radiochemical burnup of 0.54 percent (4300 MWD/T) for the outer tube and 0.42 percent (3360 MWD/T) for the inner tube. This inner tube failed by clad splitting. The uranium - 2 w/o zirconium tube/tube element had a radiochemical burnup of 0.45 percent uranium (3300 MWD/T fuel) and 0.38 percent uranium (2900 MWD/T fuel). The uranium - 2 w/o zirconium tube/tube element increased in volume more than the uranium tube/tube element.

An obsolete NPR inner tube KSN-1 with end caps fitted flush to the uranium fuel failed in a KER loop after 1700 MWD/T. The thermal incompatibility between the end cap and uranium fuel induced a shear failure of the Zircaloy-2 clad near the end cap. Although water entry was evident in both ends of the failed element, the above failure mechanism is based upon the observed incipient shear failure of the clad in an unfailed element irradiated in the same charge. The density of the failed element decreased 2.1 percent at the mid-length of the element while the over-all volume increase calculation based on diameter measurements was 3.1 percent.

As a sequel to the MTR test GEH-4-57, 58, another test, GEH-4-63, 64, has been prepared to further test the brazed closure concept. This experiment will use production brazed fuel elements, brazed with the 5% Be - 95% Zry-2 alloy. As previously reported, GEH-4-57, 58 failed at the base of the heat affected zone through a possible extrusion defect. GEH-4-57, 58 was brazed at a temperature of 950 C and these elements were brazed at 1050 C. If brazing temperature is a critical variable in fuel life, this test should

provide a reasonable indication of its severity. GEH-4-63, 64 will operate at essentially the same power and temperature as GEH-4-57, 58.

Radiometallurgical examination of KSE-3 single tube fuel elements exposed to 1200 MWD/T is nearing completion. The Be-Zr eutectic braze closures retained their pre-irradiation integrity. At this exposure no shortcomings were evident.

Examination of KSE-3 elements exposed to 2000 MWD/T is progressing. Slight surface distortion of the inner bore in the braze heat-affected zone was negligible. A limited crack in the fuel at the cap-clad-fuel juncture was observed, but it may have been produced during the post-irradiation examination.

Additional KSE-3 tubes were successfully irradiated to 3500 MWD/T. These elements are scheduled for June 6 discharge.

Fuel Component Development. A new type of NPR inner tube self-support was made. The support was intended to replace one that decreases its height when the fuel element is heated with one that is stable or increases in height. Not only does this new support correct the negative temperature coefficient of support circle diameter, but it also has superior deflection characteristics. A load of 340 lbs on the currently specified inner support will reduce its height over 1/3, while over 1000 pounds of load are required to reduce the height of the new support by this amount. The new support has an elastic range of 25 to 30 mils at a spring constant of 0.6-mil deflection per pound of load. The support becomes very stiff after the initial soft elastic deflection. By making the support height 15 mils greater than nominal width of the annulus, elastic flexure will compensate for size variation in the fuel elements. The new type support was installed on a number of two-foot long NPR elements for discharge testing. Report HW-69745 contains the details of the initial comparison of the standard and the new folded ribbon fuel element support.

One out of eight irradiated 5/8" OD x 0.020" wall thickness Zircaloy-2 burst capsules fractured as a pin-hole failure whereas the other seven burst suddenly into a one-inch long fracture. These capsules were burst in the Radiometallurgy cell with nitrogen pressure at 337 C. All capsules were exposed to about 2 x $10^{19}$ nvt fast neutrons. Examination of a metallographic cross section through the pin-hole failure revealed necking and strain produced voids in the necked area. From this cross section, small longitudinal cracks were apparent on the inside of the tube. These cracks were probably produced during fabrication of the burst capsules. The average circumferential fracture strain in the seven tubes that burst normally was ten percent, and the average circumferential strain in the capsule with a pin-hole fracture was 1.7 percent. The burst strengths of all the capsules were comparable.

[redacted]

NPR Support Attachment. A high quality reproducible weld is required to attach supports to NPR fuel elements. In order to test the reproducibility of these welds a run of 1000 welds was made on 0.040" clad material. The run was interrupted twice for other jobs. The machine was reset to the original conditions each time and the run continued without any further machine adjustment. Thirty-one welds were picked at random for metallographic examination. All others were shear tested. The results are shown in Table I.

TABLE I

| Shear Strength | | |
|---|---|---|
| Between | 700 - 800 lbs | 0.5% |
| | 800 - 900 | 2.0% |
| | 900 - 1000 | 9.3% |
| | 1000 - 1100 | 21.2% |
| | 1100 - 1200 | 31.7% |
| | 1200 - 1300 | 33.3% |
| | Above 1300 | 2.0% |

The welds were made on a 100 KVA resistance welder operating single phase with the following settings. Phase shift 34%, 1 cycle, 1 impulse; weld force 100 lbs (low inertia holder); class 1 electrode with 4" radius tip. The secondary voltage was 8.8 volts.

Metallographic examination showed no disturbance of the uranium or of the bond layer. The heat affected zone in the Zircaloy clad was approximately 2/3 the clad thickness.

Closure Development. Destructive and non-destructive analyses of the closures formed by the "self-brazing" process indicate that entirely sound bonds are formed between the jacket wall and the cap in something less than 50% of the output when processed by the simple hot pressing technique (730 C, ~70 tsi). The incompletely bonded closures typically exhibit spots of sound bonding interspersed with small zones where the jacket has not been metallurgically attached to the cap, although the primary closure (the weld) is invariably sound.

To overcome this deficiency, a simple additional step has been put in the process. This consists of placing a snugly fitting Zircaloy ring around the fuel element at the closure end and heating the end face by means of the electron beam welder to about 950 C as rapidly as possible, then allowing it to cool in vacuo. Under these conditions, the cap, expanded by the heat, is pressed tightly against the surrounding Zircaloy restrainer ring which expands less because it is much cooler. The Cu-Zr eutectic alloy which forms by interaction between the copper plating and the Zircaloy components, at the attained temperature, flows by capillarity into the tiny interstices remaining between jacket and cap, bonding these members together. When the assembly cools, it shrinks away from the restrainer ring which may be easily lifted off by hand. The bond formed in this way is sound, even though it may have been quite spotty after initial pressing.

Metallographic examination of the variable beryllium in Zircaloy-2 coupons with known uranium additions has been completed. This examination revealed that uranium is not visible in the Zircaloy structure below 3% uranium content. Furthermore, uranium up to 1/4% was not visible in the 5% Be + 95% Zry-2 alloy. However, uranium additions of as low as 180 ppm to Zircaloy and to the BeZirc braze alloy were readily detected by measuring the reflected light from the etched surface. With regard to corrosion performance, in 300 C water after 20 hours the 1/4% uranium + 5% Be + Zry-2 alloy developed a heavy, loosely adhering autoclave film, while all other lower alloy compositions developed only a tarnished surface.

Welding of end caps into both ends of three tubular elements with "fluted" external surfaces was accomplished. The welding procedure required two men working on the present equipment, one adjusting the high voltage control and the other manipulating the electron gun and the turntable speed. Some welding difficulty was experienced because of loose end caps. Another difficulty, which was to be expected, occurred when the electron beam spot approached the points of the fluted clad. Since a greater amount of heat is concentrated at these points than on the larger radius of the concave parts of the clad surface, these points tended to melt considerably faster and at times, nearly burned out. Good welds at these points were made when the high voltage was lowered as the welding beam approached and went around the tip. Welding of this shape element in the electron beam welder could be programmed to be done automatically with little trouble.

A method of attaching a 1/4" diameter Zircaloy-2 stud, with a 1/8" diameter welding area, to the cladding of an I&E or NPR inner fuel element was desired to test the Zirc-2 cladding - uranium bond strength. After the stud had been attached, the Zirc cladding immediately around the stud was to be cut leaving only the Zirc-uranium bond holding the stud and the cut cladding to the uranium. The requirements of the attaching method were that it did not affect the Zirc-uranium bond and that it would hold as this bond was pulled apart. The attachment was achieved through the use of a Graham Stud Welder, a percussion welding machine. The weld produces a bond which, when pulled in a tensile testing device, is stronger than the Zirc-uranium bond.

The welding apparatus for investigating the Metal Inert Gas welding process as a method for making the final closure on the NPR fuel elements was automated to the point where the entire welding cycle, exclusive of positioning the fuel element and adjusting the turn-table speed, is done by activating a single control. This permits automatically starting the weld, timing the weld, manually controlling the crater fill and ending the weld. The weld, on the outside diameter of the NPR inner element, from the time of striking of the arc, takes slightly less than three seconds to complete.

Component Fabrication. Four Zircaloy-2 blanks were successfully cupped into 4-inch OD by 3-17/32-inch ID sleeves using the existing 700-ton press, 4-inch extrusion equipment. Sleeves fabricated by this process will be used for special coextrusion billet components in coextrusion studies.

[redacted]

The cupping punch which is normally difficult to lubricate in this type of operation was successfully lubricated throughout the entire stroke by inserting a 9/16" diameter copper rod in a hole drilled nearly through the center of the blank. A 0.015-inch thick copper disk was placed over the face of the Zircaloy-2 blank which initially contacts the steel cupping punch to prevent the Zircaloy-2 from seizing to the punch before protection is possible from the copper rod. The Zircaloy-2 blank was first copper immersion plated to prevent excessive oxidation of the blank during the 750 C preheat in air. The plate was sufficient to prevent the sleeve from seizing to the extrusion container bore during the cupping operation.

A 120° angle pointed punch and a flat punch were both tried with the cone punch producing a slightly more concentric sleeve. However, the cone punch cracked with the first sleeve.

Ten 0.600" diameter Zircaloy-2 clad extrusions have been fabricated for cladding thickness uniformity studies to be conducted by the Fuels Design Operation. Two extrusions were made from vacuum induction melted and heat treated billets of U - 2 w/o Zr, the uranium being enriched to 1.47%. Eight unalloyed 1.47% enriched rod extrusions were made from pre-extruded billet stock.

Billet stock was prepared from an arc cast ingot 3.8" diameter, weighing 144 lbs. Arc melting was performed in the consumable arc furnace in the 306 Building using a vacuum induction melted electrode. Quality evaluation of the material is in progress.

Heat Treatment Studies. Two NPR inner tube extrusions have been made, one with Zr-2 cladding and one without clad, for warp studies. Twelve, 24" long elements were cut from each extrusion, and all have been heat treated at 730 C for seven minutes followed by an 18-second air delay and quench into 300 C nitrate salt bath. Average as-extruded double-throw warp was 18 mils for the unclad tube and was 11 mils for the Zr-2 clad tube. Average post-heat-treatment warp was 38 mils for the unclad tube and 27 mils for the Zr-2 clad tube. An unusually large amount of shift was noticed in the Zr-2 clad tubes, and there appears to be a fair correlation between the plane of the shift and the plane of warp. Wall thickness measurements are being made on all tubes to see if any correlation can be found between the wall thickness and the warp.

Fuel Straightening. Fuel straightening experiments on 23.5-inch long, N inner fuel tubes indicate that double throw warp of 0.013 to 0.095 inch can be reduced to 0.003 to 0.010 inch. Straightening is accomplished by heating the element to 575 C in an argon atmosphere and cooling in the three roll straightener. After straightening, the elements were autoclaved 72 hours in 400 C steam to determine the extent of warp. Two groups of elements have been straightened. The history of the first group (six elements) is: extrusion, beta heat treatment, stress relief anneal (600 C, 4 hours), straighten, and autoclave. The average double throw warp after straightening was 0.006 inch, with an absolute range of 0.003

to 0.010 inch. After autoclaving, the average increase in warp was 0.005 inch, with an absolute increase in the range 0.001 to 0.011 inch. The history of the second group (7 elements) is: extrusion, beta heat treatment, straighten, and autoclave. The average double throw warp for this group after straightening was 0.009 inch with a range of 0.004 to 0.015 inch. After autoclaving the average increase in warp was 0.004 inch with a range of 0.000 to 0.007 inch.

Fuel Deformation Studies. To study the effects of cladding thickness variations on the susceptibility to cladding failure, a series of NaK capsule irradiations of Zircaloy-2 clad fuel rods is planned for the Hanford reactors. Eighty unalloyed uranium fuel rod samples are in various stages of fabrication and fifteen U-2 w/o zirconium fuel rods are in the final stages of fabrication prior to assembling them into the irradiation capsules. A fine mesh grid has been photoengraved on the cladding surface of the alloyed rods. Fabrication and subassembly of the thirty-four capsules is complete.

A method of analysis for the deformations and stresses in the cladding of shaped cylindrical fuel elements was derived. The analysis assumes that the fuel material exerts a uniform pressure, extensions of the mid-surface of the cladding are neglected, and the cladding deforms elastically. A computor program was written and run which analyzes shaped cylinders with any number of corrugations, any symmetric shape of corrugation, and continuous variation of cladding thickness. In order to systematically investigate various shapes, a program based on corrugations formed by two tangential arcs was coded using the analysis previously described. Families of arcs of constant length are compared.

## 2. REACTOR PROGRAM

### Coolant Systems Development

Thermocouple Slug Test in KER-1. The third thermocouple slug for measuring temperature drop across crud deposits was successfully charged into KER Loop 1, but ruptured on reactor startup. The thermocouple slug consisted of a one-inch diameter rod of natural uranium with a co-extruded 20-mil Zr-2 clad. Three thermocouples extended two inches into the uranium from one end, one on the axis and two just under the clad. Two other thermocouples measured the adjacent water temperatures. Since several previous thermocouple trains had struck on charging, the spacers in this train were of a modified design, being 16-inch lengths of carbon steel tubing with mating ends conically beveled to produce a true line feature to ensure alignment. This was charged from the front face on May 11 with no difficulty. The loop charge also included one 18-inch KSE-3, two 12-inch KSN-3, and two 16-inch KSN-3 heater elements downstream of the thermocouple train, and the heater elements were charged and discharged to ensure that the entire charge could be charged and discharged easily. The entire loop was decontaminated with Phos-1 using two similar cycles of fill, recirculate, and drain. Following this, the loop was rinsed with deionized, deoxygenated water. The thermocouple

[redacted]

[redacted]

slug ruptured six hours after reactor startup. The delayed neutron monitor indicated abnormally high activity starting about four hours before the rupture. On visual examination in the basin, the rupture looked similar to that of the previous thermocouple slug. The clad was split circumferentially near the end of the end cap and also longitudinally over the two holes for thermocouples. The thermocouple slug and heater elements had a light uniform rust colored deposit on them.

Rupture Testing Irradiated Fuel Elements. A 50-minute rupture test at 300 C, 12 fps flow, and 1650 psig was performed in the IRP on a co-extruded fuel element that had been irradiated to 2400 MWD/T in KER. The rupture was very severe. The Zircaloy-2 cladding had torn in spiral strips over five inches of length. The uranium core underneath this area appeared to have corroded uniformly. Total weight loss for the rod was 150 grams.

Nickel-Coated Fuel Elements. Nickel-coated fuel elements, for potential present reactor use, showed excellent corrosion resistance after 6715 hours at 165 C and 6867 hours at 120 C in process water. All pieces were predefected with scratches and abraded areas to expose bare aluminum metal, and in no case were these defects enlarged during the tests. The film formed on the element surfaces in the 120 C test was very thin and was only moderately adherent. The 165 C test pieces accumulated a moderately thick film.

Present Reactor Decontamination. A rear face only decontamination was performed at C Reactor as a production test by IPD. Solutions of 6 oz/gallon at 70 C were pumped through reactor rear cross-headers, pigtails, and nozzles at one to two gpm for ten minutes. The solutions were diluted by water flow through reactor process tubes. The upper two-thirds of the reactor cross-headers were cleaned with Turco 4306 C, and the lower one-third with Turco 4306 B. Contaminated samples (aluminum dummies) placed in the rear of the tubes were measured before and after to determine degree of decontamination. The Turco 4306 C removed about 90% of the activity (decontamination factor of 10), and the Turco 4306 B removed about 95% of the activity (decontamination factor of 20). Both decontamination factors (10 and 20) are acceptable for rear face decontamination.

Corrosion in High Temperature Water at pH 10. Uniform corrosion rates of A212 c/s and 304 s/s are being studied in recirculating, deionized, deoxygenated water at 300 C with the pH adjusted to 10 with LiOH. The test is in a loop constructed entirely of stainless steel. After 1300 hours of exposure, penetrations of 0.01 and 0.03 mils, respectively, on stainless steel and carbon steel, were obtained. The carbon steel is corroding with a linear relationship with time at a rate of 0.16 mils/year, which is comparable to the rate obtained in a carbon steel test loop. The corrosion films on both the carbon steel and stainless steel have a dark gray, shiny appearance and are very tightly bound to the metal surface.

The uniform corrosion rate of Carpenter Ferral Experimental in 290 C, pH 10 water was determined after 2426 hours of exposure. Up to the first

500 hours of exposure, the samples were easily descaled in inhibited hydrochloric acid, but thereafter the films could not be removed. However, descaled weights were obtained for the longer exposed samples by using a solution slightly corrosive to the base metal. This introduced some error in the final corrosion penetration data. Using these data, which are known to be high, the calculated corrosion rate was 0.215 mils/year.

NPR Control Rod Thimbles - Titanium-Graphite Galvanic Corrosion. Corrosion of titanium samples in contact with graphite is negligible at 50 and 70 C. Samples with a titanium-to-graphite surface ratio of about 1:2 were exposed for 11 months to a humid atmosphere. Some samples occasionally were immersed in filtered water (concentrated by evaporation). Total penetration of the titanium ranged from less than 0.001 mil to a maximum of 0.003 mil.

## Structural Materials Development

Zircaloy Retubing Program. Smooth bore Zircaloy-2 tubes for corrosion tests in K Reactor have been provided by butt welding short tube sections onto C Reactor tubes. An inert-gas, tungsten-electrode, welding technique was developed for this purpose. A novel one-piece, expandable copper chill block was used providing tube alignment and inert gas shielding as well as heat extraction.

Present fabricating technology requires heavy copper jacketing of Zircaloy billets for extrusion at temperatures above 1000 F. Successful extrusions have now been made at 1150 to 1350 F and an extrusion ratio of 4 to 1 with the simpler less expensive billet preparation lubricant. This plating and lubrication technique will be tested under more severe conditions imposed by higher extrusion ratios.

Fifteen Zircaloy-2 tubes for the overbore test at C Reactor have been produced by a new fabricating process promising over-all metal yield from sponge to finished tube of about 75%. This high yield is made possible by cupping the billets and maintaining close dimensional control in the subsequent extrusions. By annealing the extrusions at low temperatures an ultrafine grain structure is developed. With this refined grain structure, which makes greater amounts of cold work possible, the tube can be formed to final size by one tube reduction of 75% reduction in area.

## Nonmetallic Materials Development

NPR Graphite Irradiations. A series of irradiations of NPR core graphite is being started in the GETR. Three capsules, H-4, H-5, and H-6, each containing 24 samples, will be used in the program. Length, x-ray parameters, electrical resistivity, modulus of elasticity, and thermal conductivity measurements are made on each sample. Each capsule will be irradiated for approximately 100 effective days of reactor operation and then removed and disassembled. The samples will be measured and installed

in a new capsule for further irradiation. Two capsules will be under irradiation simultaneously while the samples from the third are being measured and rebuilt into a new capsule.

The first capsule of the series, H-4, has been built and will be installed in the GETR during the cycle 24 shutdown starting June 5. The H-5 capsule is under construction and will be installed during the cycle 25 shutdown. Samples for the H-6 capsule are being prepared and this capsule will be installed upon removal of H-4.

The GEH-13-7 capsule which was being irradiated in the ETR to compare NPR core and reflector graphite has apparently developed a leak. On May 10, all the sample temperatures suddenly dropped to slightly above reactor water temperature. It will be removed on May 29, and examined to determine the cause of the failure.

Graphite Compatibility with Helium Containing Water Vapor. Tests of graphite oxidation by moist helium were conducted for one week in an atmosphere with the following composition ranges: 0.4-0.6% $H_2$; 0.4-0.6% CO; and 0.6-0.8 mm Hg partial pressure of water vapor in helium. Average oxidation rates were $1.5 \times 10^{-5}$, $2.4 \times 10^{-5}$ and $4.0 \times 10^{-5}$ gm/gm-hr at 750 ± 10, 800 ± 10, and 850 ± 10 C, respectively. These rates, which are about two orders of magnitude greater than the present process limit, are unacceptable.

The second test was a three-day run at the same respective temperature, but with ~ six times as much $H_2$ and CO, namely 2.7-2.9% $H_2$ and 2.5-3.1% CO. There were no significant weight changes during this test, illustrating the retarding effects of $H_2$ and/or CO on graphite oxidation. The tests at the lower $H_2$ and CO level will be repeated, but the results indicate a possible need to maintain ~3% $H_2$ in the NPR atmosphere if $H_2O$ is needed to prevent zirconium hydriding.

Curing Hypalon Compounds with Gamma Radiation. Curing elastomers with ionizing radiation offers several advantages over the conventional chemical and heat cures in that unique physical properties can often be obtained. Environmental resistance can be improved because those chemical curing agents which are detrimental to environmental resistance are eliminated. Studies are currently under way of the properties and environmental resistance of gamma-radiation-cured Hypalon 40 (chlorosulfonated polyethylene) compounds. Experimental results to date indicate that, although the curing agents can be eliminated, other ingredients are still very essential. The resulting compounds with carbon black added for reinforcement have good original properties, but their resistance to hot water and heat aging is marginal. With respect to heat aging resistance, the data indicate that the addition of antioxidants, stabilizers, etc., are still highly desirable.

## Thermal Hydraulic Studies

Heat Transfer Conditions for Eccentric Annuli. Experiments were continued to determine the heat transfer conditions when fuel elements are not situated in a coaxial position within the process tube. Collection of laboratory data applicable to I&E fuel elements in a BDF process tube was started for the case of 75% eccentricity. (Percent eccentricity is the fraction of the normal annulus thickness that the fuel element is displaced from a coaxial position toward the wall of the process tube.)

The test section used was a 30-inch long electrically heated rod, 1.445 inches in diameter, placed within a 1.604-inch tube. All of the heat generated with the rod was transferred to water flowing through the annulus. The data were obtained at a constant flow rate of 23 gpm and a pressure of 121 psig; these conditions correspond to those in the flow annulus for I&E fuel elements in the fringe tubes at a BDF reactor. During each run, while the heat generation rate was gradually increased, temperature measurements were made of the heated surface and cooling water at points around the annulus of the test section. Each run was terminated at boiling burnout conditions as detected by a large temperature excursion at some point on the surface of the heated rod. The conditions at boiling burnout were as follows:

| Run No. | Flow Rate (lb/hr-sq ft) | Bulk Water Temperature (°F below boiling pt.) | Heat Flux (B/hr-sq ft) |
|---|---|---|---|
| 1 | 4,400,000 | 30 | 621,000 |
| 2 | 4,400,000 | 55 | 616,000 |
| 3 | 4,400,000 | 77 | 598,000 |

The water temperature in the narrow part of the annulus was always higher than the bulk temperatures and reached the saturation temperature prior to boiling burnout.

The data are very similar to the results obtained for the K Reactors and indicate that excessive temperatures can result when fuel elements are not coaxially positioned within process tubes in the Hanford reactors.

Fuel Element Temperature Resulting from an Inlet Pipe Rupture on a BDF Process Tube. Heat transfer experiments were completed to allow a prediction of the fuel temperatures during the shutdown transient following a rupture of an inlet pipe to a process tube on a BDF type reactor. The only 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 500 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 which simulated ruptures of inlet cooling lines to tubes operating initially at 800, 1200, and 1400 KW. Preliminary analysis of the data indicate that a majority of tubes on a BDF type reactor would not suffer fuel jacket melting during such an inlet piping failure. The data show that a rear header pressure of about 45 psig would be sufficient to prevent jacket melting at an initial tube power of 1200 KW and that 65 psig would prevent jacket melting at 1400 KW tube power. These data indicate the CG-558 front nozzle assembly used on the BDF type reactors is less restrictive to reverse flow of the steam-water coolant than the normal K Reactor front nozzle assembly. This condition of less restrictive front fittings combined with the higher rear header pressures which normally exist on the BDF type reactors places the BDF reactors in a better position than the K Reactors (HW-68214) with regard to prevention of fuel jacket melting during inlet piping failure.

Heat Trasnfer Characteristics of NPR Fuel Elements. The studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel elements were continued. Experimental data were obtained in the heat transfer laboratory to determine if increasing the test section length would produce different boiling burnout data than those determined previously for the center hole of the fuel element.

The test section for this investigation consisted of a 60-inch 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.

The major portion of the study was run at 1500 psig, where 39 boiling burnout points were obtained, and the remainder of the data were collected at 1000 psig. Flow rates varied between 500,000 and 7,000,000 lb/hr-sq ft, and the exit conditions varied from slightly subcooled to about 25% steam by weight. The burnout heat fluxes for these runs ranged from 245,000 to 1,650,000 B/hr-sq ft.

A preliminary comparison of these data with data obtained with a test section one half as long indicates that length had only a small effect on boiling burnout conditions. In general, at low mass flow rates the burnout heat flux was slightly lower for the longer test section and at high mass flow rates was slightly higher. More refined conclusions will be possible after further analysis of the data.

Calculated Time Before Melting of Uncooled NPR Fuel Elements. Calculations were made of the temperatures of NPR fuel elements discharged from the reactor but cooled only by the natural circulation of air. It was found

that if the specific power before reactor shutdown were 150 kw/ft, the fuel element would melt if discharged before two hours had elapsed after reactor shutdown. If the specific power before reactor shutdown were 225 kw/ft, the reactor shutdown time required to assure that the fuel elements would not melt on discharge was increased to 10 hours.

The calculations were made with the aid of a computer program and will be useful in evaluating hazards and establishing procedures in handling discharged fuel elements during incidents where water cooling is not immediately available.

Critical Flow of Steam Water Mixtures. A report (HW-68934) was issued covering laboratory investigations of the critical discharge of steam-water mixtures from uniform flow passages. The test sections used were tubes of 0.520 and 0.625 inch in diameter with lengths of up to four feet. Data were obtained for exit steam qualities from 0.4 to 99% by weight and for critical pressures from 40 to 110 psia. The results were compared with those of other investigators, and it was found that a model developed by Isbin and Fauske in TID-11061 characterized the data quite well.

Additional experimental work was also devoted to a study of the discharge of hot water to the atmosphere through short tubes having sharp entrance edges. This configuration is of interest because many instances of pressure vessel and piping ruptures can be idealized as short tubes or orifices for the purpose of computing discharge rates. The experiments considered tubes 0.5 inch in diameter and 1.5 and three inches in length. Upstream water temperatures ranged from 140 to 190 C and pressures from 100 to 250 psig. It was found that the critical discharge pressure is not a function of upstream pressure but depends only on the initial water temperature and the L/D ratio of the flow passage.

The results of these investigations will allow more accurate calculations of the over-all hydraulic characteristics of nuclear reactors, including those calculations involved in the design of reactor containment systems.

## 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

#### PRTR Project Management and Design

PRTR Construction. Construction of the Maintenance and Mockup Facility (including the PRTR Rupture Loop Annex and PRP Critical Facility buildings) is estimated at 92% completed versus 100% scheduled predicted to June 1, 1961. A work list of remaining exceptions has been issued. A tentative completion during the week of June 12 has been proposed by the contractor. M&M Facility and Critical Facility roofing was completed. The contractor is installing partitions on the 0'-0" floor level. Partitions in the basement were completed and are being prepared for painting. All piping systems have been hydro tested. All tie-ins have been completed. The 309 Building facilities piping installation is estimated to be 95% completed.

The PRTR and PFPP paving and landscaping contract is estimated at 83.5% completed versus 88.5% scheduled predicted to June 1, 1961. The initial phase of the roads and paving, excluding work adjacent to the M&M Facility, has been completed. Sprinkler installation and placement of top soil in preparation for landscaping are proceeding on schedule. The sprinkler system has been installed around the 308 Building and south of the 309 Building.

Installation of the Fuel Element Examination Facility viewers has been delayed by limited access during reactor operation, and the late delivery of handling bails being furnished by the CPFF installation contractor. The manipulator has been reassembled at the vendor's plant and tested successfully. Shipment is scheduled for the end of May.

Drawings of the modifications required on the $D_2O$ storage tanks being procured from the 200 areas and for installation have been completed and are being routed for approval.

The final report of Electric Boat Division of General Dynamics Corporation on the effect of earthquakes on the PRTR primary system piping and equipment recommended that hydraulic snubbers be installed in five locations. Upon request, Electric Boat has furnished the detailed functional requirements for these snubbers, and the procurement of the snubbers has begun.

Plutonium Recycle Critical Facility (CAH-842). The building construction contractor is estimated to be 99.3% complete predicted to June 1, versus 100% scheduled as of April 20, 1961. All major building equipment has been installed and only cleanup items covered by a work list remain. It appears that it will be necessary to delete some painting on the floors and north wall of the Critical Facility due to moisture seepage through the walls from the storage basin.

An estimate for equipment installation work by the CPFF contractor has been received and a request for partial release of funds has been initiated.

The drive shafts and gearing used for manual operation of fuel transfer lock doors were modified by the vendor. Both doors can now be operated manually. The hydraulic operating mechanism still has several modifications and adjustments to be made. The compression seals did not arrive in time for installation prior to filling the PRTR storage basin with water, although both inflatable seals are working satisfactorily. This work will now have to be done with water in the basin.

The Instrumentation Package vendor, GE-APED, has not yet submitted final specifications for all instruments. A request for a firm delivery date has been made. Construction of the console cabinet shell has been completed and installation of instruments started.

Development work on the control and safety rods has been delayed by higher priority reactor operating problems. Bids were received on equipment items proposed for use in the temperature monitoring apparatus and are being reviewed. The reactor tank has been completed and is being tested prior to shipment.

Fuel Element Rupture Test Facility (CAH-867). The Rupture Loop Annex building has been completed by the contractor and is being used to warehouse annex equipment. The storage tank (RLT-1), decontamination tank (RLT-4), and the cooler (RLHX-2) have been received on-site.

Bids were received on the motor control center and electric switchgear. The low bidder on the motor control center did not meet specifications. It has been recommended that the orders for both the motor control center and switchgear be awarded to the next low bidder, Westinghouse Electric Corporation.

A scope revision concerning the water filter plant was prepared and is being circulated for approval. This revision reduces the output capacity of the plant, removes flocculators from the sedimentation basins and reduces the number of export pumps from three to two. This work is presently four and one-half months behind schedule. Over-all construction is estimated at 10% complete, the annex building portion, versus 25% scheduled.

As a result of detailed information received from the instrument panel vendor, The Foxboro Company, it became necessary to provide regulated AC power to many of the transmitters and to change the locations of several voltage to current transducers from field to panel mounted. The affected tracings have been revised and are being circulated for approval.

One Zr-2 tube assembly has been shipped; two others are due before June 1, and the last two are scheduled for July 1. The last two assemblies have been delayed while corrosion specimens from the main tube sections were undergoing three-day steam tests in an autoclave at HAPO. These two specimens

have failed to have a good oxide appearance on all three tests performed to date. The vendor, Chase Brass and Copper Company, is sending new samples from these same two tubes for corrosion testing at HAPO. All other corrosion samples (which come from the same two Zr-2 ingots and include the other three main tube samples) have passed the three-day corrosion test.

The two Grayloc joints were delivered along with the special 316-type, high yield strength, stainless steel studs. The studs which use certified material and rolled threads, will be tested at HAPO in the Grayloc joint under thermal cycling and combined pressure and bending conditions.

The capscrews for the test section joints were ordered from Briles Mfg. Co., El Segundo, California. These screws will use 8740 steel material, which has the equivalent strength of A-193-B7 steel (the ASME Code material) plus better notch sensitivity and toughness. Certified chemical and physical properties will be provided.

The delivery of the shutoff, butterfly-type, valves for the test section inlet piping has been delayed. The butterfly disks have been scratched during final assembly, thus causing the valve to leak excessively.

The upper test section mockup is complete and ready for testing. Machining of test section components for the full size mockup in 314 Building pit is approximately one-half completed by Tech Shops. Drawings for modifying the 314 Building pit are out for comment.

Design and Component Testing

PR-10 Primary Loop Mockup. The spare primary pump operated 541 hours during the month for a total of 6488 hours. Pump vibration remains at 0.9 mil total, but vibration at pump operating speed due to imbalance is approximately one-third this amount. The seal leak rate remains less than 0.01 gphr and occasional short duration temperature excursions are occurring.

The prototype pump with the self-adjusting seal assembly operated an additional 414 hours for a total of 7928 hours. The present seal leakage is 0.5 gphr.

The seal test stand operated an additional 155 hours and 21 starts for a total of 1030 hours and 138 starts with the two prototype mechanical seal assemblies.

No action was taken on the Aldrich pump tests this month.

Flexure Loop. The three-clamp Grayloc transition union (SS to Zr-2) has completed 896 hours and 148 cycles operation at 2000-2100 psig and 200-600 F with no leakage. Testing was halted on 5-12-61 when the loop heaters failed. New heating elements are on order.

PRTR Calandria Access Plugs. A short testing program to determine which anodize coat will best prevent galling between the access plug and calandria top plate has been completed. The best coat is a sealed oxalic acid coat, the details of which can be found on drawing H-3-13393.

PRTR Process Tube Plug. An adjustable rubber plug ("Turn-Tite" Type T) which can be inserted into the inlet of a process tube to contain water in the tube during discharge operations, has been ordered and will be tested.

Shroud Tube Replacement. A set of "Shroud Tube Replacement Mockup" drawings (SK-3-9927) has been given to Minor Construction for estimating fabrication costs of the complete mockup.

Design Analysis

PRTR Safeguards Analysis. Shift coverage of PRTR Operation by reactor safeguards specialists continued during the month. Several deviations to Process Specifications were issued to permit performance of special tests. Reactor power was reduced twice upon the advice of safeguards personnel. In both cases the reduction in power was caused by nonconformance with Process Specifications (excessive containment vessel pressure, low primary system storage tank level).

PRTR Startup Tests. Preliminary results of the final Critical Tests and the early Power Tests may be summarized as follows:

1. Temperature Coefficients - Data obtained to date indicates the coefficients as follows:

   Coolant plus fuel - $5.5 \times 10^{-5} \frac{\Delta k}{k} / {}^{\circ}C$

   Fuel - $4 \times 10^{-5} \frac{\Delta k}{k} / {}^{\circ}C$, considerably more negative than previously estimated

   Moderator - $1 \times 10^{-4} \frac{\Delta k}{k} / {}^{\circ}C$, in good agreement with previous calculations.

   These values are preliminary at this point and may contain large error. Additional data will be obtained during the Power Tests to substantiate or correct these values.

2. Cell Flux and Kinetics Experiments - Data from these tests have been analyzed and the results appear satisfactory at this time.

3. Moderator Level Coefficient - Further analysis of the data was made using least squares techniques and various weighting functions.

4. Shim Rod Tests - Work has begun on the analysis of the shim data obtained throughout the Critical Tests. A method to normalize the data for useful analysis was developed. This will require a complete analysis on the vertical flux distributions before further work can be done.

5. Xenon Transients - The xenon transients were followed through the reactor power operating periods. Calculations agree within 10% with experimental results from the reactor. A computer code was initiated to aid in these calculations.

6. Photoneutron Flux - Photoneutron flux measurements were obtained after reactor shutdowns. Preliminary data show six to eight definite half-lives in the decay of the flux from two to 30 hours after shutdown. Apparent half-lives range from 900 to 85 minutes.

7. Fission Chamber Positioning - Data obtained from traversing one of the fission chambers through the refelctor indicate an exponential decrease in flux as the chamber is moved out. Further measurements are planned.

PRTR Shielding. Initial measurements of PRTR shielding adequacy have been completed. The results of these measurements at low power indicate satisfactory shielding except for neutron streaming through the large gas lines penetrating the bottom shield.

Gold foils were placed on the top and bottom primary shields of the PRTR to determine the thermal neutron flux. The following table is a summary of the data obtained at a power level of about one megawatt.

Thermal Neutron Flux ($n/cm^2/sec/MW$)

| Tube Number | Top | Bottom |
|---|---|---|
| 1546 | $1.6 \times 10^4$ | $2.4 \times 10^4$ |
| 1548 | $4.6 \times 10^4$ | -- |
| 1550(center) | $1.3 \times 10^4$ | $2.2 \times 10^4$ |
| 1552 | $4.8 \times 10^4$ | $2.1 \times 10^4$ |
| 1554 | $1.2 \times 10^4$ | -- |

Foils were also placed on one of the dump valve assemblies near the face of the bottom primary shield. The measured thermal flux in this position was about $3 \times 10^5$ $n/cm^2/sec/MW$, higher by a factor of about ten than the fluxes measured elsewhere. With the reactor operating at 70 MW and using the flux measured at the dump valve assembly, the thermal flux extrapolates to about $2 \times 10^7$ $n/cm^2/sec$. The activation of stainless steel has been calculated on the basis of the activation of its components. Using a thermal flux of $2 \times 10^7$ $n/cm^2/sec$ and slab geometry, it was estimated that eight hours after shutdown the dose from the stainless steel would be about 20 mr/hr. The large gas lines in the lower access space have been wrapped with cadmium foil to reduce the activating flux through

these large shield penetrations. Further foil activation measurements will be performed at higher power levels to check these results and to determine the effectiveness of the cadmium wrapping.

PRTR Loss of Coolant Study. An investigation of the effects of loss of coolant in the PRTR with conditions of varying coolant and moderator quality has been completed. Experimental data are available only for loss of $H_2O$-degraded coolant (0.25% to 100%) and 0.25% $H_2O$-degraded moderator. Calculations were carried out for other moderator qualities as well. The experimental effects have been substantially reproduced by calculation with regard to both whole reactor coolant loss and radial tube traverse.

The calculations were performed using the "SWAP" computer code. The SWAP method provides an estimate of a neutron multiplication change or perturbation (coolant loss) at the center of the reactor and deduces the effect of the same change occurring elsewhere in the reactor through the application of statistical weight distributions. For loss of up to 10% $H_2O$-degraded coolant from all tubes, no positive reactivity effect was found with moderator degradations of 10% $H_2O$ or less.

PRTR Operations

Reactor Testing and Activation. Power tests were initiated during the month. The reactor operated at levels up to 15 MW, accumulating approximately 53 MWD of core exposure during the month. Prior to month-end, the reactor was shut down for extensive maintenance and modification work, for repair of PuAl fuel elements and for investigation and correction of halogen contamination of the primary coolant.

Continuing from last month, all $UO_2$ fuel elements were discharged for cleanup and removal of ion exchange resin. The primary coolant was flushed extensively through temporary screens to remove all resin from the primary coolant system. Following this, the fuel elements were recharged, and startup preparations began on April 30.

On May 2, startup preparations were complete and Power Tests were started. After low power shielding tests, the reactor was brought to one MW for cold tests. The coolant systems were then brought to elevated temperatures for hot tests including measurement of the temperature coefficients of reactivity.

Power tests were interrupted on May 6 for electrical and water supply outages external to the PRTR facility. Miscellaneous items of maintenance work were performed while the reactor was shut down. During this outage a spurious trip of the light water injection system occurred due to a loose fitting in the air line to Valve E-17. This incident resulted in dilution of the primary coolant to approximately 96.6% $D_2O$.

On May 7, power tests resumed but were again interrupted on May 8 due to excessive primary coolant activity and due to excessive air activity in the containment vessel. Following fuel element rupture investigations and correction of process gas leaks, the reactor was restarted on May 9. Power tests at levels up to 10 MW continued until May 12. A maintenance outage was taken on May 12 and 13.

On May 14, power tests resumed at 10 MW, raising to 15 MW on May 17. The reactor was shut down on May 18 due to failure of the instrument power MG set and remained shut down for an extended outage which had been planned to begin a few days later. This outage continued through month-end.

The fuel transfer equipment was made ready for the first "hot" discharge operation; the storage basin and the transfer pit were filled with water. Three $UO_2$ elements and one PuAl element were discharged to the storage basin. Inspection revealed broken bands on the PuAl element; further PuAl discharge and inspection revealed this to be a general problem. Study of this problem revealed up to 25 ppm chloride, and up to 110 ppm fluoride in the primary coolant. Investigation into the source of this contamination and checking for any further harmful effects is in progress at month-end.

The mechanical seals and neoprene seals in all three primary pumps were replaced in the outage beginning May 19, 1961. All three pumps had overheated during operation at primary system temperatures of 415 F. Seal temperatures reached as high as 225 F on PP-1 and PP-2, and the thrust bearing temperatures reached the limit of 150 F due to high cooling water temperatures in the oil heat exchangers. Examination of the seals revealed that overheating caused by improper seal lubrication resulted in rapid wearing of the faces and damage to the neoprene seals. The low pressure secondary seals were damaged most. It was concluded that the helium evolved during cooling at the primary seal and during depressurization at the secondary seal was a larger volume than the seals could purge themselves of at this particular system operating temperature. The operating temperature of 415 F is in the range of maximum solubility of helium in water at 1000 psi, and is therefore the most severe operating point which could be selected. At the design operating temperature of 478 F, helium solubility is reduced to less than half that at 415 F, and the severity of service is less.

A modification of the primary system piping was made to furnish cold $D_2O$ injection to each primary pump. Injection will be provided from the storage tank and normal injection pumps through a new manifold with selector valves and a pressure regulating valve. Helium-free $D_2O$ will then continually be injected at a rate of 0.5 to one gpm to purge out helium saturated $D_2O$. Additional cooling will be provided and leakage through the primary seal should not evolve helium to damage the low pressure seal.

Two precautionary measures were taken to protect the system in case of future overheating. They are as follows:

1. The primary pump oil heat exchangers were provided with a separate water supply to prevent overheating the pump thrust bearings.

2. The seal leakage water to IX-1 was routed through a heat exchanger to guard against overheating the ion exchange resin.

Two diaphragm failures occurred in low pressure helium compressors during the month. One pair of failed diaphragms exhibited severe galling and pitting on the surfaces which face each other. These diaphragms, which operated less than 70 hours, have been saved for metallurgical examination. The high pressure helium compressors have been erratic in performance and have frequently overloaded or failed to start. There is no indication of diaphragm failure. The oil regulators in these compressors were overhauled during the current shutdown.

The high pressure helium system has had a very satisfactory degree of leak-tightness during the month. Numerous repairs were made to the bulk storage and low pressure systems to reduce the excessive helium consumption. The reactor dry gas moisture detection system is still inoperable because of excessive air inleakage.

Effluent piping modifications were made to reduce radiation background from short half-life activities at the effluent activity monitors. The pressurized shield coolant drain was rerouted to bypass the monitoring chambers and those cooling streams which could become contaminated by fission products were relocated to remain monitored.

The fueling vehicle and fuel transfer system performed satisfactorily during the first discharge of irradiated fuel. Some minor alterations will be made to improve ease of operation of the vehicle. One pair of idler wheels was removed from the vehicle to facilitate travel to the fuel examination facility over an uneven spot on the rails.

Difficulty has been experienced with deaerator level control, boiler feedwater control, and boiler feed pump relief valves during continued operation at low power levels and low boiler pressures. Valve repairs have been made and a fine control valve added to the boiler feedwater.

Various difficulties, including repeated loss of $D_2O$ flow to the gas balance compressor and vacuum breaker, have been experienced because of piping vibration. Additional supports have been placed on offending lines and on piping most vulnerable to mechanical damage.

Repairs and maintenance of the ventilation system were performed in order to improve air circulation paths in the containment vessel and reduce airborne contamination problems during reactor operation.

Modifications to the log N flux monitoring system in the form of adding a third channel were started. A third log N amplifier was obtained and modified to be compatible with the two installed amplifiers. The amplifier is currently undergoing operating tests in the panel. The log N period trip portion of the safety circuit was rewired as a coincident circuit. Overlap features of the safety system will be rewired as a coincident circuit next month. A third compensated ion chamber for feeding the log N amplifier was obtained. It will be installed in monitor hole 3L next month after Minor Construction fabricates a new side shield plug to accommodate this chamber. The second startup chamber (a fission chamber) currently located in 3L will be relocated in monitor hole 1L along with startup channel number 1. Triplication of the log N system should improve reactor time operating efficiency by reducing the number of spurious safety circuit trips.

The instrument power motor-generator set failed and caused a reactor outage on May 18. The output voltage of the system increased from 480 V to something in excess of 600 V. This caused the current in the circuit supplying power to the flux instrumentation to increase to the point where the circuit breaker opened. Loss of power to the flux instruments in turn caused the reactor shutdown. The over-voltage also caused (1) five recorder fuses to blow, (2) two period control amplifier fuses to blow, and (3) failure of all three seismoscopes. The failure also resulted in discovery of a power phasing problem between flow monitors in "C" cell and the data system in the control room. This was resolved by providing power to a portion of the data system from the "C" cell power supply for the monitors. All neutron instrumentation was thoroughly checked for possible damage, but none was discovered. Operation of all instrumentation is currently being checked to insure that further failures did not result. Seismoscope repair will be complete prior to reactor startup.

A comparison of flow monitor readout in "C" cell with the flow readout in the control room showed 15 channels having differences of 2-5 percent scale reading. The differences are currently being resolved. A recheck of all flow monitor calibrations will be made prior to reactor startup.

Flow in process tubes with take-offs near the inlet ring header bull tee fluctuates approximately ± 7 percent. To reduce the number of unnecessary flow monitor trips, the valves in the sensing lines to the venturis for these tubes were throttled. Thermal Hydraulics is currently testing the relationship between trip time delay and throttling to insure continued reliability of flow monitor protection. Special operating procedures for checking trip action and for limiting the amount of throttling permitted were initiated.

The cables to two outlet RTD's were found broken near the RTD connector. Spare cables were connected to the subject RTD's and the broken cable was subsequently repaired. A similar break was discovered in the cable to the inlet RTD. It will be repaired prior to reactor startup.

During the last operating run it was discovered that the $D_2O$ recovery air flow in the upper and lower access space affects tube temperature measurements. All of the outlet RTD's were insulated to try to alleviate the problem. The inlet RTD will likewise be insulated. Four spare RTD's were installed on various inlet jumpers to further test the effect of air flow on inlet temperature measurements. Accuracy of temperature data will be evaluated further during the next operating run.

Additional backup instrument air has been provided for the control room and the containment vessel. Further backup to specific instruments and controls will be provided when design is formally approved. The additional backup provides an added degree of protection against failure of instrument air headers in any portion of the system.

Work continues on the rupture monitor system. Essentially 100 percent failure of the flow throttling valves has occurred. A vendor's representative tentatively places the cause of these failures on improper lubrication of the valves at the factory prior to shipment. Replacement valve parts will tentatively be furnished by the vendor.

A special gas sample line has been run from the degasser on the primary purification system to the rupture monitor. This gas is piped to a bulk sample activity monitor so it can be continuously analyzed during the next operating period when special rupture tests will be run. Other phases of the test will include continuous monitoring of a bulk liquid sample, continuous monitoring of the radiation level at the top of the pressurizer and at the LP He storage tanks, and intermittent sampling of various samples by Chemical Research and Development personnel. The special test is designed to obtain further information on the existence or non-existence of a ruptured fuel element.

A bypass was installed in the light water injection system so the system can be bypassed when the gas balance compressor is not operating. A second solenoid was installed in the control air line to the two light water injection valves to provide protection against solenoid failure. Further changes are contemplated to protect against failures in the electrical circuitry of the system.

Radioactive sources were positioned approximately 19 inches above the HM chambers monitoring aqueous effluent activity. The sources were positioned to give an on scale indication on the effluent monitors at all times. The low trips on the monitors were connected to an alarm annunciator such that any failure of the monitors that gives a downscale reading will be alarmed. Such a non-fail safe failure occurred during the month.

Plans and Procedures. Eight new operating standards and four new operating procedures were approved during the month. Numerous standards and procedures were revised as experience was gained through reactor operation. At the month-end five standards and five procedures remained to be approved by the PRTR Startup Council.

## Plutonium Fuels Development

Fabrication Development. The study of gas evolution from $UO_2$ and $PuO_2$ powders is being continued. There is some evidence that swaging of fused $UO_2$ may increase the gas pickup from some Oak Ridge and Chalk River experience on swaged rods. A sample was taken from a rod which had been cold swage reduced by 40 percent to a density of 10.0 g/cc, sectioned for density determination and metallographic examination and stored for two months. The first two inches of the open end of the rod were removed and discarded after which a $UO_2$ sample was taken for analysis. This sample released total gas amounting to 0.166 cc/g (at 1000 C) as compared to 0.03 cc/g for a sample of -20 mesh material from the same oxide lot. The rod was swaged with prewelded end caps which should preclude the pickup during swaging of any gas other than helium (the welding atmosphere). The fact that the open end of the rod was exposed to the atmosphere for two months does not eliminate the possibility that the swaging had increased the surface activity of the particles to the extent that they would pick up this amount of gas during their exposure to air. Previous tests have shown that fused oxide of this type in the unswaged condition does not pick up this much gas. To check the source of the gas, swaged rods will be opened and the oxide immediately placed into the gas collection apparatus.

Compaction by hot rolling is being investigated as a method of obtaining high density $UO_2$-$PuO_2$ for oxide fuel core material. A 5 x 5 x ½-inch, 304 stainless steel can with a 3/8-inch evacuation tube was filled with $UO_2$ and heated to 1000 C. The evacuation tube was pinched shut at 35 microns vacuum and then welded shut. The method employed for flattening and sealing the evacuation tube was not completely successful because the can enlarged slightly on reheating after the evacuation tube was welded closed. The powder-filled, stainless can was heated to 900 C and rolled at a speed of 100 inches per minute. A 50 percent reduction was taken in one pass. The rolled can was cut open and the compact was broken up for examination. A portion of the material appeared to be completely sintered while the remainder seemed to be only partially sintered and somewhat lower in density. Further experiments are planned.

The incremental loading of fuel rods requires a loading device that will reproducibly deliver small, accurate amounts of oxide material. The particles to be loaded will consist of both fine sized particles (-325 m) and mixed particle sizes (-20 m). Vendors have been contacted and requested to forward information on automatic loading devices which would have suitable application to this process. Two replies have been received describing devices that appear applicable. One device operates on the principle of delivering a unit of constant weight; the other operates on the constant volume principle.

A shotgun powder loader has been tested, using both mixed and uniformly sized oxide feed material, to examine the load reproducibility of the device; several tests were run, using various weight increments.

Reproducible results of ± 3 - 4 w/o were obtained. Modification of the loader would be necessary to make it suitable for production use.

Two elements have been destructively sampled, prior to swaging, for longitudinal plutonium analysis. One of the elements was bottle loaded by the high percentage of fines method; the other was incremtnally loaded by hand. A blend was made of $PuO_2$ fines and $UO_2$ fines to determine if there was any segregation of the $PuO_2$. The $PuO_2$ was sprinkled over a large area of $UO_2$, manually mixed, and then blended for two hours in a twin shell blender. Samples were taken of the blend for analyses. Analytical results have not been received on any of the above samples.

To verify a report of possible incomplete calcination of plutonium oxalate to plutonium oxide, several samples were heated up to 900 C for one hour. Weight losses of approximately three percent were found by this method. Calcination of the $PuO_2$ will be necessary, prior to any blending or loading step, for all future elements. Incomplete calcination not only affects the total plutonium content value, but would contribute to gas evolution and pressure buildup within the fuel rod during reactor operation.

The possibility of outgassing a loaded rod prior to welding in order to reduce the pressure that would be caused by entrapped and adsorbed gases during reactor operation was investigated. It was felt that outgassing of the rod would be difficult due to the extremely large mean free path presented to the atoms except in the immediate region of the outgassing surface. A thermocouple vacuum gage was inserted at one end of a full length tube. The tube was then loaded with fused $UO_2$. Outgassing was done at room temperature, recording the differential vacuum gage readings at both ends of the tube. The experiment was repeated several times, each time reducing the tube length by half. Negligible outgassing was observed until the tube length (originally 62.5 inches) had been reduced to 15 inches. At this point after 3.5 hours outgassing, the gage at the tube bottom read 600 microns versus one micron at the manifold. At 7.5 inches in length, after 18 hours outgassing, readings were 40 microns versus two microns.

Gamma autoradiographs were taken of $UO_2$-$PuO_2$ capsules, in which the film was wrapped completely around the capsule. Exposure time, using a slow fine grained film for maximum resolution, was 65 hours. As with previous autoradiographs, the intentionally defected areas were easily detected. As previously reported, the defect distribution in certain capsules did not appear uniform across the diameter. The capsules which were loaded from a large "batch" mixture, also showed varying film densities along the length of the autoradiographs indicating probable nonuniform distribution. Previous information has shown nonuniformity of $PuO_2$ in large batch blending operations. Additional capsules, which will be incrementally loaded to give better distributional control, are planned.

The use of the gamma autoradiograph technique as a nondestructive test for $PuO_2$ distribution appears promising; since it appears to be able to detect variances in concentration below that currently obtainable with electronic nondestructive testing devices.

Five-inch segments were cut from seven $UO_2$-$PuO_2$ rods to provide irradiation pieces. After counterboring both ends of the capsules, the outer surfaces and counterbored areas of four of the capsules were decontaminated. Decontamination of the counterbore was especially difficult due to some of the oxide material being ground into the cladding. The weld zones on these four capsules became contaminated during the welding step. Machining of the weld zone followed by rewelding, or removal of the end caps and additional counterboring will be attempted.

A dummy rod with swagable end caps and containing fused $UO_2$ was fabricated as a prototype rod for a seven-rod $UO_2$-$PuO_2$ cluster. Additional dummy rods are being prepared to obtain more data prior to loading the mixed oxide. The seven-rod cluster will be uniformly enriched, and loaded incrementally.

Additional design changes on Zircaloy-2 swagable end caps were completed. A slight change in the weld joint was made to decrease the sensitivity to welding conditions such as angle of electrode and heat input. Trial end caps with heavier wall thickness were fabricated in order to find maximum wall thickness and still maintain full penetration. Evaluation of these end caps has not been completed. Two sections of swaged end caps and tubing were corrosion tested in superheated steam at 400 C and 1000 psi for 48 hours. No white corrosion product was observed.

The vibratory compactor has been set up to load eight-foot rods. A number of these have been loaded with fused $UO_2$ to study the density variables; techniques are also being developed to minimize the contamination problem at the open end of the tube. Rods have been packed to an average density of 89 percent of theoretical. There is usually a slight decrease (less than one percent) in density at the top and bottom. The best mixture found to date has been a ratio of 65 percent coarse, 25 percent medium and 10 percent fine. The use of an eight-pound follower rod increased the average density by about four percent and flattened out the density variation markedly. The best technique for loading the tubes to date utilizes a teflon end fixture which also acts as a guide for the follower rod. Various strip coats are being investigated to further protect the weld area during loading.

Fabrication has started on fuel specimens for two experiments to be conducted by Reactor Lattice Physics Operation. One, the Pu-Al Fuel Temperature Coefficient Experiment, will require forty fuel element rods of one-half inch diameter Pu-Al core, Zircaloy-clad and 20 inches long. Twenty elements use low exposure plutonium and the other twenty high exposure plutonium (approximately 16 percent $Pu^{240}$). Plans call for operation at 600 C. In order to check out safe operation at this

temperature, twelve two-inch capsules have been fabricated for determination of diffusion as a function of time at 600 C. A second experiment, the $Pu^{240}$ Effective Resonance Integral Experiment, requires the fabrication of 22 rod-type elements, using aluminum-plutonium cores canned in 35 mil wall 0.680 inch ID Zircaloy tubing approximately 31 inches long. Eleven rods contain high exposure plutonium and 11 contain low exposure plutonium. Preliminary investigation indicates it will be possible to hold to the specification for Zircaloy which states: "The Zircaloy mass shall not vary from rod to rod more than one-tenth of one percent."

Fuel Evaluation. The Zircaloy-clad aluminum-plutonium seven-rod cluster rupture experiment has been operating satisfactorily in the ETR 3 x 3 loop since May 5. Inlet and outlet coolant temperature thermocouples indicate the power generation of the element is about 15 percent lower than the predicted value and the surface heat flux at the point of rupture is about 216,000 Btu/hr-$ft^2$. The element will continue operation until May 28 to build up fission products at which time it will be ruptured. Coolant flow rate, pH, and temperature will be maintained at PRTR conditions and the element will continue operation for as long as three days after rupture. If the coolant activity is not excessive at the end of this period, a power cycle will be requested to determine the effects of water logging on this type of element.

A 42-inch long Zircaloy-clad aluminum-plutonium injection cast cluster has been shipped to the ETR for irradiation in the 3 x 3 loop. The irradiation test proposal, HW-69434, has been published and the element will generate a maximum of 15 kw/ft with an associated maximum heat flux of 345,000 Btu/hr-$ft^2$. It will be irradiated under PRTR coolant temperature and flow conditions.

The two capsules (GEH-14-27, 28) with Al-2.1 w/o Pu - 2.0 w/o Ni alloy cores fabricated by injection casting have been irradiated to an exposure of $2.80 \times 10^{20}$ nvt. They were discharged on May 22, 1961. The specimens operated with a specific power generation of about 25 kw/ft.

Reactivity measurements are being made on the Phoenix capsules in the Advance Reactivity Measurement Facility (ARMF) at the MTR. Irradiation of the capsules is awaiting approval of the revised Form 22. It was originally planned to attach boron impregnated polyethylene tape to the outside of the poison standards for calibrating the ARMF. This technique is often used; however, it is not as satisfactory as having the boron uniformly dispersed throughout the specimen. Aluminum-plutonium-boron alloys are now being made in an effort to uniformly disperse the poison material in each sample. Four different boron alloys are needed. Some of the alloys have been cast and extruded and are now being chemically analyzed. It is necessary to develop a new analytical technique for these samples.

Work has commenced on a 42-inch long $UO_2$-$PuO_2$ Zircaloy-clad seven-rod cluster for irradiation testing in the ETR 3 x 3 loop. It will be as

prototypical of the currently proposed PRTR fabrication process as possible. Fused depleted $UO_2$ will be enriched with $PuO_2$ fines by incremental loading to a uniform enrichment of 0.46 w/o $PuO_2$. The rods will be cold swaged using swagable end caps.

Another geometrically similar irradiation test is being planned. The rods for this element will be incrementally loaded with $PuO_2$; however, the enrichment will be varied along the rods to balance the longitudinal flux variation over the 42-inch fuel length. The enrichment will vary from 1.75 w/o $PuO_2$ at the top, to 0.46 w/o Pu at the center, and 1.23 w/o Pu at the bottom. With this type of loading, the rods should generate about 15 kw/ft over their entire length. This type of enrichment is of interest because the enriching technique under development could be adapted to a full-scale fabrication effort. A full-size reactor loading with this type of element should greatly reduce the vertical peak/average flux ratio and hence increase efficiency.

Rod length measurements have been made on fourteen of the rods from the irradiated aluminum-plutonium nineteen-rod cluster. This element was fabricated by swage-sizing 0.030-inch Zircaloy tubing onto the aluminum-plutonium cores. It was irradiated in 2000 psi coolant. The results of the length measurements are given in the following table:

| Rod No. | Length After Irradiation (Inches) | Length Before Irradiation (Inches) | L (Inches) |
|---|---|---|---|
| 4 | 35.441 | 35.325 | +0.116 |
| 5 | 35.430 | 35.375 | -0.055 |
| 33 | 35.385 | 35.375 | +0.010 |
| 55 | 35.418 | 35.260 | +0.158 |
| 69 | 35.398 | 35.439 | -0.041 |
| 70 | 35.371 | 35.411 | -0.040 |
| 80 | 35.422 | 35.458 | -0.031 |
| 84 | 35.376 | 35.446 | -0.070 |
| 88 | 35.348 | 35.424 | -0.076 |
| 89 | 35.474 | 35.469 | +0.005 |
| 90 | 35.369 | 35.440 | -0.071 |
| 92 | 35.416 | 35.463 | -0.047 |
| 94 | 35.427 | 35.488 | -0.061 |
| 99 | 35.350 | 35.429 | -0.079 |

It is estimated that this element was subjected to about 15 thermal cycles during its irradiation in the ETR. With the exception of rods four and 55, the measurements indicate a general shortening of the rods of about 1/16 inch. Similar results were obtained from ex-reactor thermal cycling tests when using 0.030-inch thick Zircaloy and high test pressures. The measurements on rods four and 55 are probably in error and will be rechecked.

## $UO_2$ Fuels Development

High Energy Impact Forming of $UO_2$. High temperature annealing (1300-1700 C) of $UO_2$ compacted to high density by high energy impact forming may result in a density decrease of one to two percent, depending upon the previous history of the material. Preliminary evidence indicates that it may be due to release of residual stresses in the high energy impacted material. Presumably, high temperatures permit the deformed $UO_2$ particles to undergo a slight relaxation, resulting in a small decrease in density of the bulk material. Compacted, micronized $UO_2$ having a bulk density of 98% T.D. was reduced in hydrogen at 800 C for 12 hours to an O/U ratio of less than 2.01. The density was practically unchanged at 98.3% T.D. Part of $UO_2$ was then heated in hydrogen 12 hours at 1300 C, and another part 12 hours at 1500 C. The density of the sample heated at 1300 C decreased to 96.2% T.D., and that of the sample heated at 1500 C decreased to 96.4% T.D.

In a previous experiment, sintered $UO_2$ was crushed to -200 and to -325 mesh and compacted by high energy impact to 97.9 and 98.1% T.D., respectively. At the same time, $UO_2$ powder from pressurized water oxidation of uranium metal, having an O/U ratio of 2.19, was compacted to 97.6% T.D. Samples of the three materials were heated in hydrogen 12 hours at 1700 C. The density of the sample from -200 mesh sintered $UO_2$ decreased to 96.4% T.D., and that of the sample compacted from -325 mesh $UO_2$ decreased to 95.6% T.D. The "water oxidized" $UO_2$ remained essentially unchanged at 97.4% T.D.

Electron micrographs of polished and etched surface of the samples compacted from -200 mesh sintered $UO_2$ revealed a marked difference in the structure of the $UO_2$ before and after sintering. Etching of the compacted material resulted in many shallow rounded depressions, with no evidence of preferential etching related to crystal structure. This type of etched surface can be expected in non-crystalline or amorphous materials. Etching of the compacted, sintered sample resulted in etch pits characteristic of highly oriented crystals.

Examinations of PRTR Swaged $UO_2$ Fuel Elements. Three PRTR Mark I swaged $UO_2$ fuel elements examined in the load-out basin after irradiation to 15 MW reactor heat output were not visibly changed from their pre-irradiation appearance. Subsequent examinations of one element through the windows of the PRTR fuel element examination cell revealed only a slight surface color variation along the length of the element, possibly due to film deposition. All fixtures and wire wraps appeared tight, uncorroded, and in place. Non-autoclaved wire-end spot welds remained clean and bright.

PRTR Thermocoupled Swaged $UO_2$ Fuel Element. A 19-rod PRTR Mark I swaged $UO_2$ fuel element including six rods containing thermocouples swaged into axial positions indicated fuel temperatures during PRTR power runs to 15 (nominal) megawatts heat output. A maximum fuel temperature 173 C in excess of coolant temperature was recorded at 15 MW, at a cladding surface heat flux of approximately 50,000 Btu/hr-ft$^2$. Preliminary evidence

of improving bulk $UO_2$ thermal conductivity was obtained during reactor operation at constant power levels of 10 and 15 MW. Transient response of the fuel rod thermocouples is easily and accurately correlated with transient behavior of the reactor as recorded in the control room.

Tubular Fuel Element Irradiation - ETR. Irradiation of a prototypic nested tubular (PRTR Mark II-C) fuel element (GEH-12-22) in the ETR facility was terminated. The three-foot long assembly operated with a maximum surface heat flux of 350,000 Btu/hr-ft$^2$. About 450 MWD/T exposure had been accumulated. The test was discontinued after release of fission products into the loop occurred during startup of the reactor after a shutdown. During the shutdown, water circulation through the in-reactor portion of the loop was blocked by maintenance crews, permitting the element to severely overheat and probably contributing materially to failure.

Tubular Fuel Irradiation - HAPO. A tubular, vibrationally compacted $UO_2$ test element (HAPO-6) recently discharged after accumulation of 150 MWD/T in KER-1 loop was visually examined in the KE basin. The elements had essentially the same appearance it had before irradiation. There was no evidence of swelling, warp, or other dimensional changes. A small number of "handling marks" were visible. The element will be returned to Radiometallurgy Operation for examination.

Fabrication Development. Inconel-X and Hastelloy-F clad fused $UO_2$ fuel rods were successfully hot swaged at 850, 1000, 1100, and 1200 C. These fuel rods were fed through the continuous induction heating coil and the swage at a rate of two feet per minute. No cladding ruptures or excessive oxide scale formation were observed. The densities obtained have not yet been determined.

An attempt was made to hot swage fused $UO_2$ clad in Fansteel 80 (columbium - 1% zirconium) at 1400-1600 C. This material, however, could not be heated to 1400 C in the existing induction coil. At one-half foot per minute, the maximum temperature attained was 1100 C. A sectional induction heating coil is capable of more efficient heating and will be used in future experiments.

Recent results indicate that hydrogen is not absorbed significantly by Zircaloy cladding during induction heating and hot swaging. These results contradict results obtained from analyses of turnings from resistance heated Zircaloy cladding. The previous results may have resulted from the machining operation used to prepare the turnings. Additional experiments are in progress.

Autoclaving at 400 C and 1000 psi for 69 hours had no effect on the 0.009-inch thick, AISI-406 steel cladding of a four-foot long, 0.564-inch O.D. fuel rod being prepared for high temperature irradiation studies. The $UO_2$ fuel was bivfationally compacted to 88-89% T.D., and successfully sealed by Magnetic-Force welding. The welded closures withstood applied accelerations greater than 80 g, both before and during loading and compaction.

Spacing Members for Nested Tubular Fuel Elements. Spacer ribs were welded to four Zircaloy-2 tubes, 3.068-inches O.D. x 0.60-inch wall x 89½-inches long, for use in fabrication of nested tubular fuel elements by vibrational compaction.

After machining, the tubes were sand blasted to remove any $ZrO_2$ from the weld. The weld joints were nondestructively tested by an ultrasonic method. Test standards were made from an extruded, ribbed tube by electro-machining crevices at the base of the ribs, 0.002-inch wide, ½-inch long, and 0.010-inch, 0.020-inch, 0.030-inch, and 0.075-inch deep. The tube was submerged in water and each rib scanned by the transducer. Flaws on unbonded lengths approximately 0.005-inch long could be detected, and weld widths, at any point, could be determined by comparison with the standard.

Hydriding of Zircaloy. Distinct differences in the extent of hydride formation in cold swaged and hot swaged Zircaloy cladding have been observed in metallographic studies of samples of each type heated at 400 C for 200 hours. Hydride platelets were large and numerous in the cold swaged material. Hydride was not detected, however, in the hot swaged Zircaloy (transformed beta structure). Examination of samples of each type heated at 600 C for 200 hours showed that the hot swaged, transformed beta phase material had recrystallized and that the number and size of the hydride platelets were essentially the same in both the cold swaged and hot swaged materials. In other words, it appears that the transformed beta phase structure markedly inhibits the growth of hydride in Zircaloy. This may be significant both in fabrication studies and in-reactor fuel performance. Irradiation tests are in preparation.

## Corrosion and Materials Studies

Process Tube Monitoring. Four Zircaloy-2 pressure tubes in PRTR were examined visually and the I.D. and insulating gas gap were measured. Prior to this examination the tubes had been subjected to operating conditions up to 1100 psi and 450 F for a period of about two weeks. Analysis of the I.D. measurements showed that there has been no significant change in the process tube diameters since they were installed in the PRTR. Comparative diameter measurements made on three occasions fall within a range of 4 mils or less. Hence, internal diameter changes, if any, are less than 4 mils or less than about 0.1% strain. Tensile creep specimens subjected to 12,000 psi at 550 F would exhibit approximately 0.1% to 0.2% strain after 100 hours. Short-term pressure creep tests on annealed PRTR tubes at internal pressures equivalent to 12,000 psi hoop stress and at 450 F, 550 F and 650 F exhibited no measurable strain in 48 hour tests. Hence, the process tubes in PRTR are performing in a manner consistent with pre-irradiation tests.

Comparing insulating gas gap measurements reveals an apparent decrease in the minimum gap for 3 of the 4 tubes measured and no change in the fourth tube. The reason for the change is not known; however, the nominal temperature of the reactor was about 50 F higher during the previous measurements. In no case does the minimum gap exceed design limits.

Ultrafine Grained Sheath Tubes. A three-pronged program to develop sheath tubes with an ultrafine grain size, less than 5 microns, by three different fabricating techniques is progressing rapidly. In cooperation with technical personnel of three different fabricators a program was devised to evaluate the effectiveness of: (1) warm extrusion, Rockrite tube reducing and low temperature salt bath annealing; (2) hot extrusion at low temperatures, Rockrite tube reducing and low temperature vacuum annealing; and (3) hot extrusion at low temperature followed by drawing with low temperature intermediate air and vacuum anneals. Twenty-five base tubes were double warm extruded by Bridgeport Brass Riverside plant, sent to HAPO for examination and salt bath annealing and forwarded to Reactive Metals, Inc., for tube reducing. Tube reducing is scheduled for completion in early June. Nondestructive testing of the twenty-five extrusions showed them to be of good quality. One of the base tubes had two small scale inclusions near the ends. Other than this the tubes were free from fluorescent penetrant indications on both surfaces except for the normal end defects which occur near the tail end in this type of extrusion.

A low temperature hot extrusion, 1170 F, made at HAPO exhibited a recrystallized microstructure with a grain size of 10 microns. This base tube was tube reduced by Wolverine into .680" I.D. x .035" wall sheath tubes with low temperature 1150-1200 F intermediate and final vacuum anneals. The finished tube grain size was less than 5 microns. The finish and dimensional tolerances were very good.

A warm extruded base tube (1050-1100 F) made at HAPO exhibited a highly cold worked structure. This base tube will be salt bath annealed at 1200 F and then drawn to sheath tube size by Harvey Aluminum. Intermediate air and vacuum annealing will be employed with maximum annealing temperatures of 1250 F.

Zircaloy-4 Fuel Sheath Tubes. The production of .495" I.D. low nickel Zircaloy-2 sheath tubes has fallen behind schedule again as a result of the recurrence of impressed particles on the inside surface of the tubing. Approximately 600 tubes are at finish inspection at the vendor's plant but only 10-15% of these tubes will pass the fluorescent penetrant test. In January 1961 the vendor was informed that HAPO was rejecting up to 50% of the tubing received due to small impressed particles of Zircaloy on the inner surface. These particles are slightly oblong and measure up to 30 mils in length times approximately 1/2 their length in width. Small cracks at the edges of the particle penetrate the tube wall up to 3-4 mils. The particles are attached on one end or one side to the parent metal of the tube wall. Micro-hardness measurements show the particles to be 2-3 times as hard as the parent metal of the tube. Possible originating causes are small projections left on the base tube due to incomplete removal of extrusion cladding, gouges which turn up a small mound of metal and are introduced prior to the final tube reducing operation, and saw chips which are not cleaned from the tube prior to tube reducing. Photomicrographs of typical defects were incorporated with a letter sent to the vendor in early February 1961. All 600 tubes now at final inspection at the vendor's plant have been fabricated since this information was forwarded.

Effect of Metal Thickness on Corrosion and Metal Growth. Samples of various thicknesses of X-8001 aluminum alloy autoclaved for 1, 4, 16 and 36 hours in 360 C water have been compared to thermally cycled samples at equivalent exposures. The uncycled samples showed approximately 10% more weight gain than the cycled samples. The growth of the uncycled samples was lower by about a factor of two. The thermal cycling of the samples undoubtedly has a thermal ratcheting effect due to the differences in thermal expansion of the metal and the oxide layer. The comparative results for the different sample thicknesses was the same, however, in both tests.

The 0.002" sample corrodes the most. From 0.005" to 0.062" the initial corrosion increases with increasing thickness. After approximately 16 hours, however, the thicker samples are corroding at a lower rate than the 0.005" sample. The growth of the samples decreases with increasing sample thickness. The 0.040" and 0.062" samples showed no measurable growth in either test.

Fretting Corrosion. The depth of attack by fretting corrosion is affected by the material of construction. If a Zr-2 contacted a Zr-2 tube, both rib and tube were fretted. If a steel rib contacted a Zr-2 tube, the rib was not damaged, but a groove was worn into the tube. In the latest tests, gold-covered ribs were tested in contact with Zr-2 tubes in the CEP-2 fretting assembly. Test conditions were: 316 C, pH 10.0 (adjusted with LiOH), and 30 fps. Natural loop vibration and an imposed vibration of 3 cps were studied. Examination made after 786 hours revealed nelgigible fretting ($<<$0.1 mil). Slight removal of the black oxide covering the Zr-2 had occurred, however. Deformation of the gold clad had occurred but did not appear serious.

The fretting test using a PRTR fuel element and PRTR process tube is presently undergoing a long-term test to determine if fretting pit depth will be increased by increasing exposure time. It has been impossible to realign the fuel element and process tube to the same contact points during previous discharges so that fretting always occurs in a new location after each inspection.

## 2. PLUTONIUM CERAMICS RESEARCH

### Plutonium Dioxide - Uranium Dioxide

The bulk of the effort during the past month has been concentrated on high temperature phase equilibria and melting studies in the system $UO_2$-$PuO_2$. As reported previously, the liquidus on the $UO_2$ rich end of the phase diagram exhibits a maximum melting temperature of 2825 C at $UO_2$ - 10 w/o $PuO_2$ as contrasted to 2730 C for pure $UO_2$. Detailed investigation of the $PuO_2$ rich end shows a smooth curve for the liquidus, decreasing continuously with composition to 2280 C for pure $PuO_2$. Oxidation of $PuO_2$ samples melted in helium, which may essentially be

considered as quenched from the solidus, consistently indicates an oxygen to plutonium ratio of 1.62, and probably is the phase previously identified as cubic $Pu_2O_3$. The composition 1.62, however, corresponds to a formula on the order of $Pu_5O_8$. The quenched structure is cubic face centered ($CaF_2$) and has a lattice parameter of about 5.41 Å. Debye-Scherrer photographs show the melted material to be single-phase.

This finding together with previous data allows several speculations to be made on the oxygen-plutonium system and a revision of the early LASL phase diagram is being formulated. From the data available, it would appear that cubic $Pu_2O_3$ ($PuO_{1.62}$) has at least two allotropic modifications being BCC (Type C rare earth) at room temperature and FCC (fluorite) at high temperatures. The melting point of this phase has been determined as 2350 C, slightly above that of $PuO_2$, and its calculated density is 13.85 g/cc compared to 11.46 g/cc for $PuO_2$. The transformation temperature may be 650 C where the thermal expansion hysteresis in oxygen deficient $PuO_2$ has previously been noted. The allotropic transformation will be checked out as soon as high temperature diffraction and differential thermal analyses equipment are available and with annealing experiments.

Another point of interest in this system is the composition $PuO_{1.82}$, which has frequently been seen during heat treatments of $PuO_2$ in hydrogen. During recent discuissions with Dr. L. E. Russell of Harwell, he exhibited a photomicrograph at the composition $PuO_{1.82}$ which was pearlitic in nature and apparently the result of a eutectoid reaction at this composition. Some of our previous quenching experiments have indicated oxygen deficient $PuO_2$ to be cubic at temperatures as low as 1100 C, and it is therefore speculated that the eutectoid occurs at 650 C according to:

$$PuO_{1.82}{}_{(FCC)} \longrightarrow PuO_{1.98}{}_{(FCC)} + PuO_{1.62}{}_{(BCC)}$$

giving an equilibrium two-phase structure at room temperature. The composition $PuO_{1.98}$ arises from previous sintering data and is probably the lower limit of a solid solution phase at $PuO_2$.

Melted structures of $UO_2$-$PuO_2$ compositions have also been investigated. In melted samples of $UO_2$ - 10, 40, 75, and 90 $PuO_2$, no indications of "cubic $Pu_2O_3$" have been noted. Lattice parameters of the melted samples have generally been higher than those theoretically anticipated. For example, in $UO_2$ - 40 $PuO_2$ the lattice constant determined via an extrapolation function was 5.451 ± 0.001 Å. This corresponds to a composition of $UO_2$ - 25 $PuO_2$ if it is assumed that $PuO_2$ is lost during melting. On the other hand, the increased lattice parameter may simply be the result of a loss of oxygen with no effect on the Pu/U atom ratio. A melted sample of $UO_2$ - 10 $PuO_2$ gave a lattice parameter of 5.463 ± 0.005 Å as obtained by averaging the high angle lines and is good agreement with the premelted value. Additional experiments on $UO_2$-$PuO_2$ melted structures will be performed next month.

## $PuO_2$-$ZrO_2$ System

Experiments were performed to determine the sintered densities of $PuO_2$-$ZrO_2$ pellets with compositions in the $ZrO_2$ rich region. Pellets containing 85, 95, and 98 w/o $ZrO_2$ were compacted under nine tons per square inch to 56 ± 3 percent of theoretical density. They were then sintered in dry helium at 1550 C for 12 hours. The sintered densities as determined by water immersion at 23 C were respectively 86, 88, and 90 percent of theoretical. In the region studied it may be concluded that sinterability increases with $ZrO_2$ concentration.

## Plutonium Silicides

Effort has been concentrated on obtaining a single-phase product of known composition with which to work. Although confirmation of the exact compositions of the silicides thus far produced has not been made, certain characteristics have been determined. Products obtained by arc-melting alpha-plutonium and silicon metal have no corrosion resistance to boiling water; they begin to disintegrate into a fine powder immediately upon immersion. The arc-melted buttons have a silvery metallic luster prior to exposure to oxygen. Surface oxidation at room temperature turns this luster to a gold and blue color.

An attempt was made to produce $Pu_2Si_3$ by arc-melting alpha-plutonium and silicon. The product exhibited all the characteristics described above. Its density determined at 27 C by immersion in tetrabromoethane was 9.18 $g/cm^3$, agreeing with the published calculated density for $Pu_2Si_3$. Although not solved, the X-ray diffraction pattern is not in agreement with the single hexagonal phase found by Runnalls and Baucher. A chemical analysis of the compound will be run presently as an aid to its identification.

## Surface Area Measurement

The BET apparatus was leak checked using a helium leak detector. The entire system may now be evacuated to vacua ranging from $10^{-5}$ to $10^{-6}$ millimeters of mercury. Initial determinations will be for calibration and procedural development purposes. Cement obtained from the National Bureau of Standards as well as $UO_2$ specimens will be run prior to $PuO_2$ and other plutonium bearing materials. Several tests of the commercial sorptometer (continuous flow method) were made using the N.B.S. cement specimen. Instabilities in the electronic components have denied encouraging results. Further tests will be run during the next reporting period and attempts made to correct the instrumental deficiencies.

## Thermal Conductivity

Redesign of the conductivity device insert was completed. In the new insert, the Kovar-glass vacuum seals are replaced by pressure sealing glands, the 0.013-inch bare chromel-alumel thermocouples are replaced

by 0.040-inch stainless steel sheathed, chromel-alumel thermocouples, and the grease seal is replaced by a compression sealing vacuum fitting. The size of the head has been reduced to allow easier seating. The molybdenum winding on the main heater has been replaced by Nichrome to provide greater electrical resistance.

Due to the replacement of the molybdenum winding by Nichrome, and to the retained usage of copper leads to the main heater, the goal temperature of 1000 C in the sample area will be somewhat reduced, perhaps to 800 - 900 C. This is somewhat dependent on the heat transfer characteristic of the sample material.

While the new insert was being drawn up, the rest of the device was completely disassembled in order to repair two water tube joints which leaked. A new roughing pump was installed to replace the original which was not large enough to evacuate the system to below 100 microns of mercury. The vacuum system now functions efficiently.

Most parts ordered for the insert were received; the worksheet drawings and furnished materials were sent to the shop for fabrication.

## 3. $UO_2$ FUELS RESEARCH

### Fuel Evaluation

An extensive and unusual structure was observed for the first time on polished and etched columnar grains of $UO_2$ produced during irradiation of: (1) both swaged and vibrationally compacted fused $UO_2$; (2) vibrationally compacted electrodeposited $UO_2$; and (3) sintered $UO_2$ pellets. In some grains this substructure appeared as parallel lines while in others it appeared as "elongated hexagons". Collection of voids along these sub-grain boundaries is further evidence of fission product relocation which continues to be revealed by concurrent studies of autoradiographs of cut and ground transverse faces of irradiated $UO_2$ fuel rods.

Irradiation of a purposely defected $UO_2$ fuel element (HD-2) continues after 12 weeks in a Hanford production reactor. Fission product release into the coolant is barely detectable.

The first significant irradiation of hot swaged $UO_2$ was terminated after two cycles in the GEH-4 facility of the MTR. The 12" long four-rod cluster (GEH-4-60) accumulated a total exposure of $\sim$620 MWD/T.

A $UO_2$-$ThO_2$ mixture is being irradiated in the MTR GEH-4 facility as part of a study of the effect of additives on in-reactor behavior of $UO_2$. The element, GEH-4-61, is operating with a maximum surface heat flux of 600,000 BTU/hr-ft$^2$. It is expected that a portion of the core will be molten during irradiation. The element was fabricated by vibrationally compacting a 90 w/o $UO_2$ (enriched to 1.38 w/o $U^{235}$ in U) -10 w/o $ThO_2$ mixture to 86% T.D. in 1.12" O.D. stainless steel cladding with 0.030" wall thickness.

## $UO_2$ Melting Point

Observations of increasing melting point with irradiation exposure provide a basis for describing some hypothetical phase relationships in the uranium-oxygen system. Various dissociation reactions occur with $UO_2$ at elevated temperatures. Among these are:

$$UO_2 \longrightarrow U + UO_3$$

$$UO_2 \longrightarrow U + O_2$$

$$UO_{2+X} \longrightarrow UO_2 + O$$

$$UO_2 \longrightarrow UO_{2-X} + O$$

The net effect of these reactions is to reduce the O/U ratio in $UO_2$, which is initially stoichiometric or super-stoichiometric. The feasibility of the last reaction has not been demonstrated thermodynamically, but much evidence predicting the existence of a $UO_2$-X solid solution at temperatures above 1600 C exists. Specifically, metallic uranium inclusions are observed in $UO_2$ which has been heated to near the melting point. Also, a broadening of the phase boundaries to include a stable $UO_2$-X solid solution would be expected at high temperature. The existence of substoichiometric $UO_2$ and the various reactions yielding lower O/U ratios indicate a basic anomally in attempts to define the melting point of $UO_2$. Specifically, it is questionable whether or not $UO_{2.00}$ has ever been melted. More probably, what has been called the melting point of $UO_2$ is actually the temperature at which a stable $UO_{2-X}$ melts. The uranium-oxygen phase diagram reveals a high solubility for oxygen in $UO_2$ but very limited solubility for uranium. Such a condition, plus the fact that a dissociation occurs, is often indicative of the existence of a broad displaced maximum in the liquidus. In the case of $UO_2$ the displacement would be to a $UO_{2+X}$ composition which, under normal heating conditions, dissociates to $UO_{2-X}$ before the melting point is reached.

Most long lived fission fragments are metal atoms having valences less than +4. These low valence cations could stabilize a higher O/U ratio by forming an oxygen deficient defect lattice similar to that which occurs in the systems $UO_2$-$La_2O_3$, $UO_2$-$Y_2O_3$, and $ZrO_2$-CaO. If such stabilization occurs, it would lead to a higher equilibrium O/U ratio at the melting point of irradiated $UO_2$. As described above, the melting point of $UO_2$ should increase with O/U ratio and thus the introduction of fission fragments which stabilize higher O/U ratios should result in an increased melting point. Opposing this increase is the normal tendency of the melting point to decrease with increasing impurity content of a system. The sum of the two opposing influences yields a maximum in the plot of melting point versus irradiation exposure.

Electron Microscopy Studies

Evaluation of reflection electron microscopy techniques continued simultaneously with $UO_2$ single crystal examinations. Peculiar fan-shaped formations which were observed in reflection images of heated and non-heated fracture surfaces, along with firmly adherent surface "debris" were confirmed by transmission replica and optical microscopy. The formations are about 30 microns in diameter and less than one micron high with surface "ribs" emanating fan-wise from a single point. No relation to the underlying fracture surface is apparent.

Thermal Conductivity of $UO_2$

Initial measurements were made of thermal conductivity of the third irradiated $UO_2$ specimen, 0.06% burnup. Behavior up to 300 C appears similar to previous samples having less irradiation. The data are summarized below:

| % Burnup | Thermal Conductivity, watts/cm °C | | |
|---|---|---|---|
| | Initial | Minimum | After Recovery |
| 0 | 0.080 | -- | -- |
| 0.005 | 0.043 | 0.039 | 0.44 |
| 0.016 | 0.040 | 0.30 | 0.35 |
| 0.065 | 0.035 | 0.27 | 0.33 |

US/UK Newsletter #11 - Uranium Ceramic Fuels

The US/UK Newletter for April 1961, was compiled and edited, and is now ready for distribution. Contributions from nineteen sites have made this letter the longest to date (85 pages).

4. BASIC SWELLING PROGRAM

Irradiation Program

Irradiation of capsules Nos. 7 and 8, each containing three split, hollow, uranium cylinders is continuing at constant temperatures of 525 C and 575 C, respectively. Capsule No. 9 is currently being assembled for irradiation. Uranium specimens identical to those irradiated in capsule No. 6 have been given an ex-reactor thermal treatment identical to that of the irradiated specimens. These specimens are now being examined for density, microstructural, and physical changes. Two additional sets of specimens are undergoing annealing treatments in a vacuum heat treating furnace in order to simulate the in-reactor thermal histories of capsules Nos. 4 and 5. Uranium specimens identical to those in capsule No 7 and in capsule No. 8 are being prepared for similar treatment.

The ambient temperature irradiation of two unmonitored, NaK-filled capsules GEH-14-281 and 282 was completed after 48.7 days total irradiation time. This exposure amounted to about 0.3 a/o burnup in the enriched

portions of the specimens. Each capsule contains a U-U diffusion couple for the study of fission product diffusion.

Post-Irradiation Examination

Radiometallurgical examination of the specimens from irradiated capsules Nos. 4, 5, and 6 has continued. Densities have been determined on all but one of the spheres by the bouyancy technique. The sphere not measured was irradiated at about 800 C and had split open badly on one side. Initial estimates of the swelling indicate volume changes of seven to nine percent for specimens irradiated to 0.3 a/o burnup at volume average temperatures of 615 C and from six to eight percent for specimens irradiated to 0.3 a/o burnup at volume average temperatures of 575 C. Specimens irradiated to only 0.05 a/o burnup at about 550 C showed volume changes from 1.5 percent. Cracking was observed in the higher burnup specimens that appeared more severe as the samples were repetitively etched for density determination.

Additional examination of the split hollow cylinders irradiated to about 0.03 at temperatures of around 300 C revealed that considerably less "bumping" and warping had occurred with the specimens irradiated in the as-extruded condition than with the specimen that had been beta quenched. This is attributed to the large grain size that existed in the beta quenched specimen. Apparently, at least with specimens of this geometry, grain size effects are more serious than are preferred orientation effects. X-ray diffraction studies prior to irradiation had indicated that the as-extruded specimens showed definite preferred orientation.

A precharacterized, unrestrained specimen of uranium, GEH-14-36, irradiated at less than 150 C at the MTR has been processed for microstructural and density change. After an estimated burnup of 0.26 a/o, the specimen had assumed a very wrinkled external geometry due to dimensional instability effects. The microstructure shows considerable swirled twinning and lineage structure, but as yet no evidence of fission gas pores. Final density after irradiation was 18.61 g/cc compared with an original density of 19.01 g/cc.

Pore Size and Distribution

Information on the frequency and size of pores observed in irradiated uranium specimens subjected to post-irradiation annealing treatments has been tabulated for programming on IBM cards. Various functional and distribution characteristics will be tested and analyzed.

Comparison of In-Reactor and Ex-Reactor Swelling

The swelling in uranium associated with the high temperature irradiation of clad rods in thermocoupled, NaK-filled capsules has been compared with the swelling associated with the long time post-irradiation annealing of uranium that had been irradiated in a high pressure, high temperature, water loop. The swelling observed in the two experiments exhibits surprising

correspondence with regard to temperature dependence. Within the framework of the uncertainties that exist in the engineering measurements that were made, the data from either experiment is indistinguishable from that of the other - this comparison suggests that post-irradiation annealing provides a simple and convenient method of estimating the in-reactor swelling that could be expected with uranium fuel elements under a variety of temperature and pressure conditions.

Fission Product Mobility

Fission product gas mobility is being studied by two techniques. In the first, uranium specimens are being examined that have had inert gas introduced into the surface by "glow discharge" or ion bombardment. In the second, U-U diffusion couples are being studied that have had an appreciable amount of fissioning occurring in one-half of the couple, but none, or very little, in the other. The U-U diffusion couples have been irradiated and currently await shipment to Radiometallurgy. The specimens are 1/2" thick x 1/2" diameter disks cut from an extrusion that has a core of depleted uranium and a shell of three percent enriched uranium. The change in pore size distribution across the depleted-enriched interface as a function of post-irradiation annealing will be studied by quantitative metallography. Kr evolution data from two uranium disks prepared in a cathodic vacuum etching chamber using Kr gas as an etchant showed a small burst, about $0.2 \times 10^{13}$ atoms per second, when the specimens were melted. A very small peak in the evolution rate, approximately $0.07 \times 10^{13}$ atoms per second, was observed at about 400 C. No difference was observed between a specimen etched in the normal fashion and one etched under adverse conditions so that redeposition occurred. High purity uranium has been rolled for forming into cylinders for use as the specimen in the "glow" system. The hollow cylindrical specimen will rest on a uranium disk. Uranium that had previously collected on the walls of the system (trapping gas in the process) will not collect on the walls of the new tubular specimen providing a larger concentration of gas in the samples.

Restrained Irradiations

Swelling experiments of Zircaloy-2 clad uranium rods (0.570" diameter x 4" long) with selected uranium temperatures, cladding thicknesses, and exposure are being conducted employing NaK-filled temperature monitored capsules. Four such capsules, GEH 14-96, 97 101, and 103, each containing two rods have been opened and the rods photographed and measured for dimensional changes. The irradiation histories and the apparent volume increases are tabulated below:

| Cap. No. | Clad Thick. | Vol. Avg. T | Exposure a/c B | Swelling DV/V,% | Swelling R* |
|---|---|---|---|---|---|
| 14-96 | 0.020** | 440 | 0.07 | 1.0 | 14 |
| | 0.030 | | | 0.7 | 10 |
| 14-97 | 0.020** | 560 | 0.43 | 5.9 | 14 |
| | 0.030 | | | 6.7 | 16 |
| 14-101 | 0.020 | 250 | 0.30 | 0.46 | 1.5 |
| | 0.020 | | | 0.50 | 1.7 |
| 14-103 | 0.020 | 300 | 0.21 | 1.0 | 4.8 |
| | 0.020 | | | 0.9 | 4.3 |

*"R" is defined as the percent volume change divided by the present burnup.
**End cap failure.

From the dimensional measurements, there is essentially no difference between rods with 0.020" and 0.030" cladding. The observed swelling agrees well with previous data obtained with similar experiments.

One of the end caps cracked and split open at the weld in the 0.020" clad rods that were in capsules 14-96 and 14-97. The 0.030" clad rods in these capsules and all of the rods (0.020" clad) in the other two capsules were intact. The rods that failed were suspended by means of a thermocouple that was sealed through the cap. Failure occurred at this cap in both instances. It is not yet fully understood whether swelling contributed significantly to the end cap failures.

Radiometallurgy Laboratory

Measurements and density determinations were completed on capsules 4, 5, and 6 during the month. A wide variation in density results was experienced in running the same specimen at different times. This was attributed to the poor physical condition of some of the specimens revealed by subsequent metallographic examination which showed that extensive cracking of the uranium had occurred. The cracks and voids in the metal were filled with an oxide or other reaction products (RM-510).

## 5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

### In-Reactor Creep Measurements

The modified creep capsule, designated as Capsule II-2 which was charged in April, is now operating at condiderably higher temperatures than those reported last month. The gamma flux alone is producing specimen temperatures in the range of 350 to 460 C. These higher temperatures are the result of a lower than expected thermal transport within the capsule. It has been found that the capsule does not respond to helium pressure increases in the same manner as the prototype capsule and the other second generation capsule, II-4. An increase in pressure results in a temperature increase rather than a reduction. The second generation capsules were designed to take advantage of high convection heat transfer but some interference with the normal transport processes evidently exists in the latest capsule. If this interference was eliminated, the operating temperature of the capsule could be maintained within the limits of 250 to 300 C. The loss of heat transport in the capsule is attributed to the contamination of the helium gas atmosphere from the outgassing of capsule components. A mass spectrometer analysis of the gas inside did not reveal any significant contamination. Condensable vapors would not be detected with the mass spectrometer as the gas from the capsule must flow through many feet of water cooled line before the sample can be taken. To prevent the reoccurrence of the erratic thermal behavior, the next capsule is being outgassed in the laboratory prior to charging. Considerable quantities of gas have been extracted from the capsule in the laboratory at pressures of one to 200 microns at temperatures between 22 and 250 C.

The amount of gamma generated heat and the temperature distribution in Capsule II-2 will not allow a creep test to be conducted at temperatures lower than about 495 C. A test near this temperature at a stress of 8000 psi will begin in June.

### Capsule and Instrument Development

A series of six, third generation capsules are now being fabricated. Scheduled completion date for the first three of the capsules is the middle of June. A final analysis of thermal behavior of the latest creep capsule operating in the reactor prompted a design change. An exposed ring of metal in the heater support section will be covered with the same ceramic support material as the rest of the heater. The purpose of the change is to increase the symmetry of environment at the ends of the specimen.

Laboratory calibration has been completed on a proposed, high-temperature, radiation-resistant, linear variable differential transformer. The linearity and resolution of the transducer were measured as a function of temperature. The transducer would not be suitable for in-reactor measurements as the influence of temperature was greater than the resolution required for the in-reactor creep measurements. Stability of the transducer as a function of time also contributed to a low merit figure for the transducer.

## 6. GAS-GRAPHITE STUDIES

### EGCR Burning Rig Experiments

EGCR combustion hazards testing was continued with experiments which simulated reactor conditions for several credible accidents as nearly as possible. Reactor after heat decay functions were programmed as power input to a radiant heating element in the center of the fuel channel. The tests and observations were as follows:

Test 1 - Initial Conditions:
Moderator Temperature - 1095 F
Outer Surface Fuel Sleeve Temperature - 1170 F
Inlet Air Temperature - 435 F
Air Flow - 395 lbs/hr

Observations: Assembly cooled; slowest rate observed was 4 F/min.

Test 2 - Initial Conditions:
Moderator Temperature - 1095 F
Outer Surface Fuel Sleeve Temperature - 1170 F
Inlet Air Temperature - 770 F
Air Flow - 186 lbs/hr.

Observations: Assembly cooled; slowest rate observed was 1.5 F/min.

Test 3 - Initial Conditions:
Moderator Temperature - 1240 F
Outer Surface Fuel Sleeve Temperature - 1300 F
Inlet Air Temperature - 788 F
Air Flow (Center) - 287 lbs/hr

Observations: Moderator temperatures at midplane and above rose for the first five minutes to about 1325 F, remained constant for about 20 minutes and then began to fall. The SiC coated fuel sleeves apparently did not fail since cooling was noted almost immediately after air was introduced.

These observations indicate that with SiC coated fuel sleeves the EGCR will not ignite in case of an accident which introduces air into the reactor. The extrapolation of these results to the more complicated reactor situation must be verified by computer calculations.

### In-Reactor Creep

Samples from the five 150 psi compression test boats have been examined. The transverse samples irradiated under constant load at about 600 C

show significantly less initial growth than the unloaded samples after exposures ranging from 1410 to 1720 MWD/AT. The length changes of the unloaded samples were: CSF, +0.013%; TSGBF, +0.028%; AGOT-LS, +0.032%; NC-8 (EGCR), +0.039%' and TSX, +0.066%. The loaded samples have undergone essentially no initial growth.

Studies on Chemical Additives to Graphite

Additional evidence of the influence of iron oxide additives on the dimensional behavior of graphites under irradiation has been noted. Two Texas coke graphites, one with one percent iron oxide additive and one without the additive have been compared after 4241 MWD/AT cold test hole exposure. Transverse growth of the graphite with additive was 43% greater than that without the additive. This higher low-temperature growth lends encouragement to the use of additives in reducing contraction of graphite at higher temperatures.

In the parallel direction, the additive graphite grew +0.311% while the graphite without additive contracted 0.182%. Reversal of the normal low-temperature parallel contraction is unexpected and, as yet, unexplained.

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

Gas loop construction is 83% complete versus 95% scheduled predicted to June 1, 1961. Construction will be limited to 92% until installation of the in-reactor section and blowers are initiated. The ex-reactor section installation work by J. A. Jones is 75% complete versus 90% scheduled for the same date. Fabrication of the in-reactor section is in progress and is scheduled to be complete by June 9.

The interim gas blower for operation at reduced conditions has been received from Bristol-Siddeley and installed in B Cell.

During the month an order was placed with Pacific Car and Foundry for approximately $25,000 for steel shielding for the gas loop. Detailed design drawings for the steel shielding were completed by Struthers-Wells, but this contract has not been closed out, since structural calculations have not been finished.

The three Graham Heat Exchangers, which were replacements of the original undersized units, have been received and are being installed. The NaK heater modification has been completed by Struthers-Wells and the unit has been shipped, but not yet received on site.

Component Testing

The pressure tube, which was used in the test assembly in the 314 Building, was removed from the mockup and the nozzle and outlet end removed and reconditioned. A new pressure tube has been cut to size and will be assembled with the nozzle and outlet assembly. This assembly is for use with the gas loop in B Cell. Completion of this section is scheduled for June 1.

## 7. GRAPHITE IRRADIATION DAMAGE STUDIES

### Irradiation Effects on Lampblack-Based Graphite.

Samples of lampblack-based graphite originally heat treated to 3000 C, which had displayed high contraction rates upon irradiation, were again heat treated to 3000 C to determine if the radiation-induced contraction could be annealed in this material. Post-annealing measurements on samples with three exposure levels revealed that 10-20% of the radiation-induced contraction was eliminated. Possible crystallite changes are being checked.

Post-irradiation measurements of the coefficient of thermal expansion revealed little change in this property in this material. Thermal conductivity between 700 and 2000 C also showed no significant change upon irradiation.

### National Carbon Company R&D Contract

Ninety-six additional samples of six grades of graphite were received. All were made with the same needle coke. Three grades display orientation ratios of 0.8, 2.4, and 6.2 based on the ratio of transverse to parallel coefficients of thermal expansion. The other three grades were made with a particle size variation which included all flour, 0.030" and 0.060" maximum particle size. These samples will be used to investigate the effect of degree of anisotropy and coke particle size on high temperature, radiation-induced contraction in graphite.

## 8. ADVANCE EVALUATION STUDIES

### Supercritical Pressure Water Reactor Study

An interim report, HW-69246, describing the Supercritical Pressure Power Reactor as presently conceived, was prepared for comment.

Power Cycle - Cycle Efficiency. A net efficiency of 41.2% has been calculated for the SPPR power plant cycle. The efficiency is based on presently available information and is subject to some adjustment as primary feedwater preheating and turbine cycles become finalized. However, the 41.2% is believed to be indicative of the final value attainable. The power requirements presently established are:

| | |
|---|---|
| Net electrical output | 300 mw |
| Generator losses and auxiliary power requirements excluding main feed pump | 15 mw |
| Equivalent power generation for feed pump turbine | 9.8 mw |
| Total plant generation | 324.8 mw |

| | |
|---|---|
| Reactor thermal output including heat to moderator | 728 mw |
| Gross plant efficiency | 44.5% |
| Net plant efficiency | 41.2% |

Moderator Loss. Expected heat generated in or transferred to the moderator has been calculated to be about 41 MW of which 19 MW results from heat loss from the fuel elements. Approximately 13.5 MW of the total moderator heat is unrecoverable due to inefficiency in the heat exchange process. This loss may be compared to the boiler efficiency in conventional fossil fuel plants. Boiling water reactors and pressurized water reactors in which the coolant and moderator are integral will not have this loss, of course.

Fuel Element Design. Pressure drop calculations are essentially complete on the three-zone coolant pass system. For the first stage (inlet temperature of 550 F, outlet temperature of 805 F) the pressure drop is about 75 psi. For the second stage (inlet temperature 805 F, outlet temperature 1050F) the pressure drop is about 580 psi. The third stage reheats the fluid, after it gives up heat in a reheat to subcritical turbine steam, from 850 F to 1050 F. Third stage pressure drop is about 1000 psi.

While pressure drops of this magnitude (1500-2000 psi) might be feasible, it limits the flexibility which is desirable in pressure tube design, since the pressure members are designed on allowable stresses at anticipated tube wall temperatures. Hence, lower pressure drops permits higher tube wall temperatures, resulting in greater permissible temperature unbalance across the reactor, thus simplifying reactor control problems.

To achieve lower pressure drops, two proposals are being considered. The first proposal increases the inside diameter of the pressure member from 3/16 inch to 7/32 or 1/4 inch. This results in thicker pressure member wall thicknesses (than would be assumed by simple diameter considerations) because of the increased temperature drop through the wall, resulting in increased fuel cycle costs. The second proposal requires an additional preheater heat exchanger to raise the inlet temperature to the reactor while lowering the inlet temperature to the last stage. In addition, the first two stages are combined so that the coolant outlet temperature will be 1050 F. Flexibility in temperature control throughout the reactor can be obtained by proper bypassing of the preheat heat exchanger.

However, a heat exchanger of this size for supercritical service may cost from one-half to one million dollars. The effect of the two proposals on power generating costs is being investigated.

Reactor Physics. A continuing effort is being made to establish the neutron-multiplying properties of slightly enriched (U-235 $UO_2$ cells of the current SPPR design geometry. The treatment of resonance self-shielding effects has been of particular concern. This effect, strongly dependent on geometry, has been investigated experimentally only in more finely divided slightly enriched $UO_2$-$H_2O$ lattices. Calculations are being

made to determine the consistency with which currently formulated self-shielding factors lead to experimental agreement. Resolution of this problem will allow final solutions of several partially completed lattice physics calculations:

(1) For various U-235 enrichments (1% to 5%) a plot of cell $k_{\infty}$ versus $H_2O/UO_2$.

(2) A plot of $k_{eff}$ versus $H_2O/UO_2$ for uniform reactor loading of the cells in item (1).

(3) Three-energy group plot of flux and power distribution in certain cells of item (1).

(4) Three-energy group plot of flux and power distribution in certain reactors in item (2) and for reactors loaded non-uniformly to achieve whole reactor and zone flattening.

(5) An evaluation of control strength for rods of varying blackness and geometry in certain of the above reactors.

Plant Layout. Further evaluation of space requirements may result in a reduction of the containment vessel diameter from the initial 220 feet to less than 180 feet based on the space required for the turbine generators and for the removal of the generator rotors. Information from the turbine vendor indicates that the space requirement could be reduced from that initially contemplated. In the larger diameter hemisphere the turbine installation was the governing factor and not the pressure buildup upon release of primary coolant. Revised estimates of the pressure buildup in the containment shell upon release of primary coolant are being made based on current piping layouts. Cost of containment vessel is a function of the cubic power of the diameter. Thus, small reductions in vessel diameter can result in significant decreases in vessel cost. There is, therefore, considerable incentive in working toward further diameter reduction.

Conceptual Design - Fuel Element Fabrication Plant

The final draft of Part II has been completed and transmitted for approval. Part III, "Design Study of Plants for Plutonium-Enriched Fuel," of the Fuel Element Fabrication Economics Study was completed in rough draft form and issued for comment.

Estimates of plant cost for the nine uranium fuel cases and the nine plutonium fuel cases are scheduled to be complete by June 5.

A draft of a report "Group Testing in 100% Inspection" was prepared and circulated for comments. It will be put in final form and submitted to Technical Publications for issuance as a "blue cover" report by June 5.

## 9. ALUMINUM CORROSION AND ALLOY DEVELOPMENT STUDIES

### Evaluation of Molybdate as Inhibitor

Testing is in progress on X-8001 aluminum alloy, Zr-2, and sensitized 304 stainless steel at 300 C in water adjusted to a pH of 4.5 with $HMoO_4$. Preliminary data indicate penetrations of 0.07 to 0.10 mil on X-8001 after 315 hours. Penetration measurements on 304 SS after 613 hours show values of 0.029 to 0.032 mil. In general, the corrosion data of the various alloys are similar to $H_3PO_4$ data. However, fairly thick crud films have been obtained (1-2 mils) primarily on the aluminum coupons. The film is a dull jet black and is present on the 25 fps coupons as a uniform film, but on the 40 fps coupons it occurs as a uniform film studded with platelets arranged perpendicular to the flow direction. These platelets are 5-10 mils in diameter. Examination is being made to determine the composition of the platelets.

## D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage in various metals, including aluminum, copper, iron molybdenum, nickel, titanium, zirconium, and type 347 stainless steel, is being studied by a number of techniques. Electrical resistance, x-ray diffraction, and mechanical properties measurements are the primary methods being used. The variation of properties with irradiation and the kinetics of property recovery upon annealing are being analyzed to arrive at a damage model. Tensile tests on irradiated "A" nickel showed a pronounced strain-aging effect of a complex nature. A specimen with an exposure of $4 \times 10^{18}$ nvt showed a sharp yield point upon initial testing, and upon unloading and immediate reloading, another yield point and a short region of Lüder's strain occurred. After aging for one hour at 200 C, the flow stress was raised by almost 8000 psi and another yield point occurred. It was also found that a yield point could be developed in unirradiated "A" nickel by straining and then aging for one hour at 200 C. Further tests have been conducted on unirradiated "A" nickel under various conditions in order to establish the nature of the aging effect. Specimens were tested at -77 C and 22 C and aged at 22 C, 100 C, and 200 C for varying periods of time. A specimen tested at room temperature and aged at 200 C required a combination of 2% strain and an aging time of 10 minutes for production of a yield point; a specimen tested at -70 C and aged at 200 C required 2% strain and only one minute aging time. Another specimen tested at room temperature and aged at 100 C required 6% strain and 200 minutes aging time to produce a yield point. In all cases, after development of the yield point, the region of Lüder's strain increased with successive straining and aging treatments. Also, as each specimen reached the yield point, the flow curve became markedly serrated, and the amplitude of the serrations increased with successive treatments. Parallel tests on high-purity (Carbonyl) nickel failed to produce yield points, increases in flow stress, or serrated flow curves. It was noted that the work-hardening coefficients of the high-purity nickel specimens were significantly lower than for corresponding "A" nickel specimens. It appears that after a critical amount of strain, "A" nickel ages while it is being plastically deformed. Defects are probably generated by moving dislocations which accelerate the diffusion of solute atoms to slow

moving dislocations or dislocation sources, resulting in serrations in the flow curve. The effect is enhanced by aging at elevated temperatures. The yield point observed upon immediate retesting of irradiated "A" nickel is also probably due to the generation of vacancies by moving dislocations, which migrate to and lock dislocation scurces; in this case, large strains are not required because of the greater concentration of extended defects which will interact with moving dislocations to form vacancies.

The analysis of x-ray diffraction effects in single crystals is being continued. Essentially strain-free surfaces have been produced on aluminum single crystals of 99.995% purity. X-ray extinction and the observed temperature factor change as the crystal surface approaches the strain-free state. As the last of the cold worked material is removed, the apparent Debye temperature of aluminum drops from 370-390 K to 355-360 K. Extinction also becomes more pronounced, affecting the medium-intensity diffraction maximum, as well as the strong reflections. Since further etching and electropolishing have no effect, it is concluded that the crystal sample is free of strains and imperfections introduced by the grinding of faces. The extinction is neither primary nor secondary but appears to be a combination of the two. No theory predicting the interaction of extinction effects has been developed. If it is assumed that the two effects operate independently, then domains approximately four microns in size aligned within one minute of angle are indicated.

## E. CUSTOMER WORK

### Radiometallurgy Service

Three wafers were removed from each of two Hanford three-railed bumper elements which exhibited severe cladding corrosion during irradiation as part of PT-IP-262-A. The three rails were 90° apart and the elements were oriented in the process tube so the side of the element which did not contain a rail was resting on the ribs. Examination and measurement of the six wafers revealed that most of the corrosion occurred on the top side of the elements opposite the ribs and that the rails on the extreme top had been nearly removed by corrosion. Non-uniform uranium growth was observed along the length of the element and ellipticity up to 0.020 inch was measured (RM-423).

Two bumper elements had failed in new process tubes in D Reactor. Some of the bumpers were badly corroded which reduced the clearance between the tube wall and the elements. Evidence of both corrosion pitting and intergranular attack on the X-8001 alloy cladding was found (RM-421).

Three self-support Hanford production elements which were irradiated as part of PT-IP-272-A were transferred to the Radiometallurgy Laboratory. Examination was requested to characterize the cladding corrosion and determine irradiation-induced dimensional changes in the fuel. Visual examination and as-received photography of the three pieces were completed. Most of the corrosion occurred in the central one-third of the element between the self-supports (RM-425).

The bonding layer on two elements discharged on the rear elevator of H Reactor was examined, but no significant change in the bonding structure was noted (RM-424).

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

Electron Microscopy Service

Continued progress has been made on the development of a technique for examination and identification of oxides formed during autoclaving of zirconium alloys. Zircaloy-2 autoclaved in 360 C, deionized water for 7072 hours is being used in the study. An oxide surface of the corrosion coupon was glued to a bakelite metallographic mount and hand-polished until a very thin layer of zirconium metal remained above the oxide layer. The final thinning was accomplished by Syntron vibratory polishing and was allowed to continue until oxide was completely exposed on one edge of the coupon. Metal still covered the greater portion of the oxide, however, Since the specimen was polished at a very small angle, with respect to the oxide layer, an elongated cross-section can be viewed. Small islands of metal in the oxide and oxide in the metal remained at the region of oxide-metal interface. It was noted that regions immediately surrounding oxide islands were more reflective than the rest of the metal when viewed through the optical microscope. If we assume such regions to be areas of thinnest metal, a thin interfacial layer possessing some chemical or structural variation is suggested.

A fifteen-second "B" etch exposed an 0.017" wide strip of previously unexposed oxide between the polished oxide surface and the receded metal boundary. This region was replicated for examination in the electron microscope. At 5000 magnification the unpolished oxide beneath the zirconium metal which had been removed by "B" etching appeared as rows of furrows. These furrows, in turn, were made up of thin, flat plates, stacked on end, side by side, having the long axis perpendicular to the furrows. An electron micrograph of an unpolished oxide island showed a one-micron-wide ring surrounding the oxide. The ring could be seen because it was attacked differently by the "B" etch. This ring may be the same type of highly reflecting material which was seen in the optical microscope. The fact that some polishing scratches still remained on the polished oxide and that there was an over-all smooth appearance of the area would indicate little or no etching attack on the oxide itself. A 750X magnification optical micrograph has confirmed the presence of unpolished oxide furrows.

A specimen identical to the one mentioned above has been polished until one oxide island is visible in the central portion of the metal. X-ray work is in progress to focus a finely-collimated x-ray beam on the island and, by use of back reflection techniques, identify crystal structure and preferred orientation.

Metallography Service

A document, "Metallographic Study of the Annealing Behavior of Aluminum-Silicon Eutectic Alloy," (HW-69401), has been written and is now in process of being approved by the library for publication as a formal report. This work by

R. H. Todd has been accepted for thesis credit by the University of Idaho.

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 | 508 |
| Replicas | 37 |

Photographs:

| | |
|---|---|
| Micrographs | 548 |
| Macrographs | 238 |
| Electron Micrographs | 230 |
| | 1016 |
| Negatives Printed | 1824 |
| Prints | 7075 |

NPR Charging Machine

Mechanical work on the machine is estimated to be 80% complete; hydraulic piping work is estimated to be 70% complete. No significant electrical work has been done.

Fabrication and assembly of the transfer arms, idler rollers, console support, and drive rollers were completed during the month. The transfer arms, idler rollers, and console support have been installed on the machine. Fabrication of the plug conveyor assemblies was started and is estimated to be 20% complete. Fabrication of the magazine positioning cylinder assembly is complete. Installation of this assembly has not yet started.

Some testing work has been done on the cross travel drive and the vertical lift drive. The transfer arms have been operated.

F. W. Albaugh

Manager, Reactor and Fuels Research and Development

FW Albaugh:kb

[redacted]

# PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

## MONTHLY REPORT

## MAY 1961

## FISSIONABLE MATERIALS - 02 PROGRAM

### REACTOR

#### Exponential Measurements for NPR

In order to place all results applicable to N-Reactor on a common basis, the graphite density (1.695 gm/cm$^3$) of the mockup exponential pile was taken as a standard. The measurements in the condensed lattice have been corrected to preserve the number of graphite atoms. The material buckling of the condensed lattice with 0.946 percent enriched fuel (wet) is 249 x $10^{-6}$cm$^{-2}$ instead of 239 x $10^{-6}$cm$^{-2}$ as previously reported. With dry fuel the buckling is now 62 x $10^{-6}$cm$^{-2}$ instead of 48 x $10^{-6}$cm$^{-2}$.

#### Lattice Parameters for Large Diameter Fuel

The program for calculating lattice parameters from data collected in PCTR experiments and calculating the probable error associated with the parameters is running on the IBM-7090. A discussion of the input for the program has been written, describing the order of information on each card and the order of the cards.

Analysis of data from lutetium foils irradiated in a 10½-inch graphite lattice containing concentric-tube fuel (2.5 x 2.0, 1.66 x 1.12) has given the spectral indices listed in Table I. Corrections for epithermal activation were made from a six-group spectrum calculation.

TABLE I

| | Wet | | Dry | |
|---|---|---|---|---|
| | $g^{176}$ | T°K | $g^{176}$ | T°K |
| Fuel Center | 2.01 | 339 | 2.20 | 368 |
| Fuel Edge | 1.99 | 334 | 2.14 | 358 |
| Graphite | 1.95 | 329 | 2.05 | 344 |
| Cell Edge | 1.92 | 324 | 1.99 | 334 |

#### TTR Measurements for NPR

Preliminary drawings have been completed for a controlled temperature system that would allow simulation of NPR conditions in the TTR thermal column. With minor changes the system could be used in the PCTR core. Graphite temperature of 500°C and water temperature to 280°C can be attained. Detailed flux plots through the lattice can be made under varying temperature conditions. If modified for PCTR use the flux spectra and distribution would be improved over TTR conditions. The cost estimate is $120,000. Although a review of the design

indicates that this can be reduced to $100,000, no further work is planned until funding is assured.

Digital Computer Program for Reactor Analysis

Development of HFN, the multi-group neutron diffusion theory code, is continuing. A generalized input-reading routine, which may be used with any FORTRAN language program, has been written and is 90 percent debugged.

Debugging of HFN has recently been hampered by a lack of computer memory space. There are 32,461 memory locations available to FORTRAN programs on the IBM-7090. Of these, all but two are used by the present version of HFN, which includes the changes in logic, but not the input changes, mentioned last month. Several bugs have been discovered which would require five or six additional memory locations if they were corrected. Incorporation of the required changes in input format, mentioned last month would require considerably more memory if the present input scheme were simply extended to the new input data format.

In order to simultaneously decrease the core storage requirements and introduce the desired 72 column input format, a generalized input-reading subroutine has been written. The FAP programming system was used to code this routine which, relative to the present HFN setup, uses about 1000 fewer memory locations and should be about twenty percent faster. In addition, future changes in HFN will not require changes in the input program, which will work with any FORTRAN monitor program. This input subroutine is presently being debugged using a test program written for the purpose. Debugging is 90 percent complete. HFN is simultaneously being modified to use the new input routine.

Computational Programming Service

An informal document, HW-68806, "VT0CL, A 709 Program for Reduction of Exponential Pile Data," was issued. This is intended as a manual for the users of the code, as well as a record of the formulation and procedure used by the code. HW documents on C0FIT2 and INELASCAT are in preparation.

Production use of INELASCAT has revealed a defect which prevents the code from handling certain input data combinations. The code has been corrected.

At the request of Critical Mass Physics, a cross section library on binary cards was prepared in the format required for AIM-6. This was done by altering an Atomics International program written for this purpose. An auxiliary program to read and print the library contents for verification has been written and debugged.

An investigation of the fast source corrections in C0FIT-2 confirmed that the code was correctly evaluating the formulas.

Green's Function Treatment of Exponential Piles

The three-dimensional Green's function for the diffusion equation has been derived for the boundary condition of zero flux on the six faces of a rectangular parallelepiped. By use of this Green's function the flux distribution for a slowing down source in a moderating pile has been obtained. Corrections to a simple exponential distribution arising from the finite base of the pile, the finite height of

the pile, harmonics, and different neutron ages appear naturally in the theory. An attempt to compare these corrections with the ones in current use is being made. Since small source theory and a Green's function approach are compatible, the treatment of an exponential pile with horizontal fuel rods placed in the moderator has been undertaken within such a framework. The general solution involves error functions and is relatively complicated, although it could be easily evaluated with a computer. The possibility of finding a simpler approximate expression is being considered.

Instrumentation

Circuitry modifications and satisfactory calibration, line voltage variation and temperature variation tests were completed on the prototype transistorized Logarithmic and Linear (multi-range) Scintillation Area or Building Monitors. One unit was calibrated for 0-10 mr/hr decaded to 0-10 r/hr linear range with corresponding log scale coverage. The second unit was calibrated for 0-5 mr/hr decaded to 0-5 r/hr linear and similar coverage for the log scale. Less than ± 5% reading errors, on any range, were produced by line voltage variations from 105 VAC to 130 VAC. All linear range reading accuracies are within ± 5% for $Ra^{226}$ calibration, and the log scale is accurate to ± 20% from greater than 20 mr/hr to full scale. All log scale reading errors below 20 mr/hr are positive on the "safe" side. Long-term drift and temperature tests just commenced. Initial temperature tests showed reading errors of less than ± 5% from 75°F to 135°F for temperature tests of the complete system including probe.

Experimental circuitry development continued on the Fast and Slow Scanning Type Fuel Failure Monitor. Fail safe circuits using ferrous-reed relays were developed to replace the original solid state devices with a definite gain in both reliability and economy considering the large number of such circuits to be employed. A 400-cycle converter circuit was completed for use with a 400-cycle magnetic amplifier used as the fast scan dc amplifier. The wheel and slip ring operation continues to be satisfactory after three months of continuous operation.

A conference was held with CE&UO, IPD, and Kaiser Engineers personnel concerning the turret portions of the NPR Fuel Failure Monitor. The conference concerned the apparent low bidder on this portion of the system. Technical advice and assistance were rendered to CE&UO concerning the electronics portion of the Slow Scan Gamma Energy Analysis part of the same system.

A light-tight containment enclosure was completed and the two lucite light pipes were nearly completed for use in investigations of uranium contamination on the surfaces of NPR fuel elements by alpha particle detection.

A prototype experimental high temperature (300°C) ceramic tube pulse cathode follower was completed and satisfactorily tested at temperature and for driving 1000 feet of cable. The circuit can be useful for use with proportional counters and other detectors used in certain reactor and other high temperature locations.

A proposal was made to Operational Physics, IPD, concerning a comparatively inexpensive method of checking the NPR graphite core by use of simple "purity" measurements rather than by the traditional diffusion length measurement methods which are expensive, time-consuming, and require a large amount of instrumentation.

Developmental support was rendered to IPD and CE&UO concerning in-core monitoring for existing reactors and actual installation of test units at 105-KW.

Bids for special octant monitor neutron chambers were reviewed for IPD and specific recommendations were made. In addition, advice was rendered concerning developmental scoping for a confirmation rupture monitor (CGI-904).

Advice was given to, and investigations undertaken with, Instrument Development, IPD, concerning commercial in-core flux monitors. Two commercial Anton units were tested satisfactorily. The measurements performed gave valid experimental data, and the information obtained will provide a basis for predicting the magnitude of the gamma-induced component of the signal from future in-core flux monitor fission chambers.

Measurements of the infrared signal emitted from a jet of 100°C carbon dioxide gas were made in connection with possible detection of costly reactor gas leaks. Helium leaks in HAPO reactors, especially in the rear faces, are difficult to find by standard leak detecting methods due to the size of the area to be covered and general background level of gas. Leaks in the range of 1 to 35 cubic feet per hour are of interest. The temperature of the gas is about 100°C as it comes out of the reactor shortly after shutdown. It may be possible to use an image-forming infrared radiometer to detect points at which hot gases are leaking from the reactor. Since the gases cool quickly upon contact with the cool outer atmosphere, general background due to leaks would be small. Carbon dioxide has a high infrared emissivity, and it is permissible to fill the reactor with it soon after shutdown. Experiments using a commercial infrared radiometer showed that a jet of 100°C carbon dioxide issuing at one cubic foot per hour from a 1/8-inch-diameter tube gave a signal about twice as great as the general infrared background in the laboratory. The radiometer was focused on a point one-half inch from the end of the tube. Moving the field of view closer to the tube increased the signal, and no appreciable signal could be seen at approximately 12 inches from the tube. Although the laboratory results were encouraging, the infrared background at the rear face of a reactor due to hot objects would probably be higher than in the laboratory. It is expected that further evaluation of this leak detecting method under actual rear face conditions will be made by Process and Reactor Development, IPD, with the assistance of Physical Measurements, HLO.

## Systems Studies

A study is being conducted for the NPR design group to determine the effects on the reactor system of producing power as well as plutonium with the NPR. The equations describing the system have been supplied by the NPR design group. The computer model has been designed and wired on the GEDA computer. This model will probably be useable in the NPR plant simulation. The dynamic characteristics will be studied in detail to determine what simplifications can be made in the model.

Simulation studies of the NPR have developed a need for an analog transport delay, the period of which may be varied during the simulation process. The specific case to be studied for the NPR is the transport of cooling water from the reactor to the heat exchanger and from the heat exchanger back to the reactor. The proposed system for developing the transport delay will convert an analog signal to binary form for storage. A 256-word magnetic core memory

will be used (8 binary bits per word). The analog signal will be sampled at intervals and stored in the memory in a circulating manner. The system will begin reading out stored information as it returns to the addresses previously filled with the binary converted signal. The binary information read out of each address will be converted back to analog form for use in the analog computer simulation. The rate of sampling the analog signal will be controlled by the total desired time delay so that 256 samples (one circulation of the memory addresses) are taken in one transport delay period. At the present time the necessary digital and logic modules along with the magnetic core memory and power supply have been ordered and should be delivered soon. Enough equipment for two units is being purchased. (Two transports are needed, one for the loop from the reactor to the heat exchanger and one for return loop from heat exchanger to reactor.) The necessary core drive circuits have been developed but significant work is yet to be done on a fast analog-to-digital converter. The circuits are being designed to operate at optimum speed so that a larger memory may be added at a later time if it becomes apparent that faster sampling rates are desirable.

As a result of the difficulties encountered in previous attempts to use the existing multipoint temperature recorder for reactor control tests at 100-D reactor, it was decided to suspend further tests until a better measuring system was available. During the month, Instrument Development Operation, IPD, completed fabrication of a high sensitivity temperature measuring system suitable for these tests. The system can accept twelve RTD inputs and is quite stable on a full scale range of 10 degrees centigrade. The multipoint recorder used with the system has a printing interval of two seconds. Arrangements were made to use this system for further automatic control tests.

A test, using manual control by procedures simulating automatic control on only the four corner sections, was conducted at 100-D just before the last shutdown. Permission to decrease power level by changing temperature control setpoints was obtained. Five step function setpoint changes were made starting with temperature changes corresponding to approximately five megawatts and increasing to 25 megawatts. An undershoot of approximately five megawatts was observed on the largest power level change (25 MW), but the oscillation damped out in one cycle. These tests will be used as the basis for requesting permission to raise power level "automatically" on the next in-reactor test.

The statistical (noise) technique for measuring reactor frequency response, which has been used in the past primarily for the measurement of prompt neutron lifetime, is expected to be useful in control studies planned for NPR and the K reactors. Methods of extending the low frequency capabilities of the technique are being investigated.

Work was initiated on the NPR confiner pressure buildup problem. The problem simulates pressure transients in four areas around the reactor: the front face room, the rear face room, the pipe gallery, and the heat exchanger cells. The transients are caused by the introduction of high-pressure steam into the building. It is desired to determine whether the steam will cause building pressure to exceed the 5 psig design pressure. The analog circuit has been prepared and is apparently working properly. Results should be ready by early June.

The specifications for the experimental control digital computer are with AEC Purchasing and are to be sent this week to prospective bidders for their comments.

Initial analysis of the new reactor speed-of-control simulation, exhibiting space and time dependent neutron flux in 19 side-to-side regions, has been completed and the results forwarded to IPD. It is expected that additional runs will be requested in the near future.

## SEPARATIONS

### Plutonium Critical Mass Facility

Work continued on the preparation of the Laboratory for the criticality experiments with plutonium solutions. New high level probes were installed in the tanks and the tanks were recalibrated. Flexible drive couplings were installed on the fast addition pump for the critical assemblies and on the main transfer pump in the mixing hood; this effected a considerable reduction in the leakage at the packing glands of these pumps. Piping was installed in the air sampling system so that the experimental cell air and the critical assembly hood air can be sampled from the mixing room by means of the main air sampling system.

Tests were run with nitric acid solutions in the process system to determine the amount of liquid holdup in the lines and tanks of the Facility. Tests were also run to determine the degree of mixing, and the time required to mix solutions under different initial conditions in the mixing tank. Under the conditions of the tests, the time required for complete mixing ranged from about 5 to 30 minutes.

On the evening of May 25 a power outage occurred in the 200-East Area. As a consequence, the air compressor in the Facility stopped running; when the air pressure became sufficiently low, the deluge sprinkler system in the reactor room was automatically set off. In all, a total of 750 gallons of water was sprayed into the reactor room. Some minor water damage occurred to the instruments in the reactor room. The reactor room was cleaned up on the morning of the 26th, and the equipment dried out and placed in operation within several days. Steps are being taken to prevent the occurrence of this kind of incident in the future; the compressor for the air supply will be equipped with a self starter, and plans are to install a separate air storage tank for the sprinkler system.

The processing of selected fuel in the Redox Plant was begun in order to obtain plutonium with a lower than average Pu-240 content for the initial series of critical mass experiments; the isotopic analyses which have been run on the material during processing indicate that the plutonium as received will have a Pu-240 content of about 4.5 percent.

During the month 39.6 Kg of Pu metal were received from the Dow Chemical Company and stored in the 308 Building. The plutonium is reported to have a Pu-240 content of 2.5 percent, which is probably the lowest Pu-240 content plutonium currently available in any large quantity. The plutonium will be used in both critical experiments with solutions and in experiments with $PuO_2$-polystyrene compacts. In order to determine the effect of Pu-240 on criticality, experiments will be conducted with plutonium containing different percentages of Pu-240.

Several additional critical assembly vessels were ordered for the critical mass experiments. The vessels ordered were for an 11-inch, and a 13.5-inch diameter sphere.

In Situ Neutron Multiplication Measurements with Plutonium Metal

In situ neutron multiplication measurements with plutonium metal were continued in the 234-5 Building, with the measurements being made during week ends. Personnel of CPD performed the experiments with instrumentation from Critical Mass Physics. Senior personnel from Critical Mass Physics provided technical supervision during the conduct of the experiments.

The purpose of the experiments is to obtain critical mass estimates for Pu metal under the operating conditions encountered in the Plant. The data will be used to establish mass limits for nuclear safety.

On April 29 and 30, the in situ multiplication measurements started earlier were extended to include the airlock between hoods 2D and 20A and the furnace in hood 20. Two positions in the airlock were used for the tests, one next to the door of hood 20 and the other within the rather massive flange connecting the airlock to hood 20. The same 2.75-inch discs used in the first experiment were used in this experiment. The extrapolated critical mass was determined to be 11.2 Kg in each case.

For stacking in the crucible within the furnace, the pieces were centered in a tantalum crucible and held in place by aluminum spacers. Water was in the cooling coils to complete the in situ mockup. The critical mass was determined to be 9.90 ± .3 Kg in the crucible located within the furnace coils. A further experiment is being planned to more accurately mock up the melting geometry with discs of 3.35-inch diameter.

On May 13, an experiment was performed in hood 20B on the stacking of rough castings. The purpose was to establish that stacking as many as three such pieces per pallet in hood 22 SR was no additional hazard. The experiment was carried to 14.3 Kg (in six pieces), and the extrapolated critical mass was roughly determined to be in excess of 60 Kg. The experiment was not carried close enough to critical to make an accurate determination of the critical mass, however, 60 Kg represents the minimum predicted by the three counters. Thus, from the results of these measurements, the mass limit for hood 22 SR was increased by a factor of three.

On May 28, the experiments with the 2.75-inch diameter discs of $\alpha$ phase metal were completed. Two multiplication measurements were made. In one case the plutonium was positioned in a 3/32-inch thick tantalum crucible which was, in addition, partially reflected by an aluminum holder. A total of 8.2 Kg of Pu were used in the assembly. The critical mass was estimated to be about 13.9 Kg of Pu. Data were also obtained for estimating the effect on the critical mass of a pair of hands held on top of the assembly.

In the second case the plutonium metal was unreflected and positioned on a light metal support so as to minimize neutron reflection from the hood floor. From the multiplication data, the critical mass was estimated to be approximately 16 Kg of Pu for the 2.75-inch diameter bare cylinder of $\alpha$ phase metal (Pu density of 19.4 gm/cc).

## Plutonium Critical Mass Data from Dounreay, Scotland

During a visit by E. D. Clayton to the Experimental Reactor Establishment at Dounreay, Scotland, on May 18 and 19, some preliminary results were obtained for the initial critical mass experiments with $PuO_2$-polythene. The data of interest which are presented below were obtained in the initial experiments in the new Plutonium Critical Mass Facility at Dounreay(1).

A split-half remote assembly machine was used in the conduct of the critical experiments.

The plutonium-polythene compacts were positioned in half-inch thick polythene boxes, with each box containing about half of the material. The average density of plutonium in the boxes was 2.83 gm/cc. The H/Pu atomic ratio was seven. The face of each box making contact was covered with 0.007 inch of tinned iron. Thus, with the boxes brought together, the two halves would have been separated by a 0.014-inch thick layer of tinned iron. The assemblies were completely reflected with a layer of polythene at least six inches thick.

| Core Dimensions of Rectangular Parallelepiped | Reflected Critical Mass (H/Pu of 7, Pu-240 - 3.24 Percent) |
|---|---|
| 7" x 7" x (6.6" nominal) | ~15.7 Kg total Pu |
| 6" x 6" x (9.5" nominal) | ~16.7 Kg total Pu |

The temperature rise due to $\alpha$ heating was used in one of the assemblies to obtain a rough estimate of the temperature coefficient of reactivity. During a temperature increase of up to ~65°C, the reactivity coefficient was indicated to be ~ $-2 \times 10^{-4}$/°C. Ambient temperature was 24 ± 1°C.

The above results are of particular interest to Critical Mass Physics, since the first experiments which are planned for Hanford with $PuO_2$-polystyrene mixtures will have a nominal H/Pu ratio of 15.

As previously reported the British still plan to terminate the experimental program of plutonium critical mass experiments at Dounreay in December of this year.

## Measurement of $k_\infty$ in the PCTR for Dilute $Pu(NO_3)_4$ Solution

The experiment to measure the limiting concentration, i.e., the concentration for which $k_\infty = 1$, for a $Pu(NO_3)_4$ solution was begun once more in the PCTR. No contamination problem has developed.

The problem of containment of the Pu solution was solved by welding a cap over the spout of the tanks and then welding the tanks into their jackets.

---

(1) E. D. Clayton, Criticality Discussions in Britain During February 14-17, 1961, HW-68708.

No preliminary results are currently available, but the reactivity measurements with tanks containing twice and three times as much stainless steel as the normal core tanks indicate the stainless steel to have an appreciable effect on the measured value of $k_\infty$ which will have to be corrected for in the analysis of the data.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

Monte Carlo Code - HISMC

The HISMC code, a Monte Carlo code to study the slowing down and diffusion of neutrons in infinite homogeneous systems, has been completed. The first calculation carried out with the code was a determination of the age ($\tau$) of fission neutrons in water. For this calculation, which required 25 minutes on the IBM-7090, a total of 10,000 neutron lifetimes, 169,855, collision events, were sampled. Each neutron was followed to its first collision event above indium resonance (1.44 ev). The age value computed by HISMC refers to the slowing-down density rather than the flux. A simple correction to obtain the age flux has been derived(2), assuming that in the vicinity of the final neutron energy collisions with heavy nuceli can be neglected and the hydrogen cross section taken to be constant with energy. The correction from the slowing-down age to flux age is given by,

$$\tau_f(1.44) = \tau_q(1.44) + \frac{1}{3\xi \Sigma_s \Sigma_{tr}} = \tau_q(1.44) + 0.43 \text{ cm}^2.$$

The results of the calculation are:

| | |
|---|---|
| Neutron Slowing-Down Density Age ($\tau_2$) | = 28.7 $cm^2$ |
| Neutron Flux Age ($\tau_f$) | = 29.1 $cm^2$ |
| Second Moment (Slowing-Down Density) ($\overline{r^2}$) | = $0.1724 \times 10^3$ $cm^2$ |
| Fourth Moment (Slowing-Down Density) ($\overline{r^4}$) | = $0.7493 \times 10^5$ $cm^2$ |
| Mean Slowing-Down Time | = 0.747 $\mu$ sec. |

The value of the foregoing calculated age is somewhat larger than the recently reported measured value(3) of 27.86 ± 0.10 $cm^2$. It was observed that the random number generator used in this calculation would not give consistent results with different start numbers, a simple matter of calculating a few random numbers

(2) H. Goldstein, P. F. Zweifel, and D. G. Foster, Jr., The Slowing Down of Neutrons in Hydrogen Media - Status of Theory and Experiment, Proc. of the International Conf. on the Peaceful Uses of Atomic Energy, 1958, P/2375.

(3) R. C. Doerner, R. J. Armani, W. E. Zagotta, and F. H. Martens, Age of Fission Energy Neutrons to Indium Resonance in Water, Nuclear Science and Engineering: 9,221-240 (1961).

before starting the calculation[4], whereas the random number generator used with the RBU code would give consistent results. A new calculation is, therefore, presently being undertaken with the RBU generator which will also make use of more recent cross section data for oxygen.

Criticality Hazards Specifications

Nuclear Safety in HLO

1) In order to accommodate a special series of density tests, a temporary increase in the mass limit of the balance hood, Room 34, 231-Z Building, was approved for the Plutonium Metallurgy Operation[5,6]. The hood is normally limited to 4.5 Kg of plutonium metal; under the waiver, the hood may contain 7.0 Kg. In both cases, the unit mass is limited to 2.8 Kg and a spacing of at least 18 inches is required between units.

2) Calculations were made for the Reactor Engineering Development Operation to compare the nuclear safety parameters of fuel elements made with U-235 enriched $UO_2$ and plutonium enriched $UO_2$.[7,8] The questions submitted and the specific answers which were given are as follows:

   a. What is the maximum $PuO_2$ addition which can be made to natural uranium oxide (sum of Pu-239 and Pu-241) disregarding Pu-240 and Pu-242, which would permit the same nuclear safety criterion as would be used for 1.5% U-235 $UO_2$ fuel elements?

      Answer: 0.47 w/o Pu in $UO_2$ (0.72% U-235)-$PuO_2$.

   b. What is the maximum $PuO_2$ addition which can be made to $UO_2$ depleted in U-235 to 0.2% and still use the same criterion for handling?

      Answer: 0.79 w/o Pu in $UO_2$ (0.2% U-235)-$PuO_2$.

   The evaluation was made by comparing material bucklings. In each fuel case, a lattice of 2.2-inch diameter rods in light water was used. The buckling curves for the $UO_2$ and $UO_2$-$PuO_2$ fuels have similar shapes and the maximum values occur at essentially the same water-to-fuel volume ratios. The oxygen

---

(4) R. D. Cahoon, Private communication.

(5) Note, P. G. Pallmer to C. L. Brown, Request for Temporary Increase in Balance Hood Mass Limit, 4/26/61.

(6) Letter, P. F. Gast to T. C. Nelson, Temporary Nuclear Safety Limit - 231-Z Building, May 2, 1961.

(7) Letter, H. E. Hanthorn to E. D. Clayton, Critical Mass Considerations - Fuel Cycle Economics Process Study, April 7, 1961.

(8) Letter, E. D. Clayton to H. E. Hanthorn, Results of Calculations - Fuel Cycle Economics Process Study, May 25, 1961.

in the $PuO_2$ was neglected in the calculations and the plutonium was considered as all Pu-239, rather than a mixture of Pu-239 and Pu-241.

3) Comments were submitted to the Programming Operation concerning the safe storage of PRTR 2.2 w/o Pu-Al alloy Mark I fuel elements in the Fuels Re-Cycle Pilot Plant(9,10). Preliminary planning of fuel element storage areas will be based on the safe lattice spacings designated in PRTR storage.(11) When FRPP design begins, however, detailed nuclear safety calculations will be made for the actual arrangements to be used.

Nuclear Safety in CE&UO

A meeting was held with personnel of Purchasing and Stores Operation to discuss the nuclear safety of storing fissile material shipments in the 1166 warehouse building.(12) It was pointed out that the nuclear hazard from any one, or even a few, fissile material shipments together, was quite small because the safety margin required of the shipper was large. However, the margin of safety is significantly reduced by such factors as water flooding, changing container geometry, or stacking several shipments together. To further assure safety in the 1166 warehouse area, it was suggested that shipments containing more than 60 g of plutonium or 100 g of U-235, particularly fuel element shipments, be spaced at least three feet apart.

Evaluations for Nuclear Materials Operation

Two fissile material shipments were reviewed and approved for the Nuclear Materials Operation.(13,14) The first was for a shipment of 30 barrels of uranium turnings, ranging in enrichment from 0.72% to 3.063% U-235. This material comprised less than 25% of a critical mass and was shipped by AEC escorted gondola car. The second was for a shipment of five boxes of 0.95% U-235 enriched I&E fuel elements in the same railway car with 40 barrels (2,200 gal) of $D_2O$.

Mass Spectrometry

Isotopic analyses were provided for Critical Mass Physics on five samples of plutonium for possible use as fuels in criticality studies. Studies were continued on the accuracy of analyses performed on the mass spectrometer for this

---

(9) Note, K. J. Schneider to H. C. Riches, Fuel Element Storage Spacing in FRPP, May 2, 1961.

(10) Letter, C. L. Brown to K. J. Schneider to H. C. Riches, Fuel Element Storage Spacing in FRPP, May 2, 1961.

(11) Letter, C. L. Brown to R. G. Clark and W. E. Cowley, Nuclear Safety - PRTR, May 26, 1960.

(12) Letter, C. L. Brown to E. D. Clayton, Nuclear Safety in the 1166 Warehouse Building, May 25, 1961.

(13) Letter, P. F. Gast to F. J. Zelley, Nuclear Safety Approval of Uranium Turnings Shipment, May 2, 1961.

(14) Letter, P. F. Gast to F. J. Zelley, Nuclear Safety Approval for Addendum to Uranium Turnings Shipment, May 9, 1961.

program. Two additional electron multipliers were tested, and it was determined that these multipliers also gave a non-linear response for the multiplier output currents in the range of values of about $10^{-9}$ amps necessary for analyses. The nonlinearities are about one percent for current ratios of about one hundred to one.

A set of baffles was installed in the spectrometer tube which is designed to lower the background caused by rhenium ions from the ionizing filament. The value of the baffles has not been determined as yet because of the multiplier studies in progress.

## NEUTRON CROSS SECTION PROGRAM

### Slow Neutron Cross Sections

A commercially obtained germanium single crystal was studied to determine its value as a neutron monochromator for crystal spectrometry. Neutron diffraction studies indicated that the crystal possessed a very small mosaic structure, less than one minute of arc. The crystal ingot was then cut with a diamond saw into several thin slabs. Measurements made on one of the slabs showed that the crystal perfection was not noticeably perturbed and confirmed the idea that strong extinction effects were present. This crystal is of potential value as a monochromator if the mosaic structure can be widened while preserving reflection efficiency.

### Fast Neutron Cross Sections

The new pulse shape discriminator circuit for counting fast neutrons in the presence of gamma rays with a scintillator detector was tested. The apparent threshold of the circuit is about 0.7 Mev neutron energy. The discriminator was tested in the accelerator building under conditions equivalent to normal use and no operational problems were encountered. The design has been started of a five-inch diameter liquid scintillator cell to be used with a 58AVP photomultiplier as a fast neutron detector using pulse shape discrimination. Further work on the time-of-flight system was hampered by additional breakdowns of the multichannel analyzer.

### Slow Neutron Scattering Cross Sections

The measurements of differential inelastic scattering of neutrons of initial energy of 0.2 ev from room temperature water have been completed.

A sample holder which allows a metal scattering sample to be cooled to liquid nitrogen temperature has been installed on the spectrometer. Measurements are in progress of the scattering of neutrons of different incident energies from a vanadium sample at liquid nitrogen temperature. The purpose of these measurements is to determine the relative efficiency as a function of neutron energy of the analyzing spectrometer. This efficiency must be known in order to interpret the inelastic scattering data on water previously obtained.

A computer program to do least squares fitting of data to gaussian functions has been written using the Hanford version (GLC$\theta$) of a Los Alamos program. It has been debugged and is now in production. The study of the behavior of the quasi-elastic scattering of neutrons from water will be subjected to more quantitative error analysis using the least squares fitting to the data.

Instrumentation

A prototype pulse generator was developed to aid in development and use of time-of-flight instrumentation. A charged line is discharged into the external circuit by a mercury relay. The relay capsule is mounted in a coaxial chamber to approximate a constant impedance. The pulse rise time seems to be of the order of $2 \times 10^{-10}$ seconds, as measured on a $1 \times 10^{-10}$ second rise time oscilloscope. The pulse length is determined by the length of the charging line.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Program Planning

A preliminary draft of a document describing the basis for scheduling of the physics portion of the PRP was prepared. Detailed schedules have not as yet been set forth.

PRTR Critical Tests

Analysis of void coefficients using the SWAP code appears now to give good agreement with experimental results for spatial distribution of coolant voids, and excellent agreement for total coolant loss. Cell calculations using the IDIOT code were carried out to provide the basis for further calculations.

Small Source Theory Analysis of PRTR Plutonium Loadings

A small source theory analysis has begun of the PRTR subcritical tests using only plutonium fuel. This analysis is being made in an attempt to understand some discrepancies between the test results and calculations using homogenization procedures. A two-group model is being used, with fuel absorption being permitted in the thermal group only. As the small source parameter for the fuel is inadequately known at this time, calculations are being made for a range of plausible values. The finite heterogeneous lattice code HET is being used in this analysis. As HET is a relatively untried code, this work is also serving to debug the code; some inadequacies have been discovered and corrected. The results now being obtained give relative fuel element absorptions somewhat different than originally expected. These results are being rechecked and studied before being accepted.

PRTR Startup Experiments

Two sets of lutetium foils were irradiated during Critical Test 15. The first set was irradiated when the moderator had its maximum boron content of about 0.019 gms/liter and the second set when there was no boron in the moderator. The fuel loading and shim configuration were the same during both irradiations. The Lu-176 m and Lu-177 activities at the end of each irradiation were obtained by applying dead time and decay corrections to the foil count rates using a modified version of LULU. The buildup and decay of these nuclides during the irradiations were not so easily determined. This part of the analysis was complicated by the fact that each irradiation consisted of three period measurements rather than a constant power level and, in addition, a scram occurred during one of the irradiations. A spectral index must be obtained next for each set. During

Critical Test 21, lutetium foils were also irradiated at a constant power level with no boron. Thus, a comparison can be made under equivalent reactor conditions between the spectral index which is deduced from these foils and the index which is obtained from the foils irradiated during the period measurements. This comparison will indicate whether or not useful spectral data can be obtained if circumstances do not permit constant power level irradiations.

Conclusions which have been drawn from a preliminary analysis of the data from Critical Test 21 are:

a) The spectral index in the moderator is constant as a function of position in a cell; and

b) The value of $r\sqrt{\frac{T}{T_o}}$ varies from 0.06 in the moderator to 0.13 in the center rod of a 19-rod cluster of $UO_2$ rods and between 0.07 and 0.10 for the Pu-Al cluster. The r is the usual Westcott measure of the proportion of epithermal neutrons in the reactor, T is the neutron temperature and $T_o = 293°K$.

Rough drafts of summaries of the experiments and the results have been prepared for the Series III tests. In addition, the results of the shim calibration experiments have been compiled for all three series.

Seven samples of plutonium from the original fuel loading of the PRTR were isotopically analyzed for use in interpreting isotopic changes during PRTR operation.

The Critical Facility of the PRP

The fuel element requirements for experiments which are being planned for the Plutonium Recycle Program Critical Facility have been reviewed. Steps have been taken to assure that the fuel which is available now will still be available when the facility is in operation. Some additional $UO_2$ fuel elements will be required and requests for their fabrication have been initiated.

A comment issue of the "Safeguards Analysis", HW-69168 RD, has been reviewed. Comments have been forwarded to the authors.

The status of the uranium fuse which is to inject boron poison in the facility in case of an accident has been determined. It was learned that consideration now is being given to replacing the fuse by an electronic system. Careful consideration will have to be given to such a system to make sure that it does not inject the poison inadvertently.

Low Exposure Plutonium Lattices

The experiments using 1.8 w/o Pu-Al in 19-rod clusters, in a 6½-inch graphite lattice, were completed on May 9. About five shift-weeks of PCTR time were required. No Pu contamination problems were encountered.

The foil activation data have been processed, using APDAC-1, and the results are being examined. A preliminary look at the fission product activities of

Pu-Al foils relative to the fission product activities of $U^{235}$-Al foils indicate significant amounts of self-shielding of the Pu fission events within the cluster.

Neutron Spectrum Studies

The parameters which Westcott lists (CRRP-960) for the absorption cross section of $Pu^{239}$ have been modified. The modified parameters when used in a function which is a sum of single-level Breit-Wigner equations will generate values of the cross section which fit the measured data (TNCC(US)-58).

Work is in progress on determining the change in $(1 + \alpha)_{49}$ which occurs upon poisoning a plutonium fueled lattice in a PCTR experiment. Absorption rates and fission rates have been calculated with ACE for Lu, Cu, $Pu^{239}$, and Au in Maxwellian and Hurwitz flux spectra. ACE input has been prepared to obtain similar results for Maxwellian and Hurwitz absorption spectra. A polynomial fit has been made to the best available data for $\alpha_{49}$ up to 1 ev. ACE input has been prepared for determining the spectrum averaged values of $\alpha$, weighted with the fission cross section. This input can be used as soon as two new subroutines for ACE are completed. A determination of the lattice spectrum and cross sections will then be made from experimental foil activity data.

Neutron Rethermalization

The absorption rod experiments have been delayed and are expected to start June 5, 1961. In addition to the work described in March and April, a traverse will be obtained of the thermal activity of europium. The use of europium will yield an additional measurement of the variation of the thermal neutron spectrum. The activation cross section of Eu falls more rapidly than 1/v in the 0.01 to 0.1 ev region. In view of this energy dependence, Eu could be used in place of $Lu^{175}$ in the Lu spectral index detector. One could expect an increase in sensitivity.

Europim oxide resin foils and pins have been fabricated, irradiated, and counted. The differential $\gamma$-ray spectrum of $Eu^{153}$ has been compared with $Lu^{176}$ and $Am^{241}$. The prominent $\gamma$-rays of $Eu^{152}$ and $Eu^{154}$ are $\sim$35 kev and $\sim$120 kev. For long irradiations one should take account of the long-lived (16-year) activity of $Eu^{154}$ and the 13-year isomeric state of $Eu^{152}$.

Plutonium Fuel Temperature Coefficient

Design of the heating apparatus and insulated cell for this experiment is nearly complete.

Effect of Neutron Rethermalization on the Fuel Temperature Coefficient of Reactivity

The study of methods for measuring the effect of rethermalization in a heated aluminum rod by means of reactivity measurements has been concluded. Three ways of interpreting such an experiment were considered: 1) As a change in thermal lifetime in the PCTR; 2) as a change in temperature of neutrons within the rod resulting in a change in rod absorptions; and 3) as a measure of the rethermalization cross section. None of the three methods were satisfactory, however. The first suffered from lack of sensitivity and difficulty in interpretation of

the results in terms of spectral changes within the aluminum rod alone; the second was complicated by changes that occur in the spatial average of the flux over the rod as the rod is heated; and the third did not include spectral hardening. A summary of this study is currently being written.

## $Pu^{240}$ Effective Resonance Integral

Work on the fabrication of the rods for the $Pu^{240}$ effective resonance integral experiment will proceed at Plutonium Fuels Development Operation as soon as the isotopic analysis on the HX and LX plutonium is available.

## Code Development

### RBU

The NPR cell calculations without Monte Carlo resonance routines appeared satisfactory, although the amount of self-shielding of the main U-238 resonances is still inadequate. Several test runs with the resonance routines in use were tried, and results were in good agreement with values expected from experiments and other calculations. Some errors in the post-Monte Carlo treatment of resonance information were corrected, and an improvement was made which reduces restrictions on memory space in the post-Monte Carlo. The thermalization routine is now apparently satisfactory. The preliminary draft of the final report on RBU has been completed. Work is well advanced on the preparation of input for PRTR core calculations. Final debugging of the Library Edit routine was completed early in the month.

### C-6

Inconsistencies in the C-6 program have been discovered and corrected. The inconsistencies appeared when the results of cases having equivalent input were compared. The errors which were detected were in the code as received from ANPD. C-6 now gives satisfactory agreement on the three C-5 test cases.

## Advanced Pressurized Water Reactor Study

APWR runs using revised cross sections in the MELEAGER code showed an effect which has been observed previously for other reactors, namely, "runaway" spectrum hardening as plutonium concentration is increased. The resonance escape probability of U-238 decreases more rapidly, in this situation, than the other reactivity parameters can increase. The practical consequences of this phenomenon require dilution of the fuel with an inert material in order to continue operation with recycled plutonium fuel, since by reducing the U-238 content of the fuel loading the spectrum can be maintained in the thermal (high-reactivity) state.

A correlation between the Westcott cross sections used in MELEAGER and the heavy-gas-model cross sections computed by Horowitz and Tretiakoff (EANDC/E/14) is under way. In this comparison the neutron temperature required for matching of the Westcott and gas-model cross sections is being computed as a function of moderator temperature and r-factor for each isotope. For the APWR at 316°C moderator temperature the neutron temperature of 450°C which has been used in the APWR study was in excellent agreement for both U-235 and Pu-239. For other

isotopes, higher r-factors, and other moderator temperatures agreement is not as satisfactory. Comparisons with other spectrum models are planned.

The PUCK code has been updated to conform to the current MELEAGER cross sections, and an option to permit Pu-242 to be present in non-equilibrium amounts was provided.

Supercritical Pressure Power Reactor

Further considerations of lattice physics development problems were made, and a summary of these was prepared for inclusion in the SPPR report.

Instrumentation and Systems Studies

Further tests on the experimental "last ditch" safety fuse system for PRPCF will be held up until the uranium material arrives for experimental fabrication of several actual units.

Discussions were held with personnel from the Physical Metallurgy Operation concerning electronic circuitry for a stored energy calorimeter to be used for metals testing. A system design for the desired instrumentation may be started in July.

Modifications were recommended for the PRTR Fuel Failure Monitor. The detailed suggested modifications include reorienting the scanning rate control, changing the alarm reset circuit, extensive cable termination changes, changing the recorder level and reference to reduce drift which is an appreciable problem, and installing circuits and indicators to show the actual position of input and output channel sorting switches at all times. The last change will materially accelerate the checkout and test procedures by proper identification which is now impossible.

The $BF_3$ detectors used in the PRTR Critical Tests are being recalibrated in the standard pile. These detectors were calibrated before the tests in the same standard pile. The changes in calibration will be used to correct the vertical traverse data. Preliminary analysis indicates the relative sensitivity between detectors has not changed greatly.

The radiation resistant "O" rings were installed on the PRTR process tube inside diameter measuring probe and the variable differential transformer shafts subjected to a leak test. A leak found around one of the four shafts was corrected by replacing the shaft with another, less scarred. The data from one pair of transducers were made unreliable when an irregularity in the joint between the tube extension and a process tube caught and bent a transducer shaft. The damaged part is to be replaced.

The first operational inspection of the PRTR process tube assemblies was performed May 21, 1961. Four tubes were inspected during the operation and early indications are that the performance of the Gas Annulus Gauge was satisfactory. The instruction manual for the Gas Annulus Gauge has been completed and issued as HW-69264. This manual is intended to supplement the Magnatest FW-400 operating manual and contains a functional description of all modifications and additions to the original equipment, in addition to a discussion of recommended

alignment and operating procedures.

Further testing of the new ultrasonic transducers, purchased for measuring the wall thickness of the PRTR process tubes, indicates that acoustic coupling problems, previously encountered, are almost nonexistent with transducers having active surface areas of approximately 1.0 x 0.5 inches. However, Structural Materials Operation advises that further consideration of the problem has resulted in a decision to reduce the active area of the transducers to a maximum of 0.0625 $inch^2$, thus reducing the tube wall under inspection to approximately the same area. A small inspection area is considered essential for correlating the inside diameter and wall thickness data to produce information for determining the magnitude of metallurgical "creep" the Zircaloy-2 process tubes may exhibit.

The recording of PRTR neutron flux obtained last month has been analyzed in an attempt to determine the PRTR prompt neutron lifetime. It was found that a large extraneous signal was present in the recorded signal, tending to obscure the desired information. It is expected that at least part of the extraneous signal resulted from moderator level oscillations observed during the test. However, further testing will be required to isolate this source of trouble. The new ion chamber fabricated for this test is efficient enough to define the corner frequency (break) due to neutron lifetime. It is expected that a better measurement will be obtained when closer control of moderator level can be maintained. The value of $\beta/\ell$ indicated by the test was estimated to be 6.5. The calculated value is 7.3. Due to the extraneous noise signal, it is doubtful that the accuracy of the experimental value is better than ± 20%. Further tests are planned after completion of the power tests.

The alternate method of obtaining the "noise" signal, from the output of a proportional counter-count rate meter combination, yielded results which are encouraging. The low frequency end of the frequency response curve nearly matched that of the curve obtained with the ion chamber. However, the high frequency (lower amplitude) portion of the curve was masked by the "detection noise" signal generated within the counter. This effect was expected since the available equipment was not capable of handling high counting rates. It does appear that the method can be used, however, if a high speed counting system is obtained. The maximum count rate used during the test was approximately 7.5 million counts per minute.

The PRTR Gas Balance System Simulation is in progress. Under certain operating conditions, the enclosed gas system may become oscillatory. The gas pressure oscillation will in turn cause an oscillation in the moderator level and consequently, a power level oscillation. This study was initiated in an attempt to determine the necessary system changes to eliminate the possibility of oscillation. The preliminary work has been completed and the problem is ready to go on the analog computer as soon as sufficient time is available.

NEUTRON FLUX MONITORS

Preliminary investigations show the graphite moderator temperature is nearly constant for a given lattice cell and tends to follow, with an approximate one-hour delay, the neutron flux in a unique manner over a localized in-core region. The correlation holds for a particular coolant gas composition, and

since such compositions are recorded for HAPO reactors, particular flux-versus-temperature curves can be selected for use. This selected pattern, combined with fission cross sections for $Pu^{239-241}$ which are monotonically increasing with neutron temperature, can show that the macroscopic fission cross section for various neutron temperatures can be made constant over large flux-time intervals by detector material choice. In addition, the pattern shows that the epithermal neutron ratio tends to be constant in the graphite. The foregoing relationships have led to an idea for a nonlinear, easily calibrated, in-core flux monitor.

The proposed monitor would have immediate response to neutron density changes and a slow transient response, delayed about one hour, to gradual effective neutron temperature shifts of the graphite due to neutron density and gamma level changes. The composite equilibrium response should then correspond to a unique flux level.

It is thought that a neutron detector measuring neutron flux may be preferable to one measuring only neutron density. The local flux would seem a better measure of local power than would neutron density, since the reactor fuel does not have a 1/v cross section dependence in general.

It appears that control rod effects on the flux-versus-temperature correlations can be considered as neutron point "sinks". In this case, the rods affect neutron density to cause flux and graphite temperature changes. It is believed that the equilibrium graphite temperature attained due to rod repositioning will lie on the same flux-versus-graphite temperature plot valid before rod movement.

The Westcott thermal neutron cross sections for $Pu^{239-240-241}$ monotonically increase with neutron temperature and increase in a nearly linear fashion from 200° C to 700° C. The foregoing effects permit selection of a suitable Pu isotope composition for a constant sensitivity detector in a neutron spectrum with constant epithermal neutron ratio over a range of effective neutron temperatures for some time interval. The time interval depends on the average neutron temperature and the epithermal neutron ratio. A particular $U^{238}$-Pu isotope composition was earlier determined to show a nearly constant neutron sensitivity for neutron temperatures from 425° C to 625° C.

The approximate proportionality of $Pu^{239-240-241}$ neutron cross sections has permitted a mathematical search for an optimum detector based on the least sensitivity variation, the highest possible sensitivity, and longest lifetime. The established formulation is being programmed for use in a computer search.

## NONDESTRUCTIVE TESTING RESEARCH

### Electromagnetic Testing

Analysis of data obtained using the broadband eddy current testing equipment in tests of a mockup unbonded fuel element has shown a need for more definitive data. Mathematical analysis of the data by Operations Research and Synthesis Operation has revealed no pattern on which the design of individual parameter readout transforming circuits may be based. This is believed to be a result of lack of inherent resolving potential in the data due to experimental conditions

rather than a basic limitation in the general method of approach.

New data for this type of analysis are being obtained using an approximate equivalent electrical circuit representing a laminated metal structure which can be adjusted over a wide range of variables. The circuit includes five inductively coupled secondary coils with provision for individual resistance loading to simulate different metal layer electrical conductivities.

Problems concerned with multiple parameter readout have much in common with those encountered in the control of multi-variable systems. The extent to which multi-variable control theory can be applied to the multiple parameter readout problem is being explored.

A further review of the literature of signal analysis was made and a working bibliography in this field is being expanded.

The two delay lines for use in the segmental time reversal device to be used in analyzing the broadband eddy current signals were received, but the manufacturer had inadvertently omitted the 100 taps on each filter. The filters were returned to the factory for tapping.

An inductive (eddy current) thermometer was fabricated for use in the heat transfer tests to make the prototype available for further development use. It is desired to make modifications in the prototype to improve stability of the direct current readout, and to increase the accuracy of the automatic probe temperature control feature.

A high amperage pulsed current source using a type 6587 hydrogen thyratron tube was assembled for use in the laboratory in broadband eddy current tests and generation of ultrasound. Pulsed eddy current driver currents of 150 amperes peak and one microsecond duration have been obtained using this current source. The new pulser and other improvements will result in a 100-fold increase in sensitivity over that obtained with previous test arrangements.

Heat Transfer Testing

Heat transfer tests on Zircaloy-clad uranium fuel elements, containing 1/8-, 1/4-, 3/8-, and 1/2-inch-diameter manufactured heat transfer defects in the fuel core-to-jacket bonds, showed that present heat transfer testing equipment is capable of detecting defects down to 1/8 inch in diameter. Natural heat transfer defects have also been detected in the bonds near the ends of several Zircaloy-clad fuel elements. However, no heat transfer defect could be detected in the region of a large ultrasonic defect in the bond of one of these fuel elements. This indicates the jacket and core were in close contact, but not bonded. Tests on the welds of "suitcase handle" type self supports on both Zircaloy and aluminum clad fuel elements showed no general correlation between weld strength and heat transfer characteristics.

Heat transfer test standards were fabricated by removing 1/8-, 1/4-, 3/8-, and 1/2-inch-diameter sections of jacket from a Zircaloy-clad uranium fuel element. The uranium under the circular holes thus produced in the jacket was relieved 0.005 inch, a mica disk placed in the relief, and the circular sections of jacket electron-beam-welded back into place. Subsequent tests indicate that

heat transfer through the welds is as good as through the original jacket. However, the welds will be destructively examined when a standard can be spared for this purpose. Heat transfer tests using a radiometer and plasma arc heat source on the Zircaloy-clad standards indicate that 1/8-inch-diameter defects can be detected in the bonds of zirconium-clad fuel elements, whereas 3/8-inch-diameter defects are the smallest reliably detected in aluminum-clad uranium fuel elements thus far. Natural bond defects near the ends of several Zircaloy fuel elements occurred due to brazing. Heat transfer tests clearly indicated discontinuities due to these defects. Further tests of Zircaloy-clad fuel elements indicated, just as in aluminum-clad uranium pieces, that ultrasonic bond discontinuties do not always indicate a heat transfer defect. No heat transfer defects could be found in a Zircaloy-clad uranium fuel element which was shown to have a large ultrasonic bond defect. Since a lack of contact would be almost as effective in preventing heat flow at the low test temperature as the mica in the standards, the core must have been in contact with the jacket over the ultrasonic defect.

Welds of "suitcase handle" type self supports on both aluminum- and Zircaloy-clad fuel elements were heat transfer tested. Self supports on the aluminum-clad elements were then destructively tested in an Instron tensile tester to determine weld strengths. Although many of the welds showing poorest heat transfer characteristics were ring welds, there was no general correlation of heat transfer to strength. It was not possible to destructively test self-supports on the Zircaloy-clad element, but welds supposed to be defective on the basis of preparation showed no general trends in heat transfer qualities.

Zirconium Hydride Detection

The feasibility of applying the Hall Effect to the measurement of hydrogen concentration in Zircaloy-2 samples is being investigated. Hall voltage measurements were made on four samples having hydrogen concentrations from 0 to 1000 ppm. The measurements indicated that improvements were needed in the sample holders and in the method of attaching the Hall leads to the sample. Co-axial sample holders and spot welded electrical connections have been developed and found to reduce stray signals to an acceptable level. An oscillating detector has been fabricated to test the feasibility of using nuclear magnetic resonance for hydrogen detection.

Initial sample holders for the Hall voltage measurements consisted of Micarta blocks. Electrical contact to the sample was made with carbon steel probes pressed into the sample under pressure. The point contacts were found to be unreliable and spot welded contacts were tried and shown to work satisfactorily. The heat developed during the welding is sufficiently localized and of short duration that it does not significantly alter the concentration or distribution of the hydrogen in the sample.

The major portion of the spurious signal is due to the sample current inducing a voltage into the Hall voltage loop. This voltage is field dependent only when there is relative motion between the high current carrying leads and the Hall leads. Two methods of reducing these spurious voltages are to minimize the amplitude of vibration of the current carrying leads by rigid sample holder construction and by reducing the area enclosed by the loops themselves.

The Hall leads were firmly taped to the sample and the complete sample then enclosed in copper. The copper serves as the return path for the sample current and as an effective electrostatic shield. Thus both loops are minimized. The Hall leads are offered some degree of rigidity by the tape.

This method of holding the sample was utilized to measure the Hall voltage of a commercial quality copper sample. The Hall coefficient agreed to within 20 percent with published values for high purity copper.

The Hall voltage of a Zircaloy sample of unknown hydrogen content was measured using this technique for holding the sample. The Hall voltage-to-spurious noise ratio was better than ten with a magnetic field of 1.5 kilogauss.

Current leads have been welded on eight standard Zircaloy-2 samples and they are being prepared for Hall voltage measurements.

## PHYSICAL RESEARCH - 05 PROGRAM

### Mechanism of Graphite Damage

Measurements were begun of the change in resistance of NPR graphite irradiated with 2 Mev electrons at liquid nitrogen temperatures. Reproducible and accurately measurable results were obtained. It was found that the radiation damage could be removed (to within 0.2%) by annealing the graphite at about 150°C.

It was found that thermocouples were unsuitable as temperature monitors for the graphite at liquid nitrogen temperatures. Some thermistors were obtained that proved adequate for this purpose.

It was observed that liquid nitrogen irradiated in the Van de Graaff beam turned blue. It was concluded that the blue substance was ozone produced by irradiation of dissolved oxygen present in the liquid nitrogen.

## BIOLOGY AND MEDICINE - 06 PROGRAM

## ENVIRONMENTAL SCIENCES

### Atmospheric Physics

Two additional diffusion experiments were successfully completed at Hanford during the month, bringing the totals of the year to eleven successes in fifteen trials. Both experiments were conducted during unstable vertical temperature gradients in the lower levels of the atmosphere, utilizing a source near ground level with dosage measurements on both the horizontal and vertical sampling grids to a distance of 3200 meters. During one experiment, a temperature inversion existed above the 200-foot level on the meteorological tower, providing our first measurements of dispersion conditions under a low-level "capping inversion" at Hanford.

A second series of comparative turbulence measurements between the sonic anemometer developed at the University of Washington and the wind component meter developed at Hanford was completed. Comparison of calculations of mean square vertical velocity fluctuations over a three-minute period showed that the

wind component meter gave about four times the value computed from the sonic anemometer record. This difference is believed to arise from the combined effects of instrument response time and space average, the component meter providing the faster response and smaller space average thus measuring the turbulence to much higher wave numbers.

In Air Force-supported programs, diffusion experiments at Cape Canaveral, Florida, were started on May 15 as scheduled. Pan American Airway's field operating forces were fully trained by General Electric personnel during the previous week and scheduling procedures established with Range Supervisory Operations for the Atlantic Missile Range. By month end, eleven experiments had been completed, utilizing a source near ground level with dosage measurements made on a horizontal sampling grid to a distance of 1.5 miles. Operations were curtailed for four days when a high pressure area off southern Florida caused adverse winds over the test area. Samples collected during the first eight experiments were received on-site and assayed for tracer loadings. Moderate loadings of dust and engine exhaust were noted on some samples.

Preparations for startup of diffusion experiments at Vandenberg Air Force Base, California, progressed satisfactorily with shipment of all items to be furnished by Atmospheric Physics Operation completed.

Dosimetry

The chair in which subjects sit while being counted at the whole body counter was removed from the cell. A scanning counter placed beneath a bed was put up in its place. The purpose is to acquire data to see if this method of scanning can be substituted for our present method of counting. The counter used in the P-32 measurements was mounted so that it can be placed over the subject's chest while the scanning count is taking place. The data obtained from this counter will serve to establish normal backgrounds for use in P-32 counting. It was observed that considerable variation in this background occurs from one subject to another. When sufficient data are obtained we will try to correlate these variations with measured body burdens of other radioisotopes.

A shadow shield counter made of lead bricks was prepared. The total weight is about five tons. A moving bed was prepared so that scanning counts could be taken in the shield. This counter will be used on human subjects to accumulate data that will permit evaluation of its usefulness.

Studies of P-32 in human subjects continued. Redistribution of the P-32 in the body was still observed. It now appears, however, that errors resulting from ignoring this redistribution will be smaller than the errors due to variation in background between individuals.

In three recent cases of inhalation of Zn-65 it was observed that the initial elimination of the Zn-65 was more rapid than when the isotope was ingested. One subject lost 68% of his initial burden during the first two days and after one week had only 15% of his initial burden. Another subject showed an initial high elimination although he still had 40% after two weeks. Another subject had lost 83% of his initial burden within five days.

Radiation Protection Operation was assisted in the identification and measurement of radioisotopes in four employees involved in a contamination incident

and in preparing data for their report on results obtained with the whole body counter during 1960. During examination of the four employees an isotope emitting a 0.51 Mev gamma ray was observed. Its half-life was less than twelve hours. It was not identified.

The positive ion Van de Graaff operated satisfactorily during the month.

Studies were begun of a $Li^6I$ neutron spectrometer. Performance at room temperature was satisfactory though not good enough for spectrometry. Preparations for cooling with liquid nitrogen are in progress.

Preparations were made to use the large moderator fabricated last month for measurements of neutron emission from plutonium samples. Radiological Development Operation is developing the use of the moderator for neutron activation studies. A water cooled thick beryllium target was prepared for this purpose.

As part of the program to raise the Van de Graaff operating voltage for use during studies of alpha-neutron reactions the accelerator tank was filled with a mixture of $SF_6$ and $N_2$. This improved the insulation sufficiently that the machine operated at 2.5 MV for about one-half hour with no sparking.

While waiting for the Sb-124 neutron source to be activated studies were made to still further improve the sensitivity of the gamma ray calorimeter. The sensitivity is already sufficient for the Sb-124 measurements. The improvements were aimed at future use. It was found that about another order of magnitude increase and sensitivity can be achieved if small drifts in the resistors of the Wheatstone bridge can be eliminated.

Instrumentation

Final prototype fabrication is nearing completion on the experimental scintillation airborne plutonium monitor using coincident counting techniques. All circuitry, except for final readout, is transistorized. The readout circuit was completed in development and uses a magnetic amplifier to drive a 20-0-20 microamp meter. More data are required to establish the minimum detection levels versus time of detector exposure. The final tests must be conducted during extreme temperature inversions to determine the radon-thoron rejection ability. The complete control chassis is fabricated and tested. Final fabrication to be done concerns the phototube control chassis.

The contacting fiber plus ionization chamber approach to the pocket-size alarming dosimeter problem was temporarily shelved. Although the idea was sound and the circuit performed correctly for short-term use, the leakage problems proved to be extremely difficult to correct to permit long-term use without error.

The automatic recharge approach idea for an ionization chamber for use in the pocket alarming dosimeters continues to show excellent promise. As adjusted in benchboard form, the chamber produces an output pulse, independent of supply voltage changes of ± 50%, for each 10 to 12 mr of dose received. Because of the stated independence, a charged Mylar (very low leakage) capacitor can be used as the recharge voltage supply. A special miniature amplifier was developed to amplify the chamber-produced pulse to drive a miniature register.

The system operated satisfactorily in benchboard form for the month, and fabrication was started on a miniature prototype. As an added point, the chamber-produced pulse can, and will later, be used to pulse a miniature transmitter to send accumulated dose information to a central station. This system shows excellent promise.

All transistorized circuitry, assembled in prototype form, has been satisfactorily tested for the pocket alarming dosimeter using a photocell light-readout from a modified (illuminated fiber) self-reading pencil dosimeter. For completion of the prototype, the photocell must be more ruggedly mounted on a new pencil dosimeter.

Investigations were completed concerning an ion generator used for small animal experiments at the Biology Operation. Measurements were made of the ion concentrations available and of the proper methods for utilizing the equipment in the experiments.

Investigations concerning airborne tritium detection, using scintillation methods and a difference current from two phototubes, indicated that noise level considerations and lack of available sensitivity at the airborne tritium levels of interest would prevent proper operation. Other approaches are being considered.

Continued progress was made on the Automatic Film Badge Densitometer System and all necessary fabricated circuits have been received and installed for a complete system test. Only a few cables remain to be fabricated and some minor trouble-locating completed before the final system tests can commence.

A preamplifier was developed and is being tested for use in the communications portion of the pocket-dosimeter-to-central-station radio link for the integrated monitoring program.

Continued progress was made in the experimental fabrication of developmental surface barrier silicon solid-state detectors. A new technique of fabrication was attempted; however, it proved much less satisfactory than the previously established technique. Two neutron-sensitive units were obtained for further studies.

Reproducibility of thermoluminescent dosimeters has nearly been attained. The problem remains of obtaining constant coupling between the dosimeter metal holder and the work coil of the induction heater. This hinges upon the placement of the dosimeter into the work coil. At present, the actual dosimeter uses two 0.020-inch-thick, 0.25-inch-diameter iron or Kovar discs separated by 0.080 inch of Hevimet. The phosphor ($CaF_2$:Mn) is coated on the discs and the complete unit is Pyrex glass encapsulated in a helium atmosphere. A peaking factor of 5:1 is obtained at 70 Kev for the exposed side of the unit; whereas, the unexposed side shows a complementary (inverse) peaking effect. Dual phototubes and electronic circuitry readout methods will be used in an attempt to average the two effects to produce gamma energy independence to ± 10% down to less than 20 Kev for $2\pi$ geometry.

The experimental beta-gamma scintillation transistorized Checkout Station Monitor is approximately 75% completed in prototype form. This unit incorporates beta-gamma hand and shoe counting, a cabled probe aural clothing counter, a general area monitor, and a background suppression scheme all into one monitor.

Assembly was just started on the new inexpensive probes for the experimental scintillation transistorized combination Alpha-Beta-Gamma Hand and Shoe Counter. New probes were designed to reduce the over-all instrument cost by nearly $1000 while actually improving the detection sensitivity and probe response uniformity.

## WASHINGTON DESIGNATED PROGRAM

### Isotopic Analysis

The mass spectrometer for this program provided isotopic analyses of program samples during the month. An instrumental malfunction was discovered early in the month which was traced to a non-linear response of the electron multiplier. A near optimum mode of operation of the multiplier was found which reduced the nonlinearity of response to about 0.5 percent for a current ratio of one hundred to one. This systematic nonlinearity has required that one standard sample be analyzed for each unknown sample analysis in order to estimate the bias of the sample analysis.

## TEST REACTOR OPERATIONS

Lutetium cadmium ratios were measured in the thermal column of the TTR to obtain data for epithermal corrections to the neutron temperatures that have been measured previously inside fuel elements.

One unscheduled TTR shutdown occurred, which was caused by instrument failure.

The PCTR operated throughout the month mostly on a two-shift basis. Two unscheduled shutdowns occurred, one as a result of incorrect instrument bypassing and the other caused by electronic failure. Final adjustment of the front face rails was made, but reactivity reproducibility was not up to standard. It is believed that this is a result of the lifting of the face and removal and reinstallation of the rails that was required for plutonium decontamination.

The plutonium-aluminum fuel in 6½-inch graphite lattice experiment was completed, and the plutonium nitrate solution experiment was started. The nuclearly safe concentration in infinite volume is being determined. Using PCTR techniques 200 liters are required as contrasted with 3000 liters for the infinite critical assembly method. Base concentration is 11.4 gm/liter. All solution is contained in double canned and welded stainless steel tanks. There has been no contamination.

Revision of the PCTR manual was started. Sections B, C, D, E, and G of HW-69714 were issued covering Operating Standards, Operating Procedures, Check Sheets, Temporary Revisions to Safety and Interlock Circuits, and Radiation Work Procedures.

## CUSTOMER WORK

### Weather Forecasting and Meteorological Service

Consultation service was rendered on meteorological and climatological aspects of 1) shipping of radioactive materials, 2) fission product releases from process and laboratory buildings, 3) siting of Civil Defense Emergency Relocation Center,

and 4) ozone release from process vents.

The last in a series of three scheduled reports on prospective 1961 crests of the Columbia River flow at Hanford was issued in Mid-May. Abundant precipitation in the portion of the Columbia River watershed affecting Hanford Works was noted during April and early May, much of which has accumulated as snow at high elevations. Slight upward revision in the forecast was required.

| | | 1961 Forecast | 1960 Observed |
|---|---|---|---|
| Peak flow (units of $10^3$ CFS) | | 400-470 | 311.4 |
| Peak stage (feet MSL) at: | 100-B | 406-409 | 403.4 |
| | 100-K | 401-404 | 397.7 |
| | 100-D | 395-397 | 392.2 |
| | 100-H | 387-390 | 384.0 |
| | 100-F | 382-385 | 378.8 |
| | Richland | 349-353 | 346.5 |

Since extremes of weather could alter the predictions given above, short-range forecasts will continue to be included on tape-recorded messages (telephone 2-7888).

Meteorological services, viz., weather forecasts, observations and climatological services were provided on a routine basis.

| Type of Forecast | Number Made | % Reliability |
|---|---|---|
| 8-Hour Production | 93 | 83.8 |
| 24-Hour General | 62 | 80.9 |
| Special | 165 | 86.1 |

Temperatures averaged well below normal during May and precipitation totaled well above. A highlight was the occurrence of a rather severe storm to climax the 25th, one of the month's few warm days.

Instrumentation and Systems Studies

The transistorized scintillation beta-gamma prototype air monitor, using a moving tape filter, operated satisfactorily for the month in the 327 Building.

Testing of the electronic circuitry is nearly complete for the combined Alpha-Beta-Gamma Cell Exhaust Monitor for Chemical Research Operation, 325-A Building. The mechanical portions of the detector head were received and are being assembled. Complete system tests should start in two weeks.

One of the two High Level Alpha Air Monitors from 231-Z was returned to the field and it operated satisfactorily for the month. Several replacement parts for the second unit were ordered but have not been received yet.

A majority of the electronic design was completed for the experimental conveyor-system Alpha-Beta-Gamma Laundry Monitor. All necessary commercial components have been ordered and fabrication was started, onsite, on the 25 printed circuit boards for the system. One experimental 12-inch-by-12-inch effective-area alpha

probe was assembled and tested.

At the request of the Biology Operation, a new, specially-machined, terphenyl-in-polyvinyltoluene detector will be fabricated for use in $Ca^{45}$ uptake studies in fish. The original detector, which performed quite satisfactorily for nearly a year, was damaged by cleaning solvents.

The $Pu^{239}$ Wound Monitor System, for detecting imbedded $Pu^{239}$ in wounds using detection of the 17-Kev X-rays, was modified for personnel at the Medical Building, 200 West Area. A new combination amplifier and pulse height analyzer was received to replace the old commercial units originally used. Tests indicate that easy detection of less than seven millimicrograms of $Pu^{239}$ can be obtained. The system is ready for reinstallation and use.

Fabrication, in the 328 Electronics Shop, was accelerated on the special sensitive scintillation Beta-Gamma Portable Field Monitor designed for the Biology Operation. The transistorized instrument employs a single channel pulse height analyzer, a low-power scaler system, a multi-range count rate meter, an amplifier, a high voltage supply, and a rechargeable battery.

Calibration of micro-displacement readout systems, to be used by Physical Metallurgy for in-reactor creep measurements, has continued during May. The final calibration runs on the Schaevitz DRS-100 were completed this month and the data forwarded to the Experimental Statistics Operation to be analyzed. During the final calibration run, the transducer being evaluated developed an extremely high secondary winding resistance resulting in erratic system performance. When this transducer was replaced by the space, it was also found inoperable due to a mechanical failure of an internal lead connection. Since only two transducers were supplied with the DRS-100, the system is now totally inoperable. In an effort to improve the over-all precision of the reference system, minor modifications have been made, and a re-calibration performed to determine the degree of improvement. A preliminary analysis indicates the precision of the 0.004-inch range is of the order of ± 0.000005 inch (this is within the precision of the standard used), and the precision of the 0.30-inch scale is 0.00015 inch or better. The reference system has now been converted for the calibration of a Physical Science three-range Electromicrometer system. Calibration of this system is expected to begin during June.

Development is nearing completion on the Panellit-Heise gage readout device for 105-DR. Originally the device was to consist of one hand-held gage readout box in back for the Heise gage, and one in the front of the panel for the Panellit readings. Information was to be punched on a tape and typed by an electric typewriter. Requirements have been changed and the present device will consist of three hand-held gage readout boxes in the front of the panel, one for each panel. The Heise gage information will, as before, be transmitted to the front of the panel by telephone. An adding machine-tape punch will provide a base computation feature by subtracting the Panellit reading from the Heise reading. Disadvantages of this system include a long, hard-to-handle adding machine tape readout. The device will probably not save any time in the actual gage readout procedure, but it will save time between the control room and the 7090 data processor. It should eliminate the card punching procedure at the 7090 and the manual typing in the control room. A breadboard model of the entire instrument is nearly complete and is operating satisfactorily with one gage-readout box. All major components have been received except for the adding machine. Fabrication

of the finished instrument will start in the near future.

The Hazards Analysis for the EGCR (Experimental Gas-Cooled Reactor) was completed. The analysis consisted of a study of a loss of coolant accident. If the gas coolant is lost under operating conditions, and air admitted to the coolant annulus around the fuel element, the surface of the graphite will burn. A mockup of this system has been built using Calrod electric heaters to simulate the heat produced by the operating reactor. This study was designed to determine the operating parameters of the Calrod heaters.

Physical Testing

A total of 15,131 tests were made; about half of these were occasioned by the start of conditioning of NPR pressure tubes where many individual re-penetrant tests and local ultrasonic wall thickness measurements must be made. The number of pieces handled this month totaled 4,990 items. The length of material represented by these items amounted to 139,897 feet; the greater part, about 22½ miles, was NPR pressure tubing. Test work included: autoclaving; borescoping; dimensional measurements (micrometric); eddy current; leak detection; magnetic particle; penetrant (contrast and fluorescent O.D. and I.D.); radiography (autoradiography, gamma-ray, and X-ray); stress analysis; surface treatment (alkaline cleaning, pickling for autoclaving and conditioning, steam detergent cleaning, ultrasonic cleaning, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements). Work was done for 23 organizational components representing most of the operating departments and service organizations at HAPO. Advice was given on 40 different occasions on general testing theory and applications.

High production rates are being achieved in the testing and treatment of NPR pressure tubes. Work is being scheduled on a six-day week and additional temporary technologists have been added. As a result of the increased activity, there have been an increasing number of mechanical failures but the work is proceeding routinely. Tooling up has been completed by Kaiser Engineers for conditioning of the O.D. and the I.D. of the pressure tubes. This work is now in full progress and many of the development order tubes are being reclaimed. All of this work involves the removal of metal where there is evidence of a surface discontinuity giving rise to a fluorescent penetrant or ultrasonic indication. The work is affording an excellent opportunity to substantiate fluorescent penetrant and ultrasonic indications. The great majority of the indications are being removed within between three and five mils of the surface. There have been one or two surface discontinuities that have been opened up into defects of considerable depth; on the order of 20 to 30 mils. Examination of the ultrasonic traces of these tubes has not indicated a condition of a serious magnitude. The reason for failure of the ultrasonic test in these instances is being investigated. One of the methods that will be used for more complete examination will be to find optimum testing angles wherever indications are received. Pickling and autoclaving of the tubes is proceeding routinely and good results are being obtained in achieving uniform autoclave film.

The fluorescent penetrant examination of nozzles for the reactor nozzle modification program for bumper fuel elements is proceeding routinely. Follow-up work on the 1706 KER Loop pipe failures has been established on a systematic basis and routine period checks are now being made. Special assistance was given in recommending radiographic acceptance specifications for structural welds on the

west elevator for the 105 N Building. Field radiographs were made and evaluated on the basis of the recommended specification. A leak survey was made of propane lines in the 1706 KE Building utilizing the portable leak testing equipment. A number of pump impellers for the 190 Buildings in the reactor areas were examined radiographically for internal discontinuities. The blades and supporting structures are being examined. The impellers are about two feet in diameter and because of their intricate shape represent a challenging problem. A number of other unusual jobs were encountered including examination of steam line hangers, electric cables, and crane accessories including hooks, shackles and bolts.

The Zircaloy fuel element sheath tube inventory has been completely worked off and major effort is being devoted to various development programs. The special ultrasonic test instrumentation to provide for individual pulse measurement and recording is due to arrive in mid-July. A statistical study of the fluorescent penetrant test was initiated in conjunction with Structural Materials and will follow a formalized statistical plan.

Considerable progress has been made in the evaluation of the eddy current test for application to sheath tubes. The Zircaloy tubing samples which have electromachined notches have all been completed. The notches have been measured for length, width, and depth. Eddy current tests, using the Metrol Radac Unit, indicated that sensitivity is adequate for detecting notches which are about 0.375 inch long, 0.004 inch wide, and 0.010 inch deep. These detectable notches are located both in the O.D. and I.D. of the tubes. They are oriented parallel, perpendicular, and at 45 degrees to the tube axis, and the notch lengths follow the contour of the tube wall. Wall thinning and hole defects were also tested. Ten percent O.D. and I.D. wall thinning is easily detectable with the Radac. A hole about 0.010 inch in diameter extending through the wall, and perpendicular to it, is detectable. The Radac is capable of reliably detecting defects smaller than those mentioned above, depending on their orientation and location. Also, the Radac can be adjusted with higher sensitivity for detecting specific types of defects. All the above defects were detected at one setting of gain, balance, etc. The intentions are to use these settings for initial tests on production tubing.

Magnaflux reported they may have an eddy current test which has a chance of detecting cracks in reactor Parker fittings. However, they have not demonstrated the tester on simulated cracks and have proposed that we do further development work to determine the feasibility for detecting actual cracks. Procurement of their equipment is being investigated.

In view of the favorable results previously obtained by ultrasonic tests on Parker fittings, IPD has requested the work be continued. Some investigation at ultrasonic frequencies less than 25 megacycles has been done using a number of transducer types. So far the fabricated defects cannot be detected at these lower frequencies. The only adaptable and readily available 25 megacycle equipment is the Curtiss-Wright Immerscope. Since all of the on-site Immerscopes are in use, steps have been made to lease a unit, and lacking this, development work will be initiated for on-site construction of a special purpose instrument.

Cracks are occurring in the inside of KER piping. These cracks are believed to be caused by stress corrosion and/or high mechanical stresses. IPD has requested a test be developed which will detect the presence of these internal

cracks as early as possible. A good section of this pipe was defected by electro-machining three notches. The notches are about ½ inch long, about one-third of the way through the pipe wall, and criented traversely longitudinally, and at 45 degrees to the pipe axis. Attempts to detect these notches with eddy currents were unsuccessful. Eddy current frequencies from 3 KC to about 20 KC using pancake type probes were used. Many strong eddy current signals were found in apparently defect-free areas of the pipe. These signals must be surpassed before adequate sensitivity for detecting cracks can be obtained. Suppression of these signals is possible but very difficult. The feasibility of detecting these cracks ultrasonically will be examined.

Nested tubular fuel elements are being considered as PRTR candidates. These elements are self-supported with full length ribs. The ribs are resistance welded to the fuel element walls. Good weld bonds are desirable. Ceramic Fuels has requested the development of a nondestructive test which will detect unbonds in the welds. Since many types of unbonds are detectable with ultrasonic techniques, these were given first consideration for rib bonding testing. A standard was prepared with variable amounts of bonded rib. One standard had about ¼ inch of rib totally unbonded. Partially bonded ribs were also prepared. These were all about ½ inch long and ranged from about 20% to 60% unbond. Ten megacycles ultrasonic energy was coupled into the rib normal to the tube axis. Reflections from the rib surface and the inside surface of the wall were clearly visible. A decrease in signal from the inside wall should then be an indication of unbond. All the prepared unbonds discussed above were detectable. In view of the successful initial testing results above, three full length tubes with resistance welded ribs will be tested for unbond.

Optics

Fabrication of the first developmental model traversing mechanism has been completed. This unit will be used to determine the contour of channels in the NPR. Two wooden test channels have been received from the carpenters. One has smooth, continuous bends with the maximum radius of curvature that can be expected in a workable reactor. The other has step discontinuities. The traversing mechanism has been attached to a standard borescope. Test runs have shown that the mechanical action of the unit is very good. Readings are repeatable to within 0.005 inch per eight inches of length. Several alternate optical arrangements are possible. One arrangement is insensitive to step discontinuities but measures angular displacement. A second arrangement is insensitive to angular displacements but is sensitive to step discontinuities.

Contrary to what was stated in the last of three memos written on the traversing mechanism, no optical arrangement appears feasible for simultaneously reading out both angular displacements and step discontinuities. This means that where there are likely to be both types of displacements, two measurement runs will be required per channel. In process tubes, where no discontinuities are expected, one run will be sufficient.

A work order has been received to cover the fabrication of a developmental model Process Tube Traversing Mechanism for use in older reactors, shop testing, assistance in field testing, and further investigation of automatic readout methods. The fabrication of this unit has just begun.

A total of 480 manhours' shop work was performed during the four-week period

(April 30 to May 28) included in this report. The work included:

1. Fabrication of the first developmental model NPR traversing mechanism.
2. Coating of 29 lamps with stainless steel for use in inspecting NPR process tubes at White Bluffs.
3. Lapping of six pump seals.
4. Evaporation of beryllium in the preparation of targets for the Van de Graaff accelerator.
5. Fabrication of two quartz heater cores.
6. Repair of one microscope.
7. Repair of two camera shutters.
8. Evaporation of gold in the preparation of eight silicon diodes.
9. Fabrication of five filter units for black light inspection with a borescope.
10. Preparation of thermoluminescent material.
11. Fabrication of four pyrometer filters.
12. Fabrication of a lens mount and adapters.

## Analog Computer Facility Operation

The major analog computer problems considered during May include:

1. NPR Power Conversion.
2. NPR Confiner Pressure.
3. Reactor Speed of Control.
4. Hazards Analysis for EGCR.

The computer operation was as follows:

| GEDA | | EASE | |
|---|---|---|---|
| 146 | hours up | 146 | hours up |
| 21 | hours scheduled downtime | 21 | hours scheduled downtime |
| 1 | hour unscheduled downtime | 1 | hour unscheduled downtime |
| 0 | hours idle | 0 | hours idle |
| 168 | hours total | 168 | hours total |

## Instrument Evaluation

Recycling tests continued on a rechargeable Ni-Cd battery (12 VDC at 250 ma-hr capacity). Sixteen recycle charge-discharge tests have been completed including several to complete discharge. No damage has been noted to date.

Evaluation tests continued on two prototype portable transistorized Scintillation Dose Rate Meters.

Extensive evaluation testing was done, simultaneously with circuitry development improvements, on the two transistorized Log-Linear Scintillation Area Monitors. Linear range reading accuracies are within ± 5% for all ranges (decaded) from 0-5 mr/hr to 0-5 r/hr on one unit and from 0-10 mr/hr to 0-10 r/hr on the second unit. The two units have different ranges, since HAPO applications would typically require such ranges. Log scale accuracies are about ± 20% from above 20 mr/hr to full scale of 5 r/hr and 10 r/hr respectively. All errors on the Log scale below about 20 mr/hr are positive on the safe side. The lower end of the Log scale is purposely compressed in a positive reading direction to permit obtaining meter readings down to the 1 mr/hr to 3 mr/hr levels while retaining

the high end limits of 5 r/hr and 10 r/hr respectively for the two prototype units. Line voltage variations from 105 VAC to 130 VAC produced less than ± 5% reading error on any range, either log or linear. Initial temperature tests were commenced and readings errors were less than ± 5% from 75°F to 135° F for the complete unit including probe.

Corrective measures were taken on the twelve portable Sentinel Alarming Monitors for use on the reactor elevators. The two ranges finally agreed to were 0-200 mr/hr and 0-2000 mr/hr. The use of RCA 6655-A phototubes and 2- x 2-inch terphenyl-in-polyvinyltoluene detectors solved the problem. The units have an adjustable alarm device to cover any point on both ranges.

All acceptance tests were completed on seventy-five 50-r, seventy-five 10-r, and one hundred 200-mr pencil dosimeters. Five 50-r, seventeen 10-r, and twenty-eight 200-mr dosimeters were rejected due to excess leakage and/or erratic fiber movement.

RSPaul for

Manager
PHYSICS AND INSTRUMENT RESEARCH
AND DEVELOPMENT
HANFORD LABORATORIES OPERATION

PF Gast:RSP:mcs

# CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

## RESEARCH AND ENGINEERING

## FISSIONABLE MATERIALS - 02 PROGRAM

### IRRADIATION PROCESSES

#### New Production Reactor Effluents

The two decontamination procedures planned for use in NPR are a three-step process which will produce about 70,000 gallons of total mixed waste and rinse water, and a one-pass phosphoric acid cleaner for carbon steel portions of the loop which will produce about 1,000,000 gallons of waste solution and rinse water. The waste from the three-step process is effectively scavenged by the manganese dioxide precipitate formed when the three solutions are mixed. Laboratory research was performed to determine the effect of mixing the wastes resulting from the two decontamination procedures. Mixed solutions were examined representing one process volume of three-step waste with one process volume of phosphoric acid waste and four process volumes of three-step waste with one process volume of phosphoric acid waste, i.e., respective waste volume ratios of 7 to 100 and 28 to 100.

Unneutralized phosphoric acid waste dissolved the precipitate formed in the three-step decontamination wastes when appropriate volumes of the two wastes were mixed. When the acid mixtures were neutralized with caustic, 50 percent of the radiocobalt was removed. More importantly, $MnO_2$ precipitated again and scavenged more than 99 percent of the radiocerium, 95 percent of the radiostrontium, and 90 percent of the radiozinc from the mixture. The scavenging achieved was essentially the same for both waste volume ratios examined.

#### Reactor Effluent Treatment

Column experiments continued with minerals of promise (as shown by batch experiments, HW-69225) for large scale decontamination of reactor effluent with respect to important radioisotopes. On the basis of P-32 adsorption, the order of effectiveness of the best eight minerals found is:

sodalite > epidote > fluorite = goethite > pyrrhotite > albite = microcline > apatite

From 60 to 30 percent of the P-32 in the influent solution was removed in the mineral columns, with a column residence time of about 2.9 minutes. The fractional removal of P-32 remained constant for operation periods as extensive as two weeks and passage of nearly 3000 bed volumes of effluent. This month, beds of sodalite, epidote, and albite adsorbed 60, 47 and 34 percent, respectively, of the P-32 in 1000 bed volumes of influent; on the other hand, adsorption by beds of anorthite, labradorite, and gypsum was poor.

## SEPARATION PROCESSES

### Preparation of U(IV) Nitrate

Further studies of the photoactivated reduction of U(VI) to U(IV) in nitric acid solution have been made. In these, hydrazine has been used as the reductant rather than formaldehyde. Interest in the use of hydrazine was prompted by the successful test of hydrazine as holding reductant in the Purex plant. In a previous test, U(IV) yield was less with hydrazine than with formaldehyde as reductant. The present studies have sought to exploit the fact that hydrazine is more stable than formaldehyde to reaction with nitric acid. Higher acidities and temperatures have been used. The results indicate that, under optimum conditions, U(IV) yields with hydrazine may approach those obtained with formaldehyde.

### Evaluation of Purex Water

Additional runs in the C column facility are in progress to compare column performance when the 1CX water source is changed from 321 Building condensate water to Purex demineralized water. Observations at this time indicate that the present (5/22/61) Purex demineralized water is of a higher quality than any tested to date. The current batch of water appears to be of as good quality as the 321 steam condensate water.

### Recovery of Plutonium in Z Plant Waste

Molar sodium carbonate, used to elute plutonium adsorbed by Florida pebble phosphate beds, picked up 0.006 M phosphate which dropped to 0.003 M after passage of four bed volumes. The phosphate content of the solution is not great enough to hinder plutonium recovery by the Recuplex process. The effectiveness of such mineral adsorption of plutonium from 234-5 sump waste was reported in February.

Applying pebble phosphate recovery of plutonium to a simulated waste solution containing a high plutonium concentration (40 mg/liter) at pH 1 resulted in plutonium precipitation in the column. Part of the precipitate was washed from the column, being visible in effluent samples.

## WASTE TREATMENT

### Batch Calcination

Bench-scale studies on the calcination of simulated Purex high-level wastes by the batch method were continued.

The simulated waste used in one run contained added borax and phosphoric acid. The amounts of the additives were equivalent to the metaborate form of sodium and ortho phosphate forms of iron, aluminum, chromium and nickel.

Observations pertinent to the experiment include:

1. The solution became viscous during the boil down step and foamed moderately.
2. The foaming could not be controlled by either a silicon antifoam agent or by air sparging.

3. White crystals, identified as boric acid, deposited on surfaces above the pot.

4. The calcine became molten on heating to 900 C.

5. The solidified calcine was crystalline.

6. The 304-L stainless steel pot was severely corroded. In places 60 percent of the 1/4-inch thick wall was corroded away.

7. The calcine is much less soluble in water than a sulfate-base calcine.

A solution similar to that described above but without the borax also produced a meltable calcine. The foaming during the boil down step could be controlled by silicone anti-foams. Severe pot corrosion was noted.

Negligible pot corrosion was noted when both borax and phosphoric acid were omitted from the waste solution.

To study foaming, the same simulated waste solution was used in three different pots of varying geometry. Severe foaming was observed in a 6-inch O.D., 3-inch I.D. by 15-inch high annular pot. Foaming was not a problem, however, in an 8-inch O.D., 4-inch I.D. by 24-inch high annular pot or in a 4-inch diameter by 24-inch high cylindrical pot. Bumping and spattering were troublesome in the 4-inch by 24-inch pot. It is postulated that the bumping produced enough mechanical agitation to overcome foaming.

Flame Calcination

The processing of simulated Purex high-level waste in Mallinckrodt's flame denitration pilot plant was observed over a two week period. The object of the brief program was to observe points of comparison between spray calcination utilizing an internal flame and that utilizing a hot radiating wall. The comparative data are expected to aid in the design of a spray calciner pilot plant by Chemical Engineering Development Operation.

The reactor, which is described in MCW-1451, is a tube ten inches in diameter and six feet long into which the feed is sprayed along with a concentric flame of air-propane. Although one successful run was completed, indicating the potential applicability of a flame reactor, there were considerable difficulties in adapting the process to the calcination of simulated waste. Many of these are attributable to the presence of a sleeve within the reactor which improved the operability of the equipment for UNH denitration, but was the apparent source of considerable operating difficulties with waste calcination. This sleeve could not be conveniently removed.

Successful operation was achieved at a flow rate of 5 gph with an excess of propane (reducing conditions) which appeared necessary to improve the physical properties of the powder. This proved to be very nearly the maximum rate with the particular feed composition and reactor design.

Advantages of heating by an internal flame may include: (1) Less problem from corrosion because of the possibility of using ceramic materials within the reactor,

(2) a more simple source of heat, particularly for pilot plant studies, (3) possibly somewhat higher capacity within a given reactor size. The disadvantages may include: (1) Considerably higher off-gas volume even if pure oxygen is used in place of air, (2) a relatively narrow zone of conditions for satisfactory operation because of the limited temperature range between that required for a stable flame and that at which the waste solids will melt, and (3) the difficulty of instrumenting such a reactor to indicate off-standard operation.

Spray Concentrator Test

A test was made using the modified spray calciner as a waste concentrator (see March report, HW-69062 C). The column is run at rather low temperature and by utilizing the channel recycle principle, the spray is partially dried by the recycled heated gas. The advantage of the system is that high concentration can be obtained without fouling heat transfer surfaces since the liquid is suspended in the gas as it dries.

Although the flowrates and temperatures appear to be quite critical, the run achieved some measure of success. Channel recycle was obtained by using a 14-foot long, 6-inch diameter insert which left a 1-inch annulus for gas recycle. The bottom of the insert held a 6-inch high pad of S/S/ "York mesh" for a demister which coalesces the spray into a liquid allowing it to drip into a collection vessel. The off-gases pass through filters to a condenser. The feed rate was one gallon per hour and operating temperatures ranged from 135 to 260 C. The steam rate to the atomizing nozzle was 11.3 lb. per hr. at 61 psig. Several concentrate samples crystallized upon cooling and volume reduction factors as great as two were obtained at modest wall temperatures (180 - 260 C). Entrainment losses to the condensate were less than 0.1 percent. Fouling of the unit was very slight during the 1.75 hours of running. Some dried feed adhered to the inside of the insert (the top few inches), but none was on the top cover and the filters seemed quite clean. It is likely that proper design of the recycle channel could reduce the nozzle turbulence such that build-up of solids on the insert would not be objectionable during extended operating periods.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium Recovery Program

Hot Semiworks Operation - Exceptionally good strontium recoveries and fission product decontamination were obtained on the first full-level "hot" run at the Hot Semiworks. About 182 kilocuries of Sr-90 were fed to the process and approximately 150 kilocuries of purified product were isolated for eventual load-out. In addition, 27 kilocuries of Sr-90 (tailings from elution of the ion exchange column) were stored for recycle to the next run. Preliminary results are summarized in the following table:

## RUN SR-4

### Quantities, Kilocuries

| | Feed | Product: Solvent Extraction | Product: Ion Exchange | Waste[a]: Solvent Extraction | Waste[a]: Ion Exchange |
|---|---|---|---|---|---|
| Sr-90 | 182 | 181 | 143 to 154[b] | ≤13 | ≤3.5 |
| Ce-144 | 2000 | 7.2 | ≤0.03 | 2700 | ≤11 |
| Zr-Nb-95 | 470 | <0.09 | <0.004 | 440 | ≤0.6 |
| Ru-Rh-106 | 10 | <0.27 | <0.01 | <30 | ≤0.06 |

### Weights, Grams

| | | | | | |
|---|---|---|---|---|---|
| Ca | 2400 | 260 | 99 | - | - |
| Ba | 500 to 1000 | <120 | <18 | - | - |
| Sr[c] | 2280 | 2260 | 1790 to 1920 | - | - |

### Decontamination Factors

| | | | |
|---|---|---|---|
| Ce-144 | - | 270 | $\geq 5 \times 10^4$ |
| Zr-Nb-95 | - | $>5.6 \times 10^4$ | $>85 \times 10^4$ |
| Ru-Rh-106 | - | >37 | $7.9 \times 10^2$ |
| Ca | - | 9.8 | 19 |
| Ba | - | >4.3 | >20 |

(a) Averages based on run analyses and composited wastes. The numbers are probably biased high.
(b) Range of variation observed between analyses done by two laboratories.
(c) Sr isotopic (atom %) composition: Sr-90 = 56.3, Sr-89 = 0.659, Sr-88 = 42.5, Sr-87 = 0.5, Sr-86 = 0.7, Sr-84 = 0.04

The decontamination performance exceeded the required product specifications by at least two-fold for both radiochemical and inert (Ca plus Ba) impurities.

The flowsheet approximated the conditions of study flowsheet No. 2 (i.e., a solvent extraction cycle using 0.40 M D2EHPA followed by a cation exchange cycle) with these significant exceptions:

1. About 40 percent of the solvent extraction product was backcycled to the feed (at a volume percent in the feed of 4 percent or less).

2. Citric acid (1 M) at a pH of 2.7 to 3.0 was used as the ion exchange scrub.

3. $NaNO_3$ (4 M) was used as the primary elutriant. This elution was stopped as soon as the beta monitor on the effluent stream indicated 80 percent of the strontium had been eluted. The remaining strontium was eluted with 0.1 M EDTA at a pH of 8.0.

As of this writing, a second "hot" run is in progress using the two-cycle solvent extraction process described below under "Solvent Extraction Flowsheet Studies."

Solvent Extraction Flowsheet Studies - In laboratory studies relating to development of flowsheets for solvent extraction recovery of strontium from Purex crude cut solution, emphasis was placed on obtaining equilibrium data for the extraction of strontium from first cycle product solution. Batch contact distribution data obtained indicate satisfactory extraction of strontium at an L/V of one when this solution is adjusted to pH 4 and made 0.1 M in EDTA. Solvent composition was the same as currently used in the first cycle (0.4 M D2EHPA - 0.2 M TBP - Shell Spray Base). Strontium was stripped from the organic with dilute nitric acid. Some decontamination from cerium and zirconium-niobium should be obtained with this flowsheet. It is hoped that, with this two-solvent-extraction-cycle scheme, product strontium meeting specifications can be produced without the need for an ion-exchange cycle.

Other batch contact studies were made to determine the effect of recycling solvent extraction product solution to the feed stream (spinning the cycle to obtain additional concentration of strontium). These studies showed that the product solution can be added to the feed solution at volume ratios as high as one part product to eight parts feed without adversely affecting extraction column operation.

In assistance to the Hot Semiworks, samples of two batches of Hot Semiworks solvent were tested prior to their start-up at full level. Aside from being low in D2EHPA, the samples were satisfactory for use.

A third mini-mixer-settler run at full activity level was made in the 222-S Building cubicle. The crude cut solution used in this run contained higher concentrations of lead and iron than solutions used in previous runs. However, satisfactory feed solution was readily prepared from the crude and mini operation was satisfactory. Analytical data for the run are not yet available.

Ion Exchange Studies - Batch contact studies were made in an effort to find more effective reagents for washing cerium from the HSW ion-exchange column following loading the column with solvent extraction product solution. These studies show that either 0.1 M HEDTA or 0.2 M sodium acetate - 0.01 M EDTA, if used at pH 4 or higher, should be superior to 1.0 M citric acid at pH 3 as a wash solution. These reagents do not complex strontium at the higher pH's as strongly as does citrate. Advantage can be taken of the low distribution of cerium at higher pH without serious loss of strontium from the column.

Strontium Carbonate Precipitation - Precipitation of strontium carbonate from citrate solution (such as IBP) was studied. Precipitation of 98 percent of the strontium was obtained when a solution 0.05 M in strontium and 1.0 M in citric acid was made 0.1 M in sodium bicarbonate, brought to pH 8 - 8.5 (with NaOH or $NH_3$) and digested two hours at 80 C. When the precipitate was filtered on a 10-40 micron stainless steel screen, loss of 10-12 percent of the strontium occurred, until a filter cake was built up adequately to remove the smaller particles. In experiments in which strontium carbonate was precipitated from citrate solutions traced with cerium, little or no cerium decontamination was obtained. Also, attempts to remove cerium from cerium-contaminated strontium carbonate by washing with ammonium carbonate solution were not successful. Greater than 99 percent of the cerium and less than two percent of the strontium in a simulated ion exchange product solution (0.1 M Sr - 0.0005 M Ce - 3 M $NaNO_3$) precipitated when the solution was brought to pH 11.

HAPO II Strontium Carbonate Cask Tests - Non-radioactive testing of the HAPO II strontium carbonate filter cask was completed. The results of these tests are summarized below:

1. Strontium carbonate prepared by precipitation with potassium bicarbonate from neutral sodium nitrate solution was successfully filtered on the HAPO II insert without recourse to filter aid. Overall recovery as filter cake averaged 99.6 percent. The self-limiting flow feature of the cask filling operation was demonstrated.

2. The HAPO II-1 filter capacity was determined to be 2000 ± 100 grams of strontium, representing 150,000 curies of Sr-90 as produced at Hot Semiworks at 75 curies/gram of alkaline earths.

3. Product quality was evaluated utilizing two different wash procedures with the following results:

| | |
|---|---|
| Unwashed product | 0.20 grams Na/gram Sr |
| Water washed in cask | 0.10 |
| Batch washed out of cask | 0.013 |

Losses to wash liquors amounted to 5 grams.

4. Product removal was readily accomplished with 0.5 molar nitric acid introduced at the cake solvent inlet. Approximately 50 liters of acid were sufficient to slurry the cake into the catch tank where the remaining acid completed the dissolution. The removal, accomplished under vacuum, was smooth and uneventful with the cake temperature at 80 to 100 C. Tests at higher temperatures were not conducted.

5. Satisfactory performance of a 2300 watt "Firerod" cartridge type heater was demonstrated at 850 C for 7.5 hours.

325-A Strontium Purification - Run No. 5 was completed on May 12, the HAPO-1A Decalso cask was filled with the product of runs 4 and 5 on May 13 to 15, and run 6 was begun on May 16 and is scheduled for completion by the end of the month. One further run (No. 7) should complete the 325-A strontium commitment.

From run 5, 13,300 curies of purified strontium-90 were obtained (by ammonium nitrate elution). Purity was even better than in the preceding runs with the product analyzing one percent barium, two percent calcium, and 97 percent strontium. Fission product contamination was below the gamma spectrometer detection limit and well below specification. Feed for this run, and for run 6 and projected run 7, contains over one molar sodium and one molar nitric acid, equivalent to a sodium-plus-ammonium to strontium mole ratio of over 1000. This high concentration of monovalent ions required feed dilution by a factor of four to insure strontium absorption and, even so, limited the capacity of the ion exchange equipment. This feed was some of the first strontium crude produced at Purex and stored in 002 tank. With feed of the quality now being produced in Purex, capacity of the 325-A ion exchange equipment would be higher by a factor of at least two to four and feed dilution would not be required.

The strontium cask was returned to Hanford during the month and reloaded, without incident, with the product of runs 4 and 5, from diluted ammonium nitrate solutions.

Approximately 26,000 curies of strontium-90 was passed through the cask, and 25,000 curies loaded - for a loading loss of only 3.5 percent. Breakthrough was apparently not reached, implying that the capacity of the cask may be as high as 30,000 curies. The cask was sent to the Purex plant after filling, for observation and determination of rate of pressure build-up, prior to off-site shipment. The accumulated quantity of strontium-90 shipped off-site is 45,000 curies.

Carrier Precipitation of Strontium-Cerium Separation - The effect of pH on degree of completeness of lead-carrier precipitation of strontium and of double-sulfate precipitation of cerium was studied in order to better define conditions for minimum contamination of strontium with cerium. It was found that between pH 2.5 and 3.0 approximately 85 to 90 percent of the strontium is precipitated while over 80 percent of the cerium remains in solution. At lower pH's, too much cerium precipitates, and at higher pH strontium losses are excessive.

Strontium Glasses - The scouting study, reported last month, on the formation of high strontium glasses was continued. Several additional formulations were prepared, and hot water solubility studies were made. Not unexpectedly, solubility tended to increase with increased strontium content (for glasses of similar composition) and to decrease with increased melting point. The lowest weight losses were shown by formulations Nos. 6, 9 and 10 with values of about 0.4, 0.25 and 0.025 percent, respectively (four hour immersion in boiling water). The rate of weight loss was almost constant on successive exposures, and would be expected to be about an order of magnitude lower in cold water. Formulations No. 6 and 10 contained 50 weight percent strontium while No. 9 contained 40 percent. Number 10, which showed the lowest solubility of all the formulations tested to date, was not a true glass, since it crystallized rapidly on cooling. Another interesting crystalline formulation, No. 11, was designed on the basis of the composition of Corex glass, but with strontium oxide replacing calcium oxide. It contained 58 weight percent strontium, had a density of 3.63 (equivalent to 2.10 g/ml strontium), and melted at 1200 C. Inclusion of 2.21 percent $Al_2O_3$ lowered its solubility three-fold to a value of 3.4 percent. Further alumina additions will be tried.

Strontium Recovery Reports - A number of unclassified reports have been recently written summarizing details of the laboratory development work done on strontium recovery and purification, and related subjects. Reference is made to these for the convenience of those who may have detailed interest in this material:

HW-69534 - Fission Product Strontium Recovery from Purex Chemical Processing Plant Waste Solutions, L.A. Bray and H.H. Van Tuyl, May 15, 1961

HW-63051 - Recovery of Fission Product Rare Earth Sulfates from Purex 1WW, E.J. Wheelwright and W.H. Swift, April 27, 1961

HW-68786 - Incorporation of Ion Exchange in the Hot Semiworks Solvent Extraction Facility, L.A. Bray, March 9, 1961

HW-69511 - Determination of Radio-Strontium Using Cation Exchange, F.P. Roberts, May 25, 1961

HW-69737 - Determination of Radio-Cerium Using Anion Exchange, F.P. Roberts, May 25, 1961

HW-69533 - Fission Product Radiation and Shielding Calculations, H.H. Van Tuyl, May 16, 1961

Measurement of Sr-89 and Sr-90 - The α-hydroxyisobutyric-ion exchange strontium method has been in use for ten months. Duplicate analyses of true solutions yield results that vary by an estimated two percent. Process samples that contain foreign particles yield results that vary as much as 20 percent. Method calibration factors that agree within ten percent were obtained from repeated analysis of strontium-90 standards. The Sr-89/Sr-90 ratios were obtained by both radiochemical and mass spectrometric techniques. Typical ratios on three samples were: Radiochemical - 2.54, 1.45 and 1.35; as compared to spectrometric - 2.49, 1.46 and 1.29.

Other Fission Products Programs

Bulk Fission Product Packaging - Several filterable fission product intermediates have been calcined under nitrogen atmosphere in thermal balance equipment to determine their pyrolysis behavior. The results are:

| Compound | Calcining Temperature | Product |
|---|---|---|
| Strontium peroxide | 350-450 C | SrO |
| Strontium hydroxide | 450-550 C | SrO |
| Cerous Oxalate | 350-450 C | (70% $CeO_2$ (30% $Ce_2O_3$ |

Loss of water occurred while heating and the final reaction was complete at the higher listed temperature.

Cask Closure Development - Two 1-inch pipe size, miniature Hanford connectors were fabricated and tested, utilizing Conoseal® stainless steel gaskets. The connectors exhibited helium leak rates of less than $5 \times 10^{-8}$ cc/sec, and $5 \times 10^{-6}$ cc/sec for continued temperatures and pressures up to 520 C and 500 psi. The difference in leak rates was due to the different sensitivity of two different testing methods.

One-eighth inch flat Teflon gaskets were successfully substituted for the metal Conoseals in the Hanford connector. Helium leakage rates were less than $5 \times 10^{-4}$ cc/sec at 100 psig at room temperature. The connector should thus be suitable for use in cask loading and unloading stations as well as for closures during shipping.

A 2-3/4 inch Teflon coated stainless steel O-ring was installed in a screwed fitting with a light torque of 170 lb.-ft. The O-ring held a steam pressure of 250 psi at 400 F for 240 hours. The leak rate was less than $4 \times 10^{-2}$ gm/hr.

After four 1-inch, Natorq® seal test failures a successful seal is now under test. The Natorq seals failed from galling between the seal and the cap, caused by relative motion between the sealing surfaces.

Capacity of HAPC-1A Decalso Cask for Cerium-Promethium Shipment - The strontium-Decalso cask is a converted cerium filter cask, and the shielding and heat transfer capability is accordingly sized for cerium shipment. It was therefore of interest to determine the capacity of the Decalso insert for possible rare earth shipment. Loading experiments with a small laboratory column, using a simulated Purex

® Marmon Division, Aeroquip Corporation (Conoseal)
® Navan Products, Inc., North American Aviation (Natorq)

cerium-rare earth double sulfate solution as feed, gave a capacity of 170,000 curies of cerium-144. If the cerium is separated from the accompanying trivalent fission-product rare earths (as by peroxy-acetate precipitation), the capacity for cerium is increased to about 500,000 curies of cerium-144. However, heat transfer calculations show that 170,000 curies is about the maximum that can be safely shipped without boiling occurring in the Decalso. Use of the cooling coils would, of course, remove this restriction.

For purified promethium shipment, the indicated capacity is 670 grams (620,000 curies) and there is no heat dissipation problem.

Transuranic Recovery-Americium Recovery - The recovery of americium-241 from the Redox processing of highly burned plutonium fuels was briefly examined. Experiments were performed to determine whether double-sulfate precipitation could be carried out from the high ANN Redox waste solution and whether americium would carry, as expected, with the rare earths. Eighty-four percent recovery of americium (and 94 percent recovery of cerium) was obtained by addition of an equal volume of 2 M $Na_2SO_4$, tartaric acid in excess to the iron and chromium, adjustment to a pH of 2.0, and digestion at 60 C. These conditions are probably not optimum, and even better americium recovery is probably possible on the basis of further work.

Cesium Recovery with Tetraphenylboron - Work on cesium recovery was resumed by undertaking a rather extensive survey of the precipitation of cesium by sodium tetraphenylboron ($Na\phi_4B$). This study extends and supplements earlier work on ferrocyanide carrying and may have application to recovery from alkaline tank supernates or to cesium packaging. It was found that excellent cesium recovery could be obtained over a wide range of temperatures and digestion times, even though recovery is decreased somewhat at high temperatures. The pH was varied from 1 to 11 without significant effect, except for a possible slight decrease in cesium recovery at pH 1. Most common anions (chloride, sulfate, carbonate, phosphate, or tartrate) had virtually no effect, at least at concentrations up to one molar. Sodium nitrite had no effect at pH above 4 (nitrous acid is presumably formed at low pH) while sodium nitrate concentrations to 5 M and pH values of 11 to 13 did not affect cesium precipitation appreciably, and phase separation could be made equally well by either filtration or centrifugation. Only iron, even when complexed with tartrate, is highly deleterious.

These experiments indicate that tetraphenylboron may be an acceptable reagent for precipitation of cesium from tank farm supernates, or from cesium crude cuts, but not for cesium precipitation from LWW.

Cesium tetraphenylboron, precipitated from an aqueous solution of cesium salt, has been converted to dry cesium chloride by reaction with chlorine gas (2 percent $Cl_2$, 98 percent $N_2$ at 150-200 C). Most of the reaction products are volatile. The first cesium product was a black, sooty solid. Treatment with oxygen (gas) at 500 C removed most of the carbonaceous material, leaving the fairly clean, crystalline CsCl. The crystal mass was tightly stuck to the vessel. The bulk cake density of the precipitated cesium tetraphenylboron was 0.24 g/cc (dry) or 0.072 g Cs/cc. Volume reduction by a factor of 30 occurred during conversion to the chloride, which has a bulk density of about 2 g Cs/cc. These results indicate that the application of the tetraphenylboron process to the filter canister approach to packaging will result in excessively low package volume utilization, the net packaged density being only 2.5 curies per cubic centimeter.

## EQUIPMENT AND MATERIALS

### Air Driven Pulse Generator Study

The analog study of the dynamics of the air pulsed Recuplex H-1 column was completed and the data analyzed. The study indicated that at 60 cycles per minute and 1-inch amplitude, air pressures of 12 and 16 psig would be required with 1-inch and 3/4-inch pulse legs, respectively.

Column operating characteristics change as the air pressure is increased at constant frequencies:

1. Column liquid pressure versus time curves change from a triangular to a square wave.
2. Displacement versus time curves change from a sinusoidal to a triangular wave.
3. Velocity versus time curve changes from a triangular to a square wave.
4. Acceleration versus time curve changes from a square wave to a periodic "blip."

The column will have a natural frequency of between 11 and 12 cycles per minute. The time required for the liquid to go from the bottom of the pulse leg to less than two feet above the static liquid level (which is maximum when the exhaust line is opened) is less than ten seconds.

When the column is operating at 60 cpm and 1-inch amplitude, and the column specific gravity is changed from 1.32 to 1.44, the change in pulse amplitude is less than 8 percent and the shift of liquid position in the pulse leg is less than two inches, indicating stable column-pulser performance.

### Production of Dichromate in Nitric Acid Solutions

Corrosion in intercycle and waste concentrators could be reduced significantly if the chromium, which enters these solutions through corrosion of stainless steel, could be maintained in the tervalent state. Studies aimed at a better understanding of the conditions under which chromium(III) is oxidized to chromium(VI) in these solutions were started. Results to date show that the oxidation is too slow to be of significance in boiling one to eight molar nitric acid and of questionable significance in 10 M $HNO_3$. Reduction of chromium(VI) in boiling nitric acid by nitrogen dioxide sparging is being evaluated.

### Galvanic Corrosion Between Stainless Steel and 1020 Steel in Purex Waste

Samples of 1020 steel, one of which was coupled to a 304-L stainless steel sample of about equal surface area, were exposed to boiling synthetic stored Purex waste (pH 12) for a total of 832 hours. The test was made to determine if galvanic corrosion acceleration will occur when stainless steel valves were used in 1020 steel lines handling this waste. No galvanic effects were noted. The test is terminated.

### Corrosion in Nitric Acid-Oxalic Acid Systems

Studies on the corrosion of 304-L stainless steel and titanium in nitric acid-oxalic acid systems have been completed. The data obtained indicate effective passivation

of both materials at nitric acid concentrations of 0.5 M or greater. The presence of plutonium, which was not present in these tests, may account for the severe corrosion of 304-L noted in a 234-5 Building concentrator handling nitric acid-oxalic acid solutions.

Failure of Shear Pin Covers in a Continuous Calciner

Examination of fractured shear pin covers from a continuous UNH calciner indicate fatigue to be the cause of the failures. It was recommended that the covers be so attached as to minimize flexing, or that the covers be so designed that they do not contact the bed of calcined $UO_3$ during rotation.

PROCESS CONTROL DEVELOPMENT

Neutron Multiplication Experimentation

A plutonium-beryllium neutron source and a neutron detector system has been installed on a 4-inch diameter plutonium storage vessel in the Critical Mass Facility. Calibration with water only has been completed. This vessel will be monitored for neutron multiplication as solutions containing 20 to 300 grams per liter plutonium are transferred through it to a reactor vessel.

C Column Facility and Data Reduction

The operation of the Data Scanning Programmer with the mercury wetted relays has been quite reliable and the reproducibility of the measured voltages has markedly improved.

The increased rate of data taking (and hence larger amounts of data per run) which was made possible by the incorporation of the high-speed scanning circuitry has caused some problems. The storage capacity of the Data Reduction Code was exceeded on occasion by the data from a run. The Code was modified to accept up to 120 scans total per run of 73 voltages each, whereas formerly only 50 scans were acceptable. Up to 100 scans on any given port are also acceptable. This appears to be the maximum amount of data that can be processed for any given run on the 7090 with its 32K memory.

The Teflon bellows and pulser cam device of the 1C column test facility was replaced with a Selol metal bellows and a set of fixed pulser cams designed to produce pulse amplitudes of 0.65, 0.98 and 1.3 inches in the column. (Previous amplitudes available were 0.74, 1.2 and 1.5 inches.) Tests of the new steel bellows system showed (1) a peculiar resonant effect at about 20 cycles per minute when the column pulse amplitude decreased by about 15 percent; this was not pursued further as it was not in a pulsing frequency range normally encountered; (2) except for the resonant effect mentioned, the column pulse amplitude increased steadily with increasing pulse frequency; and (3) at frequencies greater than 120 cycles per minute some deformity of the bellows was noted.

A series of runs, which had been designed to investigate the long term stability of the column's measured variables and to study the effect of sampling and mid-column photometer flushing techniques on this stability, was completed. The effects of various flushing techniques on the operation of the mid-column photometer were also investigated.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Room Temperature Spectrophotometric Studies - As a prelude to spectrophotometric studies "at temperature," mulling techniques have been employed to measure absorption spectra of frozen (uranium-bearing) melt samples following various high temperature treatments. Much of the work to date has been concerned with development of techniques capable of yielding quantitatively self-consistent results. An early (and feared) observation is that the spectra of some frozen melt samples change with time of exposure to laboratory air but do not change with time if stored in a desiccator. Since all melt samples yet studied have received some exposure to laboratory air while cooling before being placed in the desiccator, this imposes some uncertainty on all data thus far obtained.

The results to date are interesting, however, even if accorded only qualitative significance. In the visible region, uranium in these frozen (NaCl-KCl) melt samples is responsible for three closely-spaced absorption peaks at 423, 437 and 458 mμ. The relative intensities of these three peaks can be changed with melt pre-treatments in a manner which suggests the existence of at least three distinguishable uranium species. Apparent molar extinction coefficients for uranium in these melt samples range from 50 to 100 for the strongest peak in the range 400 to 460 mμ. By comparison, the compound $Cs_2UO_2Cl_4$ gave an apparent molar extinction coefficient (for uranium) of ca. 16 at 423 mμ and $UO_3$ yielded an apparent molar extinction coefficient of ca. 20 at 430-390 mμ. The "water-insoluble" uranium in frozen melt samples appears to be a major contributor to the stronger absorption shown by the frozen salt samples. A sample of this material gave an apparent molar extinction coefficient of ca. 120 at 458 mμ.

Perturbation of the infrared spectra can likewise be achieved by different melt pre-treatments. A mulled sample containing some "water-insoluble" uranium(VI) shows a new peak at 11.6 μ in addition to the "normal" peaks at 11.0 μ. With mulled solid $Cs_2UO_2Cl_4$ the peak is at 10.9 μ while mulled $UO_3$ yields a broad band extending from 10 μ to 12 μ.

Further study has disclosed water "solubility" to be a treacherous approach for achieving distinction between uranium species present in frozen melt samples. The apparent lesser water solubility of a fraction of the uranium is apparently a measure of different rates of dissolution of different uranium species, as expected. Apparent "solubility" in a 1:1 glycerol-methanol mixture may be an identical measure, but at least it is much less time-dependent than is water "solubility." For example, a portion of one salt sample assayed 8 percent water "insoluble" uranium in a 10 minute exposure to water. However, the alcohol "insoluble" fraction was 33 percent after a two hour and after a 16 hour exposure to 1:1 glycerol-methanol. Thus alcohol "solubility" may be a reliable empirical method for distinguishing between uranium species in these melts.

No substantial amount of alcohol insoluble material has yet been isolated for study. A sample of "water insoluble uranium(VI)" assayed ca. 65 percent uranium. This is not a particularly informative number because it is subject to some analytical uncertainty and fits many potential uranium compounds. However, it does tend to rule out $UO_3$ (83 percent uranium).

Studies of NaCl-$MgCl_2$ System - This melt system has been selected for exploratory study as a potential high chloride activity, lower-melting salt system (relatively easily dried) in which there may be possibility for stabilizing plutonium(IV).

Preliminary observations on the electrodeposition of $\overline{UO_2}$* and the behavior of cerium include the following:

1. The oxygen/uranium ratio of $\overline{UO_2}$ deposits has remained consistently below 2.01 and has on occasion been as low as 2.001.

2. Even with a non-oxygen-bearing atmosphere (helium), 90 percent of the uranium can be deposited as $\overline{UO_2}$ at temperatures below 600 C. This implies a lesser rate of conversion of the uranium(VI) species to uranium(IV) via reaction with the graphite anode than is the customary case with NaCl-KCl melts at higher temperature.

3. The $\overline{UO_2}$ deposits obtained to date have tended toward "needle" type deposits or the "Christmas tree" deposit.

4. Deposits at low temperature and low uranium concentration show poor adherence to the cathode.

5. Magnesium contamination in the $\overline{UO_2}$ is in the range of 56 ppm.

6. Cerium shows a strong tendency to follow $\overline{UO_2}$ even under "partition deposition" conditions.

Decontamination factors observed for cerium were 3.3 at 565 C and 10 at 613 C. By contrast, "partition" depositions in NaCl-KCl at 750 C yield cerium decontamination factors of the order of 200.

Studies of $UO_2$ Electrodeposition in NaCl-KCl Systems - Experiments have been initiated in an "H" cell in which the atmospheres over anode and cathode compartments can be independently varied. In electrolyses using helium as the cathode atmosphere and dry air as the anode atmosphere (to facilitate re-oxidation of uranium(IV) formed by reaction with the graphite anode), the oxygen/uranium ratio in the deposit has ranged from 2.001 to 2.005. The fraction of the total cathode uranium present as uranium(VI) has ranged from 60 percent to 93 percent, vice 88 to 95 percent in the anode compartment. Differences in uranium concentrations in anode and cathode compartments have likewise been observed; in one instance the final concentration in the cathode compartment was twice that present in the anode compartment.

Chronopotentiometric studies continue to testify to complex uranium chemistry in the NaCl-KCl system. Most of this effort to date has concentrated on melts prepared by dissolving $U_3O_8$ into molten NaCl-KCl with hydrogen chloride gas. It may be recalled that early spectrophotometric studies of this system yielded a spectrum which could not be synthesized from known uranium(IV) and uranium(VI) spectra and was speculatively ascribed to uranium(V).

* A notation suggested by J.J. Katz, in which the non-stoichiometric nature of this system is symbolized by a bar over the (inaccurate) chemical formulation.

The chronopotentiometric results are in qualitative agreement with this hypothesis. Dissolution of $U_3O_8$ into NaCl-KCl with hydrogen chloride yields initially a green solution which turns yellow on further HCl treatment and on prolonged HCl treatment again becomes green. Treatment with air will change any of these melts to a brown solution. To date chronopotentiograms have been obtained only on the yellow solutions and green solutions resulting after prolonged treatment with HCl. The final green melts show curves corresponding to the uranium(IV)/uranium(III) reduction while the yellow solutions show the uranium(IV)/uranium(III) reduction and the $UO_2^{++}/UO_2(S)$ reduction as well. The amounts of uranium(IV) and uranium(VI) present in the final solution appear to be in accord with the 2U(VI)/1U(IV) ratio expected for $U_3O_8$. The observed color changes together with the fact that an eight-fold reduction in total uranium concentration allowed the initial green solution to persist longer suggests the possibility of initial dissolution to uranium(V) which subsequently disproportionates to uranium(IV) and (VI).

Growth of $\overline{UO_2}$ by Electrodeposition Out of NaCl-KCl - Further studies reveal that dense, self-supporting polycrystalline $UO_2$ compacts can be grown under a wide range of conditions and at rapid rates. Success in preparing such deposits has been achieved under the following conditions:

1. Sparge gas - dry air (40-60 percent) plus dry HCl (60-40 percent) or dry air (20-60 percent) plus dry chlorine (80-40 percent).

2. Initial melt uranium - 5 to 10 weight percent.

3. Temperature 690 to 750 C.

4. Cathode potential (vs. Ag/1 molal AgCl reference cell) - -0.5 to -1.5 volts.

Rapid deposition of $\overline{UO_2}$ by such conditions yields a rough surfaced deposit. However, changing the melt atmosphere to nearly pure HCl or $Cl_2$ allows a smooth, polished surface to be produced.

Growth of $\overline{UO_2}$ by Electrodeposition Out of KCl-$PbCl_2$ - Electrodeposition of $\overline{UO_2}$ at 510 C out of 3 KCl-$PbCl_2$ made initially 25 w/o uranium under a helium atmosphere and at controlled cathode potentials fixed at 0, -0.2, -0.4 and -0.6 volts (relative to a Ag/1 molal AgCl reference cell) produced the following somewhat mysterious comparisons:

1. $\overline{UO_2}$ deposits were virtually identical when made at -0.2 or -0.6 volts and were distinctly different from the one made at 0.4 volts. The -0.2 and -0.6 volt deposits were made up of cubes with "roughened" 100 faces; no external 110 or 111 faces were apparent. Approximately 55 percent of these deposits was +10 mesh. The oxygen/uranium ratios were virtually identical, 2.009 and 2.008. The lead content was 50 ppm for the -0.2 volt deposit and 100 ppm for the -0.6 volt deposit.

2. The -0.4 volt deposit was sufficiently coherent to allow sectioning. It was found to consist of a dense polycrystalline core adjacent to the graphite electrode surrounded by an annular area of high void content (apparently caused by needle-like growth) in turn surrounded by large, dense grains, some of which weighed as much as 1.4 grams. Over 80 percent of this deposit was +10 mesh and lead and potassium contamination levels were only 50 and 100 ppm, respectively.

3. The 0 volt deposit had a higher oxygen/uranium ratio (2.034) and was dendritic in character, the dendrites being cubes stacked corner to corner.

Quite apparently, other variables in addition to the cathode potential are operable in these comparisons. A particularly encouraging feature, however, is the lower lead contamination levels observed in these deposits, which are ten-fold lower than in many previous experiments.

Fission Product Behavior in Molten NaCl-KCl - The use of pyrophosphate as a precipitant for rare earth elements was studied further. A solution containing 0.5 w/o each of the representative elements Nd, Sm, Zr, Mo, Ag and Ru was prepared by dissolution of $Nd_2O_3$, $Sm_2O_3$, $ZrO_2$, $MoO_3$, AgCl, and $KRuO_4$ into molten NaCl-KCl with dry HCl. Excess $Na_4P_2O_7$ was then added to the melt. Analyses (by X-ray fluorescence) of filtered melt samples before and after addition of the $Na_4P_2O_7$ showed that molybdenum was apparently completely sublimed out of the melt by the HCl treatment, silver (which does not form an insoluble pyrophosphate in NaCl-KCl) was not carried on the precipitate, and decontamination factors as follows were achieved for those elements precipitated:

| Element | Decontamination Factor |
|---|---|
| Nd | 67 |
| Sm | 91 |
| Zr | 50 |
| Ru | >500 |

Uranyl pyrophosphate has only a limited solubility (3.6 mg U/g NaCl-KCl) so this direct scavenging technique could be conveniently applied only to fission product bearing melts containing no uranium. In the presence of uranium it is possible to employ $(UO_2)_2P_2O_7$ as the precipitant.

This latter technique was tested by batch equilibrating a NaCl-KCl melt containing 0.5 w/o each of Nd, Sm, Ru and Zr with a solid phase consisting of $(UO_2)_2P_2O_7$ supported on 60 mesh $Al_2O_3$. Equilibration of 30 grams of salt with 33 grams of $Al_2O_3$ - $(UO_2)_2P_2O_7$ (containing 11.1 w/o $(UO_2)_2P_2O_7$) produced decontamination factors as follows:

| Element | Decontamination Factor |
|---|---|
| Nd | 67 |
| Sm | 130 |
| Zr | 26 |
| Ru | >500 |

Melting Points of Ternary Salt Mixtures Containing $UO_2Cl_2$ - The effect of dissolved $UO_2Cl_2$ on the liquidus temperatures of KCl-$PbCl_2$ and NaCl-$MgCl_2$ or KCl-$MgCl_2$ systems has been studied by differential thermal analysis.

Addition of $UO_2Cl_2$ to KCl-$PbCl_2$ systems yields a marked depression in the liquidus temperature, as shown by the following tabulation:

| Mole Ratio K/Pb | Liquidus Temperature at Indicated w/o $UO_2Cl_2$ (°C) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | 36 | 48 |
| 0.89 | 411 | | | | | |
| 2 | 538 | 472 | 440 | 388 | | |
| 2.5 | 585 | 564 | 478 | 415 | 367 | |
| 3 | 630 | 598 | 542 | 452 | 410 | 355 |

Addition of $UO_2Cl_2$ to a NaCl-KCl-$MgCl_2$ of 0.675 Na:0.395 K:1 Mg composition increased the liquidus temperature from 395 C to 404 C at 10 w/o, 421 C at 20 w/o, and 446 C at 30 w/o $UO_2Cl_2$. The liquidus temperature for a 1.5 KCl-1 $MgCl_2$ melt was between 460 C and 466 C over the entire range 6 w/o $UO_2Cl_2$ to 30 w/o $UO_2Cl_2$.

Engineering Development - Analyses of the 20 pound electrolytic $UO_2$ produced from a $PbCl_2$-2.5 KCl salt bath in the run reported last month are 300 ppm C, 200 ppm K, 1000 ppm Pb, and an oxygen-to-uranium ratio of 2.015. Visual observation of white $PbCl_2$ in the interstices of the deposit, even after thorough washing, indicates the necessity for washing of the $UO_2$ after final particle size reduction. Additional analysis will be secured after such mechanical treatment.

An electrolysis was carried out with a 1-1/2 inch D graphite cathode and a 6-inch I.D. annular anode. A 23.5 lb. $UO_2$ deposit 1.8 cm thick was obtained during a 48 hour electrolysis. Characteristics of the deposit were similar to those of the previous run.

Chemical Decladding - The pilot plant reactor for chemical decladding and/or oxidative fuel core removal was completed. A shakedown run was made using a 1:1 mixture of chlorine and nitrogen gas to remove oxidized Zircaloy cladding from a 3-foot section of a 1/2-inch diameter PRTR fuel rod. The run was stopped in less than 30 minutes because of plugging of the off-gas line with $ZrCl_4$. Approximately 1/3 (65 grams) of the cladding was removed in this short period while operating at a total gas flow of four liters/minute and temperature between 425 and 575 C.

The pilot unit equipment was modified after the shakedown run to incorporate a gas preheater and a larger, better insulated off-gas line. The reactor tube size was also increased from a one-inch to a 2-inch pipe to provide for the treatment of seven rod clusters.

Oxidative Core Removal - Two oxidative core removals were attempted in the modified pilot plant reactor. The objective was to operate at a temperature and gas flow rate which would split the cladding and thus provide uniform removal of the core as $U_3O_8$ from long fuel pins. In the first run, a 36-inch long, 0.5-inch diameter fuel pin with two rows of 0.125-inch holes diametrically opposed and spaced one inch apart was exposed to air at temperatures ranging from 425 C to 535 C. The cladding showed bulging but did not split, and very little $U_3O_8$ was removed. In the second run, a 22-inch long fuel pin, prepared in the same manner as the first, was exposed to oxygen at 600 C for four hours. Some oxidation occurred and the cladding bulged around the drilled holes. The rod was then oxidized for another hour at 720 C. The cladding split in three places providing considerable area for attack and indicating the need for higher operating temperature in future runs.

Engineering Control of Electrode Potential in a Salt Bath - A control system for regulating the voltage at high currents between a cathode and reference electrode in a molten salt bath was designed and tested. The key components of the control system are a pH meter amplifier and a Brown Recorder with a proportioning resistor.

The system works well on controlling the cathode to anode voltage. However, the control of potential between cathode and reference electrode is uncertain at this time due to a faulty reference electrode which appears to introduce a time constant in the process in excess of the maximum necessary for adequate control. Tests with a "good" reference electrode are necessary before final evaluation of the control system can be made, and corrective actions taken if necessary.

Ion Exchange Contactor Development

Continuing experiments with the resin pump as a prime mover in a resin column confirm its utility for transporting resin slurry. The valves perform well in thin to relatively dense resin slurries. The resin flow cannot be maintained, however, when a countercurrent feed is pumped against it in a 4-inch column at a rate of 300 mls per minute. This is attributed in part to the short path length of the slip water - from the pulser chamber to the effluent outlet directly beneath it.

In an attempt to provide additional force for resin movement, the pump has been altered to produce a push-pull action under constant volume conditions. This has been accomplished by adding a second pulser operating 180 degrees out of the phase with the first. A ball check valve is placed above, between and below the pulser chambers. Resin (20-40 mesh) movement in a non-flowing liquid system is superior to the single bellows pulser, averaging about 80 percent of the nominal displacement of the bellows under pulsing conditions varying from one to two inches in amplitude (200 to 400 mls) and frequencies from two to six cycles per minute. Slip water appears negligible. The pressure in the pulser lines varied between 5-3/4 to 8-1/2 psig.

Several attempts to pump a process stream against the resin in the new unit gave negative results similar to those described above for the single bellows unit. It is thus concluded that the resin nitric acid slurry cannot be treated as a homogeneous liquid for pumping purposes. However, preliminary tests indicate that simultaneous liquid-resin countercurrent flow is obtainable in the "C" column, which is six feet farther from the pulser chamber than the "A" column. This observation implies that an improvement in "A" column performance may be attained by selecting a different location for the pulser. Simple modifications to the present apparatus will permit testing of this hypothesis.

Fission Yield Determinations

Nine irradiated Pu-239 samples were analyzed for a total of over 36 fission products in order to perfect analytical techniques and to verify fission yields from irradiations with the neutron flux conditions obtained in the Hanford reactors. Upon completion of final counting and calculation fission yield determinations on Pu-240 will be started. Data from these studies will be valuable in connection with the high exposure plutonium work expected at the PRTR.

## RADIOACTIVE RESIDUE FIXATION

### Mineral Reactions

Laboratory investigations were continued for comparing cesium adsorptions by various natural and synthetic ion exchange materials. Equilibrium experiments with a phenolic resin in 6 M sodium systems gave cesium distribution coefficients that increased linearly with the logarithm of the $OH^-$ concentration. The resin was also studied to determine the effect of salt concentration on the cesium capacity of the exchanger. No significant difference in cesium capacity was obtained for 8 M, 2 M, and 0.5 M sodium nitrate solutions traced with Cs-137 and passed at a uniform flow rate through resin columns. A rather pronounced influence of dilution on the capacity of clinoptilolite previously observed is now ascribed to the rapid flow rates used in the earlier experiments.

### Condensate Wastes

A comparison of column experiments with batch-type equilibrium experiments, which are relatively cheap in low-salt systems, showed that the batch-type may be used to estimate the adsorption capacity of candidate column materials. For each material tested - synthetic zeolite, a sulfonated polystyrene resin, and clinoptilolite - the cesium adsorption capacity as calculated from batch equilibrium distribution measurements agreed with previously obtained column experiments.

### Ruthenium Tetroxide Studies

Two base-line runs were made to determine the extent of absorption of ruthenium tetroxide on silica gel under conditions such that negligible decomposition of the tetroxide occurs. A stream of air was passed over mixed solid and liquid $RuO_4$, then through a small silica gel bed (1-inch diameter by 2-1/2 inches high), and into a trap containing hydroxylamine hydrochloride (in 4 M hydrochloric acid). Excellent ruthenium removal was observed with ruthenium decontamination factors of $2.5 \times 10^4$ and $5.9 \times 10^4$. The ruthenium was absorbed in a tight colored band with a sharp demarkation line between the saturated and unused silica gel.

## BIOLOGY AND MEDICINE - 06 PROGRAM

### Geology and Hydrology

Gravel Trains Complicate Ground Water Flow - The potential of highly complex flow patterns of ground waters within the lower part of the Ringold formation was again emphasized. Stratigraphic studies between Richland and Columbia River mile 348 (site of the proposed dam) disclosed that the so-called "blue clays" or lower beds of the Ringold formation are interlaced with extensive gravel trains that constitute a major part of the lower Ringold formation and that represent old main stream Columbia River courses. (Those gravels are distinct from the conglomerate that was earlier reported and that lies on basalt beneath the "blue clay" beds.) Such gravel trains now are recognized throughout the entire stratigraphic section and throughout most of the Pasco Basin. Previously they were recognized only locally, both areally and in that section.

The gravel trains are bordered by silts and clays, representing quiet water deposits at the margins of the stream. Thus, the silt and clay beds are not so continuous or confining as if they were lake rather than river or floodplain deposits.

The significance of the gravel trains is two-fold: (1) if wastes move to and at depth in these gravel aquifers, their flow paths may diverge appreciably from those in other aquifers, depending on the hydrologic conditions and orientation of the gravel train, and (2) construction of a dam at river mile 348 will affect ground water flow in the deeper as well as shallower aquifers. Delineation of these gravel-filled old river courses is eminently desirable if the three-dimensional pattern of flow of ground waters is to be determined.

Converting Randomly-Spaced Field Data to Grid Spacing - The problem of calculating grid point values from randomly distributed geologic and hydrologic data was studied further to obtain a satisfactory technique. The two methods tested were an application of Tchebysheff polynomials and the Forsythe method for generating orthogonal polynomials from random data. At the present time the latter method can be used only for one-dimensional interpolation, but a method for application to two-dimensional systems is being sought. Both methods gave reasonably good results in comparison test applications to one-dimensional problems.

Definition of Basalt Relief Near Reactors - Several buried basalt ridges are now known in the region between the Gable Butte-Gable Mountain anticline and Saddle Mountain. Previously the area was believed to represent one extensive syncline, with the low point more than 200 feet below sea level. Recent well drilling data and the results of an airborne magnetometer survey by the U.S. Geological Survey provided new information. The lowest depression in the basalt surface is now recognized to be a relatively narrow trench just north of and parallel to the Gable Mountain anticline. The depression bottoms more than 200 feet below sea level. At least three basalt ridges are located in the area between Gable Mountain and the Columbia River; the most pronounced ridge lies beneath 100-N Area and trends southeastward to pass beneath 100-F Area. The basalt relief is closely matched by the relief of the surface of the Ringold formation to support further the theory that the two formations are deformed concurrently.

Vertical Well Currents - Development was completed for the orifice-diaphragm meter. It stands ready to give accurate values of vertical currents in wells to help establish ground water pressure in general. In fact, partly for testing the meter, it was used to measure currents in 22 project wells, including some whose water level had fluctuated with atmospheric pressure. The currents, incidently, were generally stable, generally downward, and less than 200 cc/min.

Temperatures in Wells - A temperature-sensing thermistor probe and related circuitry were designed for measuring temperature gradients in wells. Temperature profiles in wells may help differentiate various aquifers and show the course of thermally hot water disposed to cribs.



Soil Chemistry and Geochemistry

A laboratory investigation of strontium adsorption by four natural and synthetic zeolites was continued. The factorial design of the experiments was revised to include higher calcium and potassium concentration levels. The five independent variables studied were: Residence time (1X and 5X), sodium concentration (zero, and 1.0 N), calcium concentration (zero, and 0.2 N), and potassium concentration (zero, and 0.004 N). At the 95 percent confidence level the effect totals for column residence time and sodium concentration were significant and will be studied further. In addition, effect of calcium concentration will be included because of its common occurrence in wastes and natural waters. No further study of the effect of potassium or strontium concentration is planned.

Low Background Beta Gamma Coincidence Counting

A low background beta gamma coincidence counting system was developed by using a plastic scintillation beta detector in a well of a five-inch sodium iodide gamma scintillation detector, and both in a large plastic anticoincidence shield (the Compton cancelling spectrometer). For the weak beta emitter, Co-60, a background reduction greater than a factor of 150 was obtained with only a 30 percent loss in efficiency over regular gamma counting. This will provide a very sensitive detector for beta gamma emitting nuclides.

Radioactive Noble Gas Detector

A detector was developed for beta counting radioactive noble gas samples without introducing them into the counting tube itself. By this method no purification of the noble gases is needed from other gases which would interfere with the counting process. The detector consists of a central rectangular chamber for holding the gas sample which is isolated by means of thin mylar films from four hemispherical proportional counting chambers electronically connected. Evacuation and filling of the sample chamber and the counting tubes are done simultaneously to avoid rupturing the films. The detector has an efficiency of about 59 percent and a background of less than ten counts per minute when used in an anticoincidence guard ring shield.

Trace Elements in Columbia River Water

Samples of water from the Columbia River and its major tributaries are being analyzed to determine the concentrations of the trace elements responsible for the radioisotopes formed when this water is used to cool the Hanford reactors. Changes in these concentrations with time and season will be measured as a guide for investigations designed to reduce the radioisotopes formed. Because of the low concentrations observed activation analysis techniques are being used for the analysis.

W. H. Reas

Acting Manager
Chemical Research and Development

WH Reas:cf





[redacted]

A. ORGANIZATION AND PERSONNEL

Dr. Pierre F. Nizza of S.H.A.R.P., France, visited Biology facilities for two weeks, discussing research, observing methods and techniques, and reviewing administrative procedures.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 02 PROGRAM

Effect of Reactor Effluent on Aquatic Organisms

The effluent monitoring at the 1706-KE laboratory with the exposure of young salmon to dilute untreated effluent and to like concentrations of effluent passed through a bed of aluminum turnings was terminated on May 18, 1961. The fish had reached the stage of development where they normally undertake the migration to the ocean. As expected, fish exposed to 8 per cent effluent concentrations suffered marked increased mortality, while the 4 per cent strength resulted in slightly increased death. Although rigorous statistical tests have not as yet been applied, a cursory examination of the data indicates that the presence of the aluminum made the effluent slightly more toxic.

Hydraulic Test Flume

The construction of the hydraulic test flume for testing the locomotive performance of fish was started in mid-May by Minor Construction.

C. columnaris

Tests to evaluate virulence of different strains of columnaris and sensitivity of different strains of fish are continuing. The first sampling of fish from the McNary Spawning Channel showed no incidence of columnaris among 28 fish sampled from water which was 51 F.

Three of the most virulent strains of columnaris and two of the least virulent strains were tested for their haploid or diploid status by means of sensitivity to X rays. The three virulent strains appear to be diploid whereas the two non-virulent strains appear to be haploid. This observation appears to be extremely important and necessitates a thorough check to be sure that the two groups are really both C. columnaris.

Population Dynamics - Waterfowl

The Canada goose population resident within the Hanford Reservation completed its most successful nesting season since comprehensive studies began in 1953. Approximately 1100 goslings were produced, representing a 29 per cent increase over last year. This resulted principally from an increase in successful nests from 70 per cent last year to 85 per cent in 1961. Fertility of adults averaged 97 per cent, compared to an eight-year average of 98 per cent.

Nesting colonies of California and ring-billed gulls at Coyote Rapids and Ringold were censused. Total nests at these locations were approximately 1200 and 1400, respectively. There was a significant difference between colonies in average clutch size: 2.6 at Coyote Rapids, 1.8 at Ringold. The two colonies will produce approximately 5700 young gulls this season, with 12 per cent and 35 per cent, respectively, of the hatching completed.

BIOLOGY AND MEDICINE - 06 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Deuterium

Yeast cells were cultured in synthetic media containing 0, 50, and 99 per cent $D_2O$. Cells in 0 and 50 per cent $D_2O$ grew nearly equally well with a slightly longer lag period in the cultures with deuterium. With 99 per cent $D_2O$ the lag period extended through twenty-eight hours and once growth started, the growth rate was only about half that in the control cultures.

Uptake of all substances studied was depressed in cells grown in 99 per cent $D_2O$. The reduction was, however, not uniform for all substances. Potassium uptake was reduced about 50 per cent, glucose uptake about 60 per cent, and phosphate uptake about 92 per cent as compared with controls. It appears that membrane permeability is affected by $D_2O$ and this may be the result of the dependence of the membrane potential on potassium and hydrogen ions.

Strontium and Calcium

In an attempt to determine whether the site of action of dinitrophenol (DNP) is in the shoots or in the roots, rates of transpiration and calcium and DNP accumulation were determined in plants with roots killed by boiling or freezing. The method of killing had a profound effect upon the results obtained when the roots of the treated plants were placed in solutions containing DNP and calcium ions. Transpiration was reduced by about 50 per cent in plants with boiled roots and by about 75 per cent in those with frozen killed roots. DNP caused no further reduction in transpiration. In both sets of killed roots, the DNP content was markedly reduced and there was no accumulation of DNP in the shoots. On the other hand there was an eight-fold increase in the accumulation of calcium in the shoots of plants with boiled roots and a three-fold increase in uptake in plants with frozen roots. At the moment it is not clear why a dead root is not merely a dead root.

A porometer was prepared and attached to a barley leaf to measure the air flow through the leaf. Changes in this air flow are assumed to be due to changes in the stomatal openings. When DNP was added to the root environment, the air flow ceased within forty-five minutes. A similar closure of the stomatal openings was obtained by cutting the leaf either in air or under water. Although stomatal closure is induced by DNP, it is not clear whether this closure is due to a direct action of the inhibitor on the stomata or to a change in the ease of water movement through the roots causing a water deficit in the shoot.

Previous work has shown a rapid equilibration of calcium and strontium between the inner wood portion of bean stems and the outer phloem of the stems. To determine whether this equilibration was caused by lateral movements between these tissues or to vertical transport, a plastic film was inserted between the wood and the bark tissues in the stem. Some strontium movement was noted both in an upward direction and in a downward direction in the phloem tissue. Upward movement was extremely rapid in wood but very slow (less than 1 cm per day) in the bark or phloem tissue. Data on calcium uptake are not yet available.

The tentative results of a series of tests to study the distribution of $Sr^{90}$-$Y^{90}$ in yearling trout after a single oral administration of 1.3 μc per fish showed that the body burden was about 19 per cent of the given dose at seven days after feeding. The maximum concentration observed in the blood was $1.8 \times 10^{-3}$ μc/ml at 48 hours. The force-fed isotope is transported through the gastrointestinal tract within 24 to 48 hours. On the average the concentration of isotope observed in the hind-gut increases sharply to a maximum of about 40 per cent of dose at 24 hours and decreased rapidly to less than 0.2 per cent of dose at the end of 48 hours.

Five miniature swine that have been on the 25 μc/day level of $Sr^{90}$ during their entire 19-month lifetime together with five control swine were intravenously injected with $Fe^{59}Cl_3$ and $Cr^{51}$-tagged red cells. The $Fe^{59}$ was cleared very rapidly from the plasma of all animals; however, the rate of clearance was more rapid in the animals exposed to $Sr^{90}$. Consistent with this finding was the observation that the uptake of $Fe^{59}$ by the erythrocytes of the $Sr^{90}$ group was also more rapid. (Calculations of red-cell survival as determined from $Cr^{51}$-tagging will require a longer period of study.)

If these initial observations on differences in the rates of $Fe^{59}$ loss in plasma and uptake by erythrocytes are confirmed in future studies, this method will have proved to be a sensitive indicator of damage following administration of a bone-seeking isotope. (To our knowledge, this test has never been applied in animals administered bone-seeking radionuclides.)

(Preparations are being made to begin the next phase of the study on the binding of strontium and calcium in blood. In the planned studies we will attempt to verify the earlier observations regarding the presence of non-exchangeable calcium in the blood of sheep, extend the studies to other species and begin studies on the effect of non-exchangeable calcium on strontium-calcium discrimination and the calcium regulatory processes).

Iodine

The study of the uptake and retention of $I^{131}$ in the thyroids of newborn and week-old lambs was completed. As stated in April, the preliminary results indicated a very rapid equilibrium between $I^{131}$ in the blood and thyroid of the lambs, and the low clearance of $I^{131}$ for endogenous excretion. (Since these lambs were from ewes receiving a diet containing marginal amounts of stable iodine, it may be of interest to study the effects of increased stable iodine on the blood-thyroid relationships and the endogenous excretion of $I^{131}$. It would also be of interest to repeat these studies in older animals.)

## Plutonium

Further studies with the new chelating agent (2-(B-aminoethoxy) cyclohexylamine - N,N,N',N', tetraacetic acid) indicate that it is only about one-half as effective as DTPA in promoting the excretion of plutonium injected into rats 18 days prior to treatment with the chelate. It is also less effective than DTPA when administered orally (6 mM/kg) one hour after intravenous injection of plutonium. It is, however, significantly effective via the oral route causing the excretion of some 45 per cent of the injected plutonium compared to about 60 per cent excretion in the DTPA treated animals and about 10 per cent excretion in untreated controls. It is of interest that the new agent, like another cyclohexylamine derivative previously tested, was more effective than DTPA in promoting excretion via the feces.

## Radioactive Particles

Twenty-two dogs exposed to $Pu^{239}O_2$ in October 1959 were given a periodic examination. Chest X rays show no obvious changes, although respiratory rates of a number of the dogs are high. Blood lymphocyte levels are below the normal range in all dogs. Electrocardiograms are being added to the routine examination of the plutonium-treated dogs since there is indication of a shift in the electrical axis of the heart in several dogs. Three dogs were exposed to $Pu^{239}O_2$ aerosols to continue studies of the effect of particle size on retention and translocation.

Preparations are nearly complete for cesium inhalation studies on rats.

Results of inhalation studies on rats with dust containing $Np^{237}$ are complete. At three weeks after exposure lungs contained about 2 per cent of the total $Np^{237}$ deposited. During this period about 2 per cent was excreted in urine and 95 per cent in the feces. In 30-day toxicity tests on 80 rats, only three deaths occurred. These occurred at the highest dose level, 200 picocuries (or 1 mg total dust) deposited in the lung. There was evidence of possible kidney damage. These effects were probably due to chemical toxicity of such materials as uranium, a major constituent of the dust, and not due to radiation from $Np^{237}$.

## Transfer of Radionuclides to Milk

In order to determine the ratio of radionuclides in the blood and milk and also the per cent of the administered dose in the milk, two ewes in late gestation and early lactation were administered a combination of radionuclides daily by the oral route. Both ewes received 200 μc $Cs^{137}$, 25 μc $I^{131}$, and 125 μc $Sr^{90}$, and one received, in addition, 100 μc $P^{32}$. A total of 26 samples each of blood and milk from each ewe was collected over a 21-day period. The quantity of milk produced in a 24-hour period was also determined.

The milk to blood ratio of each of the radionuclides after three days of oral administration is as follows: $P^{32}$ - ~15; $I^{131}$ - 8 to 35; $Cs^{137}$ - 10 to 20. There was considerable variation between animals, days, and time of day the sample was obtained.

## Gastrointestinal Irradiation Injury

Interpretation of the pathological findings on rats kept for duration of life following daily ingestion of 100 or 500 μc $Y^{90}$ for a sixty-day period, have been completed. A tumor arising in the intestinal tract was observed in only one out of one-hundred rats exposed in this manner. There were numerous neoplasms observed in the oral and uterine regions. There were, in addition, a number of corneal lesions indicating that radiation exposure to the head and mouth was of major consequence in this study. Absence of long-term effects in the intestine itself is noteworthy especially in view of the tumorgenic effects in organs exposed to radiations which originated within the lumen of the intestine. In man such exposures of adjacent organs should be much less significant in view of the comparative geometries involved. These results are not in accord with some limited previous studies and a careful interpretation and probably more extensive studies will be required.

## Fish Eggs as Bio-Dosimeters

The parameters necessary for fabrication of a life support system for salmon and/or trout eggs have been defined. It was necessary to take into consideration oxygen consumption, critical oxygen tension, temperature, pH, volume, carbon dioxide toxicity, mineral metabolism, heat production and other factors.

## Plant Ecology

Studies are in progress to determine environmental criteria for three of the dominant plant communities (bitterbrush, sagebrush, and greasewood) of the Hanford Reservation. Soil moisture determinations, which have been made routinely since mid-January indicated that soil moisture penetration during the 1960-61 growing season was deepest in the bitterbrush soil (2.8 meters), shallowest in the sagebrush soil (0.9 meters) and intermediate in the greasewood soil (1.4 meters).

## Project Chariot

Plans and arrangements for the 1961 Project Chariot field program were completed. Analyses were in progress on the $Sr^{90}$ content in samples collected during the summer of 1960 and in samples of caribou obtained during the past winter.

Manager
BIOLOGY LABORATORY

HA Kornberg:es

C. Lectures

a. Papers Presented at Meetings

W. J. Bair, "Radiation syndrome and mortality in dogs after inhalation of $Pu^{239}O_2$," Radiation Research Meeting, Washington, D.C., May 15, 1961.

M. F. Sullivan, "The influence of X-irradiation or nitrogen mustard administration on sugar absorption," May 14-17, 1961, Radiation Research Meeting, Washington, D. C.

J. R. McKenney, "$Sr^{90}$ and $Ca^{45}$ Binding in Blood of Sheep," Radiation Research Meeting, Washington, D.C., May 15-17, 1961.

b. Seminars (Biology)

R. H. Schiffman, "Bio-research problems related to charge particle radiations in the space environment," May 10, 1961.

M. P. Fujihara, "Microbiological studies of Chondrococcus columnaris," May 10.

W. C. Hanson, "A New Method for Measuring Water Fowl Dispersion," May 24.

H. V. Koontz, "Photosynthate Production and Translocation as a Function of the Physiological Age of the Barley Plant", May 24.

c. Seminars (Off-Site and Local)

L. K. Bustad, "Biological Effects of $I^{131}$," exchange seminar, Washington State University, Pullman, Washington, May 4, 1961.

L. K. Bustad, "Somatic Effects of Radiation," Veterinary Toxicology class, Washington State University, Pullman, Washington, May 4, 1961.

L. K. Bustad, "Radiation Tumorigenesis and Life Shortening," Radiation Biology class, U. of Washington Extension Center, Richland, May 17.

W. H. Rickard, "Fallout and Environmental Problems," Radiation Biology class, U. of Washington Extension Center, Richland, May 24.

E. M. Uyeki, "Modification of Radiation Injury," Radiation Biology class, U. of Washington Extension Center, Richland, May 31.

W. J. Bair, "Pathologic Effects," Radiation Biology class, U. of Washington Extension Center, Richland, May 3, 1961.

W. J. Bair, "Radiation Syndrome," Radiation Biology class, U. of Washington Extension Center, Richland, May 10, 1961.

D. Publications

a. HW Documents (none)

b. Open Literature

Bair, W. J., D. H. Willard and L. A. Temple, "The behavior of inhaled $Ru^{106}O_2$ particles," Health Physics 5, 90-98 (1961).

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

## ORGANIZATION AND PERSONNEL

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

## OPERATIONS RESEARCH ACTIVITIES

### Input-Output Model

Work continued in an effort to transfer some of the learning patterns found in specific processes to over-all plant operations. A report summarizing progress to date is being prepared.

## OPERATIONS ANALYSIS STUDIES

### Fuel Element Performance

Available X-ray diffraction data are being analyzed to see if such data are potentially useful in predicting dimensional distortion during irradiation. These data are being correlated with post-irradiation measurements from Quality Certification fuel elements. Although only one fuel element per lot has an X-ray diffraction measurement taken, preliminary analyses indicate that such a measurement may have real value.

A listing of lots representing nonroutine production fuel elements was compared with post-irradiation results to determine if some of the outlying data points observed are explainable by these unusual lots.

Use of available computer programming techniques have greatly simplified certain analyses of rupture data, thus making it possible to develop many models for the same set of data, where the data are divided into equal power-temperature cells in different ways. It was found that the use of weighted regression techniques on a specific set of hole failure data led to results relatively unaffected by how the data were grouped.

Confidence limits were found for the ratio of dingot to ingot rupture rates.

### Optimization of Reactor Operations

Optimum sizes were determined for supplemental crews during the period after conversion to bumper fuel elements. Existing formulas developed last year were used with some modifications. One change which affects the answer a fair amount replaces charge-discharge rates theoretically achievable by more realistic ones based on past data and projected to the future.

Z-Plant Information Systems Studies

A brief description of the Z-plant process control computer system and the associated concepts was presented at the Research and Development Meeting held by the General Manager, CPD, on May 11. Control coverage for the Products Processing Operation has been eliminated in order to accommodate recent changes in the basic concept of the Fabrication Operation within the memory limitations of the computer. These changes are currently being compiled by the IBM 7090 program assembler. The resulting machine language program will have to be sent to Phoenix to be put in the proper form for entering it into the General Electric 312 process control computer. On-line debugging should be in progress by June 8.

Reliability Studies

A study of the application of Boolean matrices to system reliability problems was initiated. Possible areas of application are being explored to demonstrate the usefulness of the method.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Data were analyzed from a designed experiment conducted in the pilot plant concerned with optimizing the canning cycle for nickel-plated fuel elements. This recent experiment was conducted at sets of conditions adjacent in three-space to a previous set analyzed in February. The region of optimum performance located for the new set of data agreed very well with that found for the original set.

Further warp data from NPR-inner fuel elements were analyzed. Of interest was the direction of warp with respect to some reference point, both before and after the heat treating. Results found were very consistent with those previously determined.

Some descriptive statistics were found for pre-irradiation dimensional measurements on a sample of OIIT and OIVT fuel elements.

Irradiation Processing Department

A study is being made of the feasibility of objectively monitoring electrical pulses showing power consumption in the 100 and 300 areas. The intent is to restrict the number of pulses observed in any given 30 minute period below a given amount by supplemental power generation when the quickened frequency of pulses indicates that power consumption has increased. This is important because monthly billing is based on maximum consumption during any given 30 minute period. Currently, the decision to generate additional power is based on operator judgment.

As a result of preliminary findings in the investigation of thermocouple variation, a more detailed analysis is being made to determine how much of the

discrepancy between thermocouple and thermohm readings is possibly due to thermohm error. Originally, it was assumed that the thermohm results were without error.

Comments were given in connection with the potential effect of a longer autoclave cycle on rupture rates.

Under present methods of discharging enriched fuel elements, there is a possible criticality problem should a sufficient number of fuel elements discharged from the near and far side of the reactor fall in the center chute. The probability of such an occurrence was calculated under various sets of assumptions.

Some further fission product decay curves were fitted using the recently developed computer program for the estimation of parameters in a nonlinear least square situation.

Chemical Processing Department

An analysis was made on dimensional measurements performed by three groups on fabricated parts. Since the measurements were performed over a considerable period of time, it is impossible to objectively sort out all the source of variation that may exist. More work will be done in this area.

Results of an analysis of data from Task III - the reduction of plutonium fluoride to buttons - were reported. This analysis was performed primarily in order to provide background information on the feasibility of using evolutionary operation techniques at this process step.

An examination is being made of data from the casting operation to assist in determining possible causes leading to castings not meeting radiographic specifications.

Comments were submitted to personnel concerned with determining what size of cesium shipments leads to the smallest risk due to potential incidents.

Work was begun on a queuing theory study of motor vehicle use in the 200 Areas for the Facilities Engineering Operation, CPD.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Chemical Development

A machine calculation is being done on mid-column photometer calibration data to determine the best mathematical method of correcting for the temperature difference between calibration and experimental runs. The results from the first machine analysis indicate that a slight change in the mathematical

[redacted]

model would enhance the experimental fit. A second set of mid-column photometer calibration data was taken under conditions closely approximating those of an actual experimental run on the pulse column. This data is being analyzed to determine the appropriate schedule for interspersing pulse column sample stream readings and pure water standard readings.

An experimental program was designed for the first full scale pilot study using the pulse column test apparatus. The program uses 16 experimental runs to investigate the relative importance of five independent variables, column capacity, aqueous to organic flow ratio, feed concentration, pulse amplitude frequency product, and pulse amplitude, on the response variables, waste stream concentration and the column concentration as a function of height.

Materials Development

Tolerance statements describing the population of graphite bars currently under consideration for use as NPR moderator were constructed from components of variance analyses on tensile strength measures, electrical resistivity, thermal conductivity and coefficient of thermal expansion data supplied by Materials Development Operation. The statements on the tensile strength properties were extremely loose. An alternative method of calculation based on extreme value statistical theory is being used in an attempt to tighten up these statements.

Corrosion Studies

A new method of estimating aluminum corrosion penetration during the breakaway stage, which is independent of any assumption on the pre-induction time corrosion mechanism was used to analyze M-400 and X-8001 alloy corrosion data. The results of the analysis were discussed with Coating and Corrosion personnel. All phases of the analysis are complete now and the evaluation in agreement with previously formed notions about the effect on corrosion rate of heat treating variables except for a peculiar dependence on the method of cooling samples following anneal. In an attempt to untangle the cooling method effect a multivariate analysis of variance is being done on some of the corrosion data.

4000 Program

Swelling Studies

The pore size distributions read on the Zeiss particle size analyzer have been transcribed onto IBM cards with appropriate identifying variables, and a master listing has been printed by the IBM 7090. Short programs are now being written to calculate void fraction and void density estimates for each of these pore size distributions.

Plutonium Recycle

Structural Materials Development Operation has not been able to obtain 32 tubes to perform the experiment to investigate the reliability of a fluorescent penetrant nondestructive test for the detection of surface defects on zirconium

[redacted]

tubes. A revised experimental plan was provided to accommodate 16 tubes. Experimentation has started with the investigation of five factors: operator effect on tube preparation, penetrant oil bath time effect, emulsification bath time effect, developer drying time effect, and operator reading effect, with a half replicate of a $2^5$ factorial design embedded in a balanced imcomplete block design, using the 16 tubes as blocks and the 16 factor level combinations of the factorial as treatments.

Statistical analysis of data from a high energy uranium oxide impacting test conducted by Fuels Development Operation is still in progress.

The first experimental run on particle packing using pre-calculated particle sizes and size ratios has yielded densities well above anything previously determined. Further experiments are in progress.

6000 Program

Biology

Statistical analysis of data from an experiment involving irradiation of a population of Mediterranean flour moths was completed and results reported to interested personnel of Biology.

Work continued on the extension to the diffusion equation of the multicompartment migration model. The multicompartment migration model was applied successfully to biological data made available by the Biology Operation. Results of this and an earlier study showed good agreement with experimental observations.

General

Instrumentation

In cooperation with Instrument Research and Development, a mathematical model is being developed to aid in the study and design of a proposed neutron flux monitor. An appropriate program is being written in an effort to optimize the desired characteristics of this detector.

Division of Research Programs

The major share of program sample data has been transcribed onto IBM cards, and the first draft of the magnetic tape master file should be ready about June 1. The least squares procedures for estimating total count at time zero and half-life of correlated counting data have been debugged and are ready for use in the evaluation of master file data.

The investigation into the question of determining what inferences could be made as to reactor characteristics and/or exposure levels, given a knowledge of Pu isotopic concentration, was completed.

[redacted]

[redacted]

MISCELLANEOUS

Methodology

Theoretical Physics personnel have adapted the program proposed in LA-2367 "Solution of the General Least Squares Problem with Specific Reference to High Speed Computers" to the IBM 7090. In addition to the changes made by them, further modification is now being made which will force reduction of the residual sum of squares on every iteration. This should result in convergence for a number of cases which to date have blown up. The modification is called NELLY. It will be available shortly for laboratory use through Operations Research & Synthesis Operation.

Z. E. Carey

for Carl A. Bennett, Manager
Operations Research & Synthesis

ZE Carey:kss

[redacted]



[redacted]

PROGRAMMING OPERATION
MAY, 1961

## A. REACTOR DEVELOPMENT - 4000 PROGRAM

### 1. PLUTONIUM RECYCLE PROGRAM

Computer Code Development. The PROTEUS 2 code was completed during the month and is now used routinely. As expected, the required computing time as compared with PROTEUS 1 is reduced by better than 50%, while retaining comparable accuracy.

The specific power extrapolation feature of PROTEUS 2 was checked by running the MELEAGER code at a number of specific reactor powers and using PROTEUS 2 to predict the results. The basis of comparison in this study was the Total Fuel Cost (TFC, mills/kwhe) calculated with a typical set of economic parameters. The percentage error in using PROTEUS to extrapolate the specific power of a typical reactor case is shown below:

$$\text{Error in PROTEUS Extrapolation of Specific Power} = \frac{(\text{PROTEUS TFC} - \text{MELEAGER TFC})\ 100}{\text{MELEAGER TFC}}$$

| Specific Power of Base Case, MW/T | Exposure MWD/T | Extrapolated Specific Power, MW/T 5 | 10 | 15 | 30 | 40 |
|---|---|---|---|---|---|---|
| | | Error, % | | | | |
| 5 | 19,190 | 0 | 4.4 | 7.2 | 12.3 | 13.2 |
| 10 | 20,270 | -3.0 | 0 | 2.2 | 6.3 | 6.9 |
| 15 | 20,760 | -4.2 | -1.9 | 0 | 3.7 | 4.2 |
| 30 | 21,540 | -6.2 | -4.7 | -3.2 | 0 | 0.4 |
| 40 | 21,610 | -6.4 | -5.0 | -3.5 | -0.4 | 0 |

By using PROTEUS 2 to generalize a MELEAGER calculation made in the middle of the specific power range, say 15 MW/T, the resulting maximum error in Total Fuel Cost in the above table is about 4 per cent. This is considered acceptable accuracy for rapid survey-type calculations in view of the great economy in IBM-7090 machine time realized by using PROTEUS 2 instead of running MELEAGER for all cases. MELEAGER, or even more sophisticated codes, can always be employed for specific cases when maximum possible accuracy is desired.

Calculations in support of a flux-volume weighted burnup study have been initiated. Present fuel cycle calculations assume that all fuel elements in a reactor accumulate exposure at an equal rate, whereas actually the fuel elements accumulate exposure at varying rates depending on their location in the reactor. The new calculation routine utilizing flux and volume weighting is expected to lead to more accurate reactor physics calculations, and subsequent fuel costs. Additional work is required, however, before programming for the 7090 computer is started.

The programming of a new economics code called "The Plutonium Fuel Value Economics Program", is nearing successful completion. The code, which is being programmed by EDPO personnel, computes the total power reactor fuel costs using strict accounting procedures. The two main sections of the program, FEFJ (Fuel Element Fabrication and Jacketing), and NPC (Nuclear Process Costs), are programmed. Debugging of the FEFJ portion of the program is nearing completion. Test cases of this portion using varying recycle factors appear to give correct answers. Initial debugging of the NPC portion of the program is in progress.

At months end, work was started to prepare and store duplicate symbolic and binary PUCK decks in Records Center.

PRP Planning and Analyses Activities. Work has been initiated for preparation and issuance of the FY-1961 PRP Annual Report. Contributors for each section have been designated and preparation and writing is in progress.

Planning has continued to develop the most workable procedure for scheduling irradiation tests in the PRTR for the various R and D customers. Integration among the various programs will be required to minimize conflicts between experiments and maximize the new and useful information procured. Assistance has also been provided in scoping the Fuels Recycle Pilot Plant to maximize capabilities and future flexibility within available budgeted funds.

Studies directed at the development of the economics of a fuel cycle utilizing the salt cycle process were continued. In order to minimize the cost penalty to be borne by fuels fabricated from plutonium-containing materials, it appears that the plutonium which is recycled to the reactor should be concentrated in as few fuel elements as possible within the limits of reactivity and heat generation imposed by the particular reactor system. Thus the reactor would be fueled with a uranium-only zone and another zone of mixed plutonium-uranium fuel. The relative sizes of such zones are significant factors in the manner in which the salt cycle plant is to be operated, and the resulting processing cost. Other factors influenced by the zoned reactor system include inventories, shipping costs, blending costs and, of course, the processing plant operating costs. Preliminary calculations indicated that the burnout costs are relatively insensitive to the sizes of the zones. It appears that existing computer codes for fuel-cycle analyses can be modified fairly easily to accommodate the present economic study. Study of the problems of remote fabrication of fuel elements was

also initiated to round out the fuel reconstitution cycle along with the economic analysis of the salt cycle decontamination process.

2. SPECIFIC CYCLE ANALYSES

Special Studies. The Atomic Energy Commission announced reduction in the cost of natural uranium feed to $23.50/kg U as $UF_6$ effective July 1, 1961 has prompted the calculation of a new set of enriched uranium costs. Print-outs of the results are available for on-site use and are also stored on magnetic tape.

Supercritical Reactor. The Supercritical Pressure Power Reactor (SPPR) fuel cost study was virtually completed during the month. Fuel costs for varied water gaps indicate that 1/2-inch water gaps between fuel assemblies results in close to optimum fuel costs. As indicated in the table below, slightly lower costs were calculated for a 0.4-inch water gap, but space limitations may require at least a half-inch gap.

SPPR MINIMIZED TOTAL FUEL COST/VS. WATER GAP FOR GRADED OPERATION

| Water Gap, (Inches) | 0.4 | 0.5 | 0.7 | 1.0 |
|---|---|---|---|---|
| MTFC, (Mills/KWH) | 2.79 | 2.83 | 3.14 | 3.15 |

Note: Results calculated at 15 MW/T of contained U with economic parameters as specified in the "Nuclear Power Plants Cost Evaluation Handbook."

A number of fuel elements were analyzed to determine the effect of specific power with the constraint of equal hot spot $UO_2$ temperature. With this condition applied, the fuel costs increase at high specific powers because so much parasitic material must be inserted in coolant channels in order to maintain equal hot spot temperatures. On the other hand, at low specific powers the total fuel cost again increases because of higher costs for interest charges. Thus, the optimum for the Supercritical Reactor appears to range in the neighborhood of 12 to 15 megawatts/ton of contained U.

MINIMIZED TOTAL FUEL COST VS. SPECIFIC POWER WITH GRADED OPERATION

| Specific Power (MW/T) | 10 | 12 | 15 | 20 |
|---|---|---|---|---|
| MTFC (Mills/KWH) | 3.08 | 3.03 | 3.02 | 3.98 |

Note: Results obtained with moderating power maintained constant and with conditions approximately equivalent to those used in the previous table. Economic parameters as specified in the "Nuclear Power Plants Cost Evaluation Handbook."

The new, lower uranium price schedule effective July 1, 1961 will reduce the above fuel costs by approximately 20 to 25 per cent for this reactor, reducing the minimum cost to something less than 2.5 mills per KWH. The near-optimum case, 0.5-in. water gap, will be repeated with the new price schedule.

Advanced Pressurized Water Reactor. The physics calculations for the revised study of the APWR have been completed except for some corroborative data to be included in the appendix for the final report. Data are available for the initial uranium-235 enriched runs followed by runs with fuel containing plutonium recycled from the previous run, plus an additional amount of uranium-235 to meet four specified values of the initial multiplication constant. The data include both batch and two types of graded discharge cases. The two different types of graded cases termed "noninteracted" and "fully interacted" result from two separate assumptions in regard to the neutron energy spectrum. In the fully interacted case, it is assumed that the neutron spectrum is constant with respect to time and position in the reactor. For the noninteracted case, it is assumed that the spectrum does change with time for an individual fuel bundle, just as in the batch case, but that the time averaged multiplication constant can be used to determine the cycle end-point. A "true" graded case in an operating reactor is expected to fall between a noninteracted and a fully interacted graded case as described above. Work is under way to determine plutonium values and various economic minima based on the physics data mentioned above.

B. OTHER ACTIVITIES

Evaluation has continued of the potential hazards of shipping thousands of curies of long-lived radionuclides. The work reported last month for cesium has been extended to include the shipment of radio-strontium both as strontium carbonate crystals, and as the cation adsorbed on Decalso inorganic ion exchange material.

Consulting assistance has been provided the Irradiation Processing Department in evaluating potential radiological hazards associated with certain postulated off-standard operating conditions.

One member of Programming participated in the meeting of the Columbia River Advisory Group in Portland, Oregon, during the month, relative to the effect of the Hanford Plant on the Columbia River.

Dr. R. H. Mole, of the Harwell, Atomic Energy Research Establishment (England) was the Hanford Science Colloquium speaker on May 5. Dr. Mole is well known as an authority on the biological effects of radiation and is Deputy Director of the Medical Research Council at the Harwell laboratory. His topic was "Radiation as a Toxic Agent".

On May 31 Professor George Gamow, of the University of Colorado Physics Department was the third Hanford Science Colloquium speaker for 1961. Dr. Gamow has a world-wide reputation both as a theoretical physcist and as a writer who interprets science subjects for the layman. His topic was "Thermonuclear Reactions in Stars". Dr. Gamow also presented a seminar on June 1 on the subject "Molecular Genetics".

Hanford Laboratories off-site visitors totaled 208 during the month. This included 40 visitors on 32 official visits, and 168 students, teachers, and Union auxiliary members on 8 separate scheduled tours. It also included 1 Swedish, 1 Japanese, and four British visitors.

F. W. Woodfield
Acting Manager,
Programming

FW Woodfield:rd

# RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF MAY, 1961

## A. ORGANIZATION AND PERSONNEL

Lois S. Peter, Stenographer, was assigned to the Radiation Protection Operation on May 8. Charles A. McCoy, Radiation Monitor Journeyman, transferred into the Radiation Monitoring Operation on May 8 from Finished Products Operation, CPD. Rosa S. Hoffman transferred into the Environmental Studies & Evaluation Operation on May 15 as a Technologist, Radiation Evaluation.

## B. ACTIVITIES

There were no new cases of plutonium deposition confirmed during the month. The total number of plutonium deposition cases that have occurred at Hanford remains 267, of which 194 are currently employed.

Three minor injury cases were examined for plutonium contamination in the Whole Body Counter. No detectible plutonium contamination was found in two cases while the other showed minor plutonium contamination estimated as $1.7 \times 10^{-3}$ μc Pu with no medical action taken.

A crew of four IPD employees received significant skin and nasal contamination at 105-F Reactor while preparing a reactor process channel for borescoping. A cloud of black dust was noted when the bayonet was removed from the process channel. The men replaced the bayonet and hosed down the charge elevator without wearing respiratory protection. The Whole Body Counter showed Zn-65 deposition ranging from 0.04 μc (0.06% mpbb) to 0.9 μc (1.5% mpbb) and Na-24 deposition ranging from 0.009 μc (0.13% mpbb) to 0.4 μc (6% mpbb). The Na-24 had essentially disappeared in 8 days while 10% of the Zn-65 was seen in the Whole Body Counter taken at 18 and 31 days after the intake.

Studies of the above inhalation cases involving Zn-65 revealed that the initial elimination of this radionuclide was more rapid when inhaled than when ingested. One subject eliminated 68 percent of his initial burden within two days after inhalation and retained only 15 percent of his initial burden after one week. Of the remaining two subjects, one eliminated 83 percent of his initial burden in five days, while the other subject, although showing a rapid clearance, still had 40 percent of this initial burden after two weeks.

At the Hot Semiworks Facility, when the twelve Cambridge filters of the "Patio" stack were changed, they were contaminated to 10 rads/hour. One was found damaged. Patio stack emissions since then have been on the order of 1 to 15 μc of strontium per day with a maximum emission of 99 μc occurring in one day.

The process stack emission, since the start of the separation of strontium at the Hot Semiworks to 0955 May 25, has been $8.8 \times 10^{-2}$ curies of strontium (about $2.7 \times 10^{-2}$ curies of $Sr^{90}$). The high stack emissions should be reduced when a backup filter is installed. This work is scheduled for completion by the start of the third run.

At the Plutonium Recycle Test Reactor incremental attainment of power levels to 15 Mw were supported by studies evaluating shielding adequacy, neutron flux changes, dose rate changes, metal activation, and airborne contamination. Several shield locations showed evidence of beams; the maximum found at one of the flux monitoring channels was 460 mrem/hour, including 450 mr/hour. Dose rates to 2 rem/hour were found in the lower access area. Metal activation was not in evidence. An air contamination problem was encountered at 5 Mw when concentrations ranging to $2.3 \times 10^{-5}$ μc/cc, identified as nuclides in the $Kr^{88}$ and $Xe^{138}$ chains, prevailed throughout the vessel. Numerous leaks in the helium system were eliminated and air concentrations had decreased to values approaching $10^{-9}$ μc/cc when the reactor was shut down late in the month.

A release to the atmosphere of particulate fission product contamination occurred in the 327 Building as a result of a faulty, overloaded, or improperly seated filter. Operations in B Cell were suspended until a filter change could be effected. Initial estimates indicate approximately 0.1 curie was discharged to the atmosphere.

Three aerial monitoring flights were made during the month which completed background surveys with the NaI crystal for all proposed flight patterns. Readings of the radioactivity from sandbars located in the Columbia River near Astoria, Oregon were higher than expected and followup surveys will be conducted to define the activity more accurately.

The Automatic Columbia River Monitoring Station operated satisfactorily during the entire month. Unscheduled downtime was limited to approximately three hours due to a failure of the jet pump. The system was recalibrated for response to $Co^{60}$ following installation of the solid state amplifiers.

Hazards evaluations continued on the potential hazards associated with the shipment of multicurie quantities of radioisotopes of strontium and cesium. The evaluation of $Cs^{137}$ was essentially completed. Work also continued on evaluation of the consequences of a maximum credible accident in the Fuels Recycle Pilot Plant.

The major design criteria of the Fuels Recycle Pilot Plant (FRPP) were discussed at a number of meetings throughout the month. Linear air flow rates for the two major cells have been agreed upon. Several changes have been made in shielding material; high density concrete has been replaced by ordinary concrete in several instances by using thicker walls. Two sets of radiation instrumentation

requirements have been presented; one proposing a complete system based on the total available instrumentation technology and the other based on the bare minimum instrumentation required to provide an operable facility. Building layout, radionuclide sampling, material handling, and waste disposal features of the facility are fairly well scoped.

At the Calibration Building, improvements in the radium source rupture monitoring system are to be added to each source well to provide prompt signals of any source ruptures. No major problems should be encountered in the installation of the associated air sampling pipe arrangements.

A device for pressure coding of dosimeter film from temporary personnel dosimeters was built using a modified perforator. It could not provide sufficient pressure to give the required darkening. Further tests also proved that it was not possible to stretch the film uniformly over the area of a coding dot to produce a density acceptable for automatic reading. A system to be used for X-ray marking the binary code on temporary personnel dosimeters, in lieu of pressure marking, is being studied.

Criticality dosimetry measurements of the angular dependence were made on the moderated foil criticality dosimeter system. Exposures at angles to the long dimension have been made and the data are being analyzed. A purchase requisition for 300 moderated foil criticality dosimeter units has been issued.

Neutron dosimetry studies of the specially-built solid state neutron dosimeters were continued with sufficient data collected to indicate that the forward current and resistance measurements of unirradiated silicon diodes are reproducible to within 0.3% and lifetime measurements are reproducible to about 1.5%.

Preliminary studies on two lead pin-hole cameras indicate very good optical performance from a 0.013 inch optical aperture. Radiation performance characteristics were also given preliminary study. While some fringe effect is encountered with a 1/8 inch aperture, the response appears entirely satisfactory. This program has been given a high priority for completion in view of the potential immediate application in studies of the shielding at the PRTR.

Four 40-liter ion chamber instruments for low level dose measurements have been assembled and calibrated. Calibration curves and operating instructions are being attached to the instruments which will soon be made available for special survey applications through the Calibrations instrument pool.

C. TRIPS AND VISITORS

R. F. Foster represented the U.S.A. on the IAEA Panel on Disposal of Radioactive Waste to Fresh Water held at Vienna, Austria on May 5 to 14.

RPO staff members met with state and federal officials during a periodic CRAG meeting held in Portland, Oregon on May 3 and 4. Among the items discussed was a USPHS evaluation of persons exposed to HAPO origin radionuclides.

R. F. Foster met with the Industrial Waste Committee of Pacific Northwest Pollution Control and attended the Pacific Northwest Industrial Waste Conference at Pullman, Washington May 24 - 26.

H. G. Ruppert participated in a training exercise at Mercury, Nevada, May 8 through 12.

K. R. Heid presented a talk entitled, "After Shelter - Then What?" to members of the Region VIII Civil Defense Council Conference at Boise, Idaho on May 18 and 19.

Consultations on film dosimetry were provided on May 22 to W. L. Gill of Newport News Shipbuilding Company, Virginia.

Nelson Gardiner of the University of California discussed plutonium hoods and enclosures on May 3.

On May 2, 31 students from Yakima Junior College and on May 18, 28 students from Odessa and Selah High School visited the Calibrations Building.

D. EMPLOYEE RELATIONS

Seven suggestions were submitted by personnel of the Radiation Protection Operation during the month, bringing the year to date total to twenty-two. One suggestion was adopted and none rejected. Sixteen suggestions submitted by RPO personnel are pending evaluation.

There were three medical treatment injuries during the month for a frequency of 1.22. No security violations occurred during May.

Radiation Protection training included: Several lectures to the AEC Fellowship students at the University of Washington; orientation on specific aspects of radiation protection to maintenance personnel, patrolmen, firemen, critical mass facility personnel and to the personnel of a HAPO subcontractor.

E. SIGNIFICANT REPORTS

HW-69723 "Existing and Proposed Studies at HAPO Relating to the Columbia River" by R. F. Foster

HW-69561 "Hazard Analysis for Cesium Shipments" by E. C. Watson, R. L. Junkins, and J. J. Fuquay

HW-69817 "Monthly Report - May, 1961, Radiation Monitoring Operation" by A. J. Stevens

HW-67245 REV "Hanford Whole Body Counter Results for 1960" by F. Swanberg

Undocumented "Status of Knowledge of Columbia River Conditions" by R. F. Foster

"A Sensitive Pocket Dosimeter Reader" by H. V. Larson was published in the "Health Physics Journal".

"Resisting Changes in Electron Irradiated Graphite" by I. T. Myers, H. V. Larson, and J. S. Loomis was prepared for presentation at the Fifth Conference on Carbon.

"Waste Control at the Hanford Plutonium Production Plant", authored by R. F. Foster, R. L. Junkins, and C. E. Linderoth was published in "Journal Water Pollution Control Federation".

ENVIRONMENTAL MONITORING - RESULTS - (Mid-April 1961 - Mid-May 1961)

| Sample Type and Location | Activity Type | Monthly Average | Units |
|---|---|---|---|
| **Drinking Water** | | | |
| 100-F Area | Isotopic | 0.5 | % $MPC_w$-GI* |
| Separations Areas | Gross Beta | $2.4 \times 10^{-7}$ | μc/cc |
| Pasco | Isotopic | 8.8 | % $MPC_w$-GI** |
| Kennewick | Isotopic | <0.9 | % $MPC_w$-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 | 1.8 | % $MPC_w$-GI* |
| Hanford | Isotopic | 2.6 | % $MPC_w$-GI* |
| Pasco | Isotopic | 22 | % $MPC_w$-GI** |
| McNary Dam | Gross Beta | No Sample | |
| Vancouver, Washington | Isotopic | 0.5 | % $MPC_w$-GI** |
| **Atmosphere** | | | |
| $I^{131}$ Separations Areas | $I^{131}$ | $1.4 \times 10^{-13}$ | μc/cc |
| $I^{131}$ Separations Stacks | $I^{131}$ | 0.8 | Combined curies/day |
| Active Particles - Project | -- | 1.9 | ptle/100 $m^3$ |
| Active Particles - Environs | -- | 0.04 | 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 |
| Eastern Washington and Oregon | $I^{131}$ | No Samples | |

*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.

## EXPOSURE EVALUATION AND RECORDS

### Exposure Incidents above Permissible Limits

| | Whole Body | Localized |
|---|---|---|
| May | 2 | 2 |
| 1961 to Date | 3 | 5 |

### Gamma Pencils

| | Pencils Processed | Paired Readings 100-280 mr | Paired Readings Over 280 mr | Lost Readings |
|---|---|---|---|---|
| May | 4,054 | 32 | 2 | 0 |
| 1961 to Date | 22,842 | 280 | 15 | 0 |

### Beta-Gamma Film Badges

| | Badges Processed | Readings 100-300 mrads | Readings 300-500 mrads | Readings Over 500 mrads | Lost Readings | Average Dose Per Film Packet mrad(ow) | mr(s) |
|---|---|---|---|---|---|---|---|
| May | 9,765 | 1,024 | 109 | 11 | 52 | 9.55 | 21.67 |
| 1961 to Date | 50,199 | 4,719 | 517 | 118 | 152 | 9.34 | 21.40 |

### Neutron Film Badges

| | Film Processed | Readings 50-100 mrem | Readings 100-300 mrem | Readings Over 300 mrem | Lost Readings |
|---|---|---|---|---|---|
| Slow Neutron | | | | | |
| May | 1,426 | 0 | 0 | 0 | 3 |
| 1961 to Date | 8,009 | 0 | 0 | 0 | 30 |
| Fast Neutron | | | | | |
| May | 177 | 50 | 14 | 0 | 3 |
| 1961 to Date | 1,936 | 314 | 72 | 0 | 30 |

### Whole Body Counter

| | Male | Female | May | 1961 to Date |
|---|---|---|---|---|
| GE Employees | | | | |
| Routine | 45 | 0 | 45 | 273 |
| Special | 9 | 0 | 9 | 40 |
| Terminal | 0 | 0 | 0 | 1 |
| Non-employees | 13 | 0 | 13 | 24 |
| Pre-employment | 0 | 0 | 0 | 0 |
| Total | 67 | 0 | 67 | 338 |

### Bioassay

| | May | 1961 to Date |
|---|---|---|
| Confirmed Plutonium Deposition Cases | 0 | 4* |
| Plutonium: Samples Assayed | 545 | 2,943 |
| Results above $2.2 \times 10^{-8}$ uc Pu/sample | 12 | 75 |
| Fission Product: Samples Assayed | 641 | 3,271 |
| Results above $3.1 \times 10^{-5}$ uc FP/sample | 1 | 3 |
| Uranium: Samples Assayed | 251 | 1,394 |

*The total number of plutonium deposition cases which have occurred at Hanford remains 267, of which 194 are currently employed on plant.

Uranium Analyses

| Sample Description | Following Exposure Units of $10^{-9}$ uc U/cc Maximum | Average | Number Samples | Following Period of No Exposure Units of $10^{-9}$ uc U/cc Maximum | Average | Number Samples |
|---|---|---|---|---|---|---|
| Fuels Preparation | 27.1 | 4.3 | 58 | 30.8 | 3.8 | 55 |
| Fuels Preparation* | 0 | 0 | 0 | 0 | 0 | 0 |
| Hanford Laboratories | 10.2 | 3.5 | 24 | 30.0 | 4.6 | 24 |
| Hanford Laboratories* | 0 | 0 | 0 | 0 | 0 | 0 |
| Chemical Processing | 60.6 | 5.2 | 33 | 55.0 | 5.0 | 36 |
| Chemical Processing* | 23.1 | 19.1 | 2 | 8.3 | 8.3 | 2 |
| Special Incidents | 24.1 | 17.6 | 12 | 0 | 0 | 0 |
| Random | 2.1 | 1.9 | 5 | 0 | 0 | 0 |

*Samples taken prior to and after a specific job during work week.

| Thyroid Checks | May | 1961 to Date |
|---|---|---|
| Checks Taken | 0 | 0 |
| Checks Above Detection Limit | 0 | 0 |

| Hand Checks | | |
|---|---|---|
| Checks Taken - Alpha | 28,225 | 149,941 |
| - Beta-gamma | 41,909 | 230,066 |

| Skin Contamination | | |
|---|---|---|
| Plutonium | 32 | 117 |
| Fission Products | 61 | 251 |
| Uranium | 2 | 27 |

| CALIBRATIONS | Number of Units Calibrated May | 1961 to Date |
|---|---|---|
| **Portable Instruments** | | |
| CP Meter | 957 | 4,583 |
| Juno | 260 | 1,193 |
| GM | 496 | 2,753 |
| Other | 193 | 884 |
| Audits | 109 | 523 |
| Total | 2,015 | 9,936 |
| **Personnel Meters** | | |
| Badge Film | 1,620 | 7,419 |
| Pencils | - | - |
| Other | 457 | 1,981 |
| Total | 2,077 | 9,400 |
| Miscellaneous Special Services | 1,028 | 4,533 |
| Total Number of Calibrations | 5,120 | 23,869 |

R. F. Foster
for Manager
Radiation Protection

UNCLASSIFIED

# LABORATORY AUXILIARIES OPERATION
# MONTHLY REPORT - MAY, 1961

## GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 2.36 for the month and 3.02 for the year-to-date.

## TECHNICAL SHOPS OPERATION

Total productive time for the period was 21,418 hours. This includes 17,892 hours performed in the Technical Shops, 3,222 hours assigned to Minor Construction, 38 hours assigned to other project shops and 266 hours assigned to off-site vendors. Total shop backlog is 20,247 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 6.7% (1,449 hours) of the total available hours.

Distribution of time was as follows:

| | Man-hours | % of Total |
|---|---|---|
| Fuels Preparation Department | 3,420 | 16.0% |
| Irradiation Processing Department | 1,457 | 6.8% |
| Chemical Processing Department | 685 | 3.2% |
| Hanford Laboratories Operation | 15,593 | 72.8% |
| Construction Engineering & Utilities | 23 | .1% |
| Miscellaneous | 240 | 1.1% |

Requests for emergency service increased sharply, requiring an overtime rate of 6.7%, compared to 5.2% for the previous period. This increase is attributed mainly to shop work required by the PRTR.

There were eight medical treatment injuries, which is considered normal for this type of operation.

## CONSTRUCTION OPERATION

There were 51 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $71,504. Sixty-eight new orders, 6 supplements and adjustments for underruns amounted to $104,498. Expenditures during the month on HLO work were $52,069. Total J. A. Jones backlog at month's end was $123,933.

Summary

| | HL | | CE&UO | |
|---|---|---|---|---|
| | No. | Unexpended Balance | No. | Unexpended Balance |
| Orders outstanding beginning of mo. | 50 | 69,924 | 1 | 1,580 |
| Issued during the mo.(Inc.Sup.&Adj.) | 68 | 104,498 | | |
| J.A. Jones expenditures during mo. (Inc. C.O. Costs) | | 52,069 | | |
| Balance at month's end | 60 | 122,353 | 1 | 1,580 |
| Orders closed during mo. | 58 | 88,429 | | |

## FACILITIES ENGINEERING OPERATION

### Projects

There were 15 authorized projects at month's end with total authorized funds of $3,033,000. The total estimated cost of these projects is $8,338,000. The expenditures on these projects through April 30, 1961, were $898,000.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end 15

Number of new projects authorized during the month: 1
CAH-927 - Additions to 271-CR Building Waste Treatment Demonstration Facility

Projects completed during the month: 1
CAH-870 - Facility for Recovery of Radioactive Materials - 325-A Building Addition

New project proposals submitted to AEC during month: 2
CAH-927 - Additions to 271-CR Building Waste Treatment Demonstration Facility
CAH-932 - Laboratory Waste Retention Facilities Expansion

New projects awaiting AEC approval:
CAH-917 - Field Service Center
CAH-932 - Laboratory Waste Retention Facilities Expansion

Proposals complete or nearing completion are as follows:
Safety and Operating Improvements - 231-Z Building
Modification to H-1 Loop - 105-H Building

CGH-935 -Metals Storage Building, and CAH-936 - Coolant Systems Development Laboratory were transmitted to Contract Accounting, but did not go to the Commission during the month.

## Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals.

| Title | Status |
|---|---|
| Pressure Vessel and Piping Systems - Engineering & Inspection Service | This is a continuing work program on HLO vessels, pressure systems and related safety devices. The work includes not only periodic inspection and engineering evaluations of plant pressure systems but engineering service during design, fabrication, installation, and operation to R&D components having process devices subjected to high pressures and temperatures. Code engineering service work is being performed on PRTR systems, Breakaway Corrosion Loop, and Equipment Projects. |
| "Split-half" Machine for Critical Mass Studies | Mechanical design of machine is essentially complete. Electrical design work remains. Components have been purchased and are being assembled. The special instrumentation for remote control is designed. |
| Control and Safety Rods for Tamper Tank (Critical Mass) | Development work is being performed prior to completion of design. |
| Electrical Modifications - 3702 Bldg. | Field work is delayed pending availability of craftsmen. |
| Special Filter Changer - CWS | Materials for testing of a proposed design using plastic bags and shielded cart is now on hand. |
| Material Handling System and Other Shop Improvements - 328 Building<br>a) Material Handling System<br>b) Coating Process Improvements<br>c) Chuck Handling Procedure | Engineering work is essentially complete. Material is ready. Field work will be performed during June. |

| Title | Status |
|---|---|
| Electrical Load Improvements - 329 Bldg. | Load studies are complete. Engineering design complete. Material is on order. |
| Cask Storage - 327 Building | Design is being performed and a work order for construction has been approved. |
| Induction Heating Unit - 314 Bldg. | Design complete. Installation work has started. |
| Install 200 KW Motor-Generator Set in 306 Building | Design complete. CPFF contractor will install. |
| Crane Overhaul - 314 Building | Work is proceeding. |
| Study - Warehouse office space | Work complete. |
| Arrange space and install utilities for business machines - 3760 Bldg. | Work essentially complete. |
| Source Positioner - 3745 Building | Design complete. Material on hand. Work is temporarily delayed due to higher priority work. |
| Zone Modifications - 325 Building Air Conditioning System | Field work is planned to start during July. |

## Drafting and Design Services

Work load in 3706 Building drafting room is constant with some overtime work required. Branch offices in 306 and 308 Buildings have light work loads. The equivalent of 138 design drawings were completed this month.

Major design and drafting work in progress includes the following:

1. Process Tube Monitor Mark III - 6 dwgs. required - 80% complete.
2. Spectroscopy Laboratory - 6 dwgs. required - work complete.
3. Shroud Replacement Tools - 20 dwgs. estimated - work temporarily stopped.
4. Waste Sludge Sluice System - 60% complete.
5. Flux Measuring Device - 6 dwgs. required - 80% complete.
6. Arc Melt Hood - 6 dwgs. required - 90% complete.
7. Conductivity Insert Model II - work temporarily stopped.
8. Filter design - SR-90 - 5 dwgs. required - 35% complete.

9. Special Tools - PRTR - 50 dwgs. required - 75% complete.

10. Autoclave Facility Modification - 5 dwgs. required - 70% complete.

Plant Maintenance and Operation

April costs were $159,610 which is 100.7% of forecast.

Analysis of Costs

The expenditure to date has risen 0.8% to 100.7% of the forecast. The chief factors in this are greater than expected improvement maintenance activity and higher than expected steam consumption. Work order control has been intensified to bring the expenditures within the budget.

Improvement Maintenance

| Item | |
|---|---|
| Relocation and alteration | $ 6,856 |
| Repainting | 4,690 |
| Reroofing | 3,581 |
| Electrical Modifications | 650 |
| Piping Modifications | 3,349 |
| H&Vent Modifications | 5,945 |
| Crane | 5,655 |
| | $30,726 |

Waste Disposal and Decontamination Service

The front end of the liquid waste trailers have been shielded with lead to provide added protection for the tractor drivers.

Studies are being continued towards better and safer waste handling systems.

Plant Engineering and Miscellaneous

Approximately 21,000 square feet of prints were reproduced during the month.

The total estimated value of the 18 requisitions issued during the month was $68,000. The majority of this procurement activity is for approved HL projects. New signs are being procured using standard terminology for use in areas requiring special radiological protective apparel.

Painting is being continued in 325 Building.

Electrical Load Studies are being made in 325 and 3760 Buildings. New lighting panels are being installed in 325 Building.

## TECHNICAL INFORMATION OPERATION

Mrs. Mildred Heatwole of Saul Herner and Company, Washington, D. C., interviewed HAPO personnel about the AEC's technical information program. Fifty-eight scientific and technical personnel (a random sample) and twelve technical information personnel were interviewed.

Two classification memos were distributed to the field. Titles are:

HW-63972 "Classification: NPR Fuel Element Work"
HW-69662 "Classification: Document Titles"

A series of local classification guides for Hanford are being prepared. A recent revision of AEC Manual Chapter 3401 on Classification designates the present Hanford Classification Guide as a program guide and provides that local guides may be issued based on the program guides.

A number of changes in Sections 100 (General) and 200 (Fuel Element Preparation) of the Hanford Classification Guide have been submitted to HOO. These changes are intended to bring the Guide in the line with current AEC classification policy and to provide a more suitable program guide on which they base the local guides.

At month's end a backlog of 29 reports existed in Technical Publications. The resultant delays in the publication of reports are getting growing attention from Research and Development components.

A major bibliography on the Columbia River was completed by B. B. Lane and Nelson Hope.

The microfilming of Files document holdings in the Records Center was substantially completed early in the month. On May 9, work began on the older documents in the Files vault. The objective of the microfilming program, to make more filing space available in the vault, is now being attained.

Over 5,000 classified documents in the S-series were destroyed during the month. The documents in this series are operating log books which are now obsolete and of no future reference value.

The mechanization of the Files issuance, routing, and mailing activities is proceeding as schedule. The IBM Card-a-type equipment arrived on Plant May 22 and a mock-up of the Files installation has been made in the conference room of the 705 Building. The Flexowriters have been received on the Plant and appear to be as ordered and ready to use. All the necessary forms are on hand. Part of the special office furniture ordered for the change has arrived and the balance is expected shortly. The Card-a-type operator has been selected and is being trained. The IBM cards needed for input have all been keypunched. A work sheet has been devised which gives

step-by-step instructions to abstractors, issue clerks, and Card-a-type operator concerning the processing of new documents under the system. The building changes required for the mechanization program are completed.

Files was recently notified by the AEC Office of Technical Information Extension that Eurochemic documents, all of which are unclassified, can be circulated only to Q-cleared personnel. In order to carry out this instruction, ORNL has been asked to send future Eurochemic documents to Technical Information, rather than to the local recipient as has been past practice

Work Volume Statistics

| | April | May |
|---|---|---|
| **Document Distribution and Files** | | |
| Documents routed and discharged (copies) | 29,057 | 22,313 |
| Documents issued (copies) | 14,206 | 15,471 |
| Documents sent off-site (copies) | 6,630 | 8,939 |
| Document reserves filled (copies) | 698 | 691 |
| Documents picked up and delivered | 18,889 | 20,261 |
| **Document Accountability** | | |
| Holders of classified documents whose files were inventoried | 638 | 278 |
| Documents inventoried in Files (copies) | -- | -- |
| Documents destroyed or retired (copies) | 16,601 | 11,625 |
| Documents revised (copies) | 1,701 | 1,450 |
| Documents pulled and documents filed (copies) | 22,654 | 17,982 |
| Documents reclassified | 781 | 279 |
| Documents microfilmed | 3,772 | 4,252 |
| Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site | 199,886 | 191,947 |
| **Reference and Publication** | | |
| Books cataloged (new titles) | 152 | 137 |
| Books added to the collection (volumes) | 374 | 303 |
| Ready reference questions answered by professional staff | 145 | 220 |
| Literature searches by professional staff | 90 | 77 |
| Reports abstracted (titles) | 296 | 302 |
| Formal reports prepared (titles) | 12 | 13 |
| Off-site requests for HAPO reports (copies) | 306 | 421 |
| Reports released to CAP (titles) | 24 | 35 |

## Library Acquisitions and Circulation

| | April | May |
|---|---|---|
| Books ordered (volumes) | 318 | 390 |
| Periodicals ordered | 174 | 142 |
| Books circulated (volumes) | 1,647 | 1,613 |
| Periodicals circulated (issues) | 3,412 | 3,012 |
| Inter-Library loans | 58 | 87 |
| Films borrowed or rented | 18 | 7 |
| Industrial film showings | 106 | 72 |
| Bound periodicals added to the collection | 5 | 79 |
| Bound periodicals discarded | 0 | 7 |

## Library Collection:

| | Main Library | W-10 Library | 108-F Library | Ind.Med. | Total |
|---|---|---|---|---|---|
| No.of books | 31,534 | 8,643 | 1,793 | 2,051 | 44,021 |
| No.of bound periodicals | 14,501 | 14 | 1,892 | 6 | 16,413 |
| | 46,035 | 8,657 | 3,685 | 2,057 | 60,434 |

## Classification and Declassification

| | April | May |
|---|---|---|
| Documents, including drawings and photographs reviewed for downgrading or declassification. | 45 | 35 |
| Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification. | 29 | 59 |
| Documents submitted to Declassification Branch, Oak Ridge. | 3 | 2 |

Manager
LABORATORY AUXILIARIES

JL Boyd:jw

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-822 | Pressurized Gas Cooled Facility | 4141 Operating |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 1,120,000 | DESIGN $ 40,000 / CONST. $ 1,080,000 | AEC $ 0 / GE $ 1,120,000 | COST & COMM. TO 5-7-61 | $ 819,466 |
| | | | ESTIMATED TOTAL COST | $ 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. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 100 | 100 | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 95 | 83 |
| PF | | | |
| CPFF | 17 | 90 | 75 |
| FP | 7 | 100 | 100 |
| Govt. Eq. | 76 | 95 | 82 |

SCOPE, PURPOSE, STATUS & PROGRESS

The J. P. Head, FP Contract (JAJ-73) was completed 5-24-61. The M & M apportionment was completed as of 5-31-61.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-834 | Modifications & Additions to High Pressure Heat Transfer Apparatus - 189-D Building | 0290 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 745,000 | DESIGN $ 67,500 / CONST. $ 677,500 | AEC $ -- / GE $ 745,000 | COST & COMM. TO 5-14-61 | $ 697,677 |
| | | | ESTIMATED TOTAL COST | $ 745,000 |

| STARTING DATES | | | ESTD. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 4-20-59 / CONST. 4-22-59 | DATE AUTHORIZED 4-8-59 / DIR. COMP. DATE 7-1-61 | | DESIGN 2-13-61 / CONST. 7-1-61 | |

ENGINEER: FEO - H. Radow

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | 3700 |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | 960 |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 100 | 100 | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 100* | 95* |
| PF | | | |
| CPFF | 100 | 100* | 95* |
| FP | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides necessary modifications to existing equipment to simulate more severe in-reactor operating conditions in out-of-reactor facilities for research and development studies.

The directive authorizing total funds of $745,000, has been received and construction was resumed 5-29-61.
The high speed valve assembly order has passed the witness test satisfactorily and shipment is anticipated by 5-26-61.

* A revised schedule is being prepared reflecting the authorized extension of time.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822 ::

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-842 | Critical Reactivity Measuring Facility | 58-e-15 |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ 360,000 | DESIGN $ 45,000 | AEC $ 148,000 | COST & COMM. TO 5/7/61 | $ 115,421 |
| | CONST. $ 315,000 | GE $ 212,000 | ESTIMATED TOTAL COST | $ 360,000 |

| STARTING DATES | | | EST'D. COMPL. DATES | | PERCENT COMPLETE | | | |
|---|---|---|---|---|---|---|---|---|
| DESIGN | 11-17-59 | DATE AUTHORIZED | DESIGN | 2-1-61 | | WT'D. | SCHED. | ACTUAL |
| CONST. | 10-3-60 | DIR. COMP. DATE 8-15-61 | CONST. | 8-15-61 | DESIGN | 100 | 100 | 100 |
| | | | | | TITLE I | | | |
| | | | | | GE-TIT. II | | | |
| | | | | | AE-TIT. II | | | |
| | | | | | | | | |
| | | | | | CONST. | 100 | 59 | 43 |
| | | | | | PF | | | |
| | | | | | CPFF | 57 | 25 | 0 |
| | | | | | FP | 43 | 100 | 99* |
| | | | | | | | | |

ENGINEER: REDO - WS Kelly

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

SCOPE, PURPOSE, STATUS & PROGRESS

Failure of fixed price contractor to complete work on schedule is delaying the start of the CPFF Contractor's work.

* Does not reflect the progress made on G. E. procured items until such items are installed.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-857 | Physical & Mechanical Properties Testing Cell - 327 Bldg. | 0290 |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ 75,000 | DESIGN $ 75,000 | AEC $ | COST & COMM. TO 5-14-61 | $ 74,941 |
| | CONST. $ | GE $ 75,000 | ESTIMATED TOTAL COST | $ 430,000 |

| STARTING DATES | | | EST'D. COMPL. DATES | | PERCENT COMPLETE | | | |
|---|---|---|---|---|---|---|---|---|
| DESIGN | 11-2-59 | DATE AUTHORIZED 10-1-59 | DESIGN | 3-1-61 | | WT'D. | SCHED. | ACTUAL |
| CONST. | | DIR. COMP. DATE | CONST. | | DESIGN | 100 | 100 | 100 |
| | | | | | TITLE I | | | |
| | | | | | GE-TIT. II | 100 | 100 | 100 |
| | | | | | AE-TIT. II | | | |
| | | | | | | | | |
| | | | | | CONST. | 100 | | |
| | | | | | PF | | | |
| | | | | | CPFF | | | |
| | | | | | FP | | | |
| | | | | | | | | |

ENGINEER: FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | 1 | 540 |
| GE FIELD ENGINEERING | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in the 327 Building.

A project proposal revision requesting the total construction funds is in preparation.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-858 | High Level Utility Cell - 327 Building | 0290 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 400,000 | DESIGN $ 50,000 / CONST. $ 350,000 | AEC $ / GE $ 400,000 | COST & COMM. TO 5-14-61 | $ 67,911 |
| | | | 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 | 36 |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | 35 |
| DESIGN ENGINEERING OPERATION | 1 | 635 |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 95 | 100 | 100 |
| AE-TIT. II | | | |
| Vendor | 5 | 100 | 100 |
| CONST. | 100 | NS | NS |
| PF | | | |
| CPFF | | | |
| 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.

Construction started 5-15-61, on footings for the cell support walls. A construction schedule is being prepared.

Procurement is progressing satisfactorily.

| 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 5-14-61 | $ 15,621 |
| | | | ESTIMATED TOTAL COST | $ 700,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 9-5-59 | 5-31-60 | DESIGN | 11-14-60 |
| CONST. | 6-15-61 | DIR. COMP. DATE 6-30-62 | CONST. | 6-30-62 |

ENGINEER

FEO - RW Dascenzo

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| 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 | 10 | 100 | 100 |
| AE-TIT. II | 90 | 100 | 100 |
| | | | |
| CONST. | 100 | NS | |
| PF | | | |
| CPFF | | | |
| FP | | | |

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.

HOO-AEC Directive HW-492, dated April 20, 1961, approved the project and authorized the incurrence of costs in the amount of $700,000. The directive completion date is June 30, 1962. Work Authority No. CAH-866(2), dated April 27, 1961, authorized $153,000 to General Electric.

The advance construction notice has been issued and the bid package was issued May 1, with the bid opening on June 1, 1961. Procurement activities have been started.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-867 | Fuel Element Rupture Test Loop | 58-e-15 |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ 1,500,000 | DESIGN $ 130,000 | AEC $ 770,000 | COST & COMM. TO 5-7-61 | $ 385,828 |
| | CONST. $ 1,370,000 | GE $ 730,000 | ESTIMATED TOTAL COST | $ 1,500,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 8-1-60* | | | DESIGN 2-15-61 |
| | CONST. 11-2-60. | DIR. COMP. DATE 10-31-61 | | CONST. 10-31-61 |

ENGINEER

REDO - PC Walkup

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| 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 | 91 | 100 | 100 |
| AE-TIT. II | 9 | 100 | 100 |
| | | | |
| CONST. | 100 | 25** | 10** |
| PF | 2 | -- | -- |
| CPFF | 24 | 30 | 0 |
| FP (1) | 10 | 100 | 100 |
| (2) | 33 | 0 | 0 |
| (3) | 31 | 25 | 0 |

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Co.
All design drawings and construction specifications have been approved.

* Detail Design. Scope design started 11/2/59, and completed 3/15/60.
** Water plant construction was scheduled for starting 3/1/61. Design drawings and
-- specs for water plant and holdup tank forwarded to AEC-HOO early in February. These have not been released for bidding as yet. The project is approximately four months behind schedule as a result.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-870 | Facility for Recovery of Radioactive Materials-325 Bldg. | 60-a-1 |

| AUTHORIZED FUNDS | | | | | |
|---|---|---|---|---|---|
| $ 486,000 | DESIGN $ 46,000 | AEC $ 446,000 | COST & COMM. TO 5-14-61 | $ 463,384 |
| | CONST. $ 440,000 | GE $ 40,000 | ESTIMATED TOTAL COST | $ 486,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 11-20-59 | 3-22-60 | | DESIGN 3-1-60 |
| | CONST. 5-6-60 | DIR. COMP. DATE 6-1-61 | | CONST. 5-31-61 |

ENGINEER

FEO - RW Dascenzo

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | 2940 |
| 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 | 10 | 100 | 100 |
| AE-TIT. II | 90 | 100 | 100 |
| | | | |
| CONST. | 100 | 100 | 100 |
| PF | 1 | 100 | 100 |
| CPFF | | | |
| FP | 100 | 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.

Physical Completion date is 5/3/61. Two claims totaling $13,000 from Triangle Construction Company are pending.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-888 | Biology Laboratory Improvements | 60-h-1 |

| AUTHORIZED FUNDS | | | COST & COMM. TO 5-14-61 | $ 39,808 |
|---|---|---|---|---|
| $ 420,000 | DESIGN $ 44,000 / CONST. $ 376,000 | AEC $ 400,000 / GE $ 20,000 | ESTIMATED TOTAL COST | $ 420,000 |

| STARTING DATES | | DATE AUTHORIZED 9-2-60 | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 12-1-60* | | DESIGN | 3-31-61 |
| CONST. | 6-15-61. | DIR. COMP. DATE 3-31-62 | CONST. | 6-15-62 |

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 | NS | 100 |
| TITLE I | | | |
| GE-TIT. II | 17 | NS | 100 |
| AE-TIT. II | 83 | NS | 100 |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| 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.

A rough draft of a purchase requisition has been prepared for fabrication of the Radiation Source Handling Facility. It is expected the AEC will request General Electric to process a purchase order for this facility. AEC has indicated that about fifteen (15) bid packages have been distributed to lump sum contractors.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-896 | Stress Rupture Test Facility | 60-1 |

| AUTHORIZED FUNDS | | | COST & COMM. TO 5-14-61 | $ 10,044 (GE) |
|---|---|---|---|---|
| $ 90,000 | DESIGN $ 7,500 / CONST. $ 82,500 | AEC $ 78,500 / GE $ 11,500 | ESTIMATED TOTAL COST | $ 90,000 |

| STARTING DATES | | DATE AUTHORIZED 3-6-61 | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 7-29-60 | | DESIGN | 12-1-60 |
| CONST. | 3-20-61 | DIR. COMP. DATE 10-15-61 | CONST. | 10-15-61 |

ENGINEER

FEO - H. Radow

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | 5 | 175 |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | | |
| GE FIELD ENGINEERING | | |

| PERCENT COMPLETE | WT'D. | SCHED. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 100 | 100 |
| TITLE I | | | |
| GE-TIT. II | 100 | 100 | 100 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | 27 | 25 |
| PF | 2 | 0 | 0 |
| CPFF | | | |
| FP | 98 | 28 | 26 |

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

The walls have been poured and preparations are being made to pour the floor slab and roof. Procurement activity for the mechanical components is underway.

It is expected the contractor will be back on schedule in the near future.

1252644

# SEMI-MONTHLY PROJECT STATUS REPORT

HW- 69822

GENERAL ELECTRIC CO. — Hanford Laboratories

DATE 5-31-61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-901 | Structural Material Irradiation Test Equipment - ETR | 0290 |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 125,000 | DESIGN $ 12,000 / CONST. $ 113,000 | AEC $ / GE $ 125,000 | COST & COMM. TO 5-14-61 / ESTIMATED TOTAL COST | $ 79,022 / $ 125,000 |

| STARTING DATES | | | ESTD. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 9-15-60 / CONST. 6-1-61 | DATE AUTHORIZED 9-2-60 | DIR. COMP. DATE 10-15-61 | DESIGN 3-31-61 / CONST. 10-15-61 | |

ENGINEER: FEO - KA Clark

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT-ENGINEER | | |
| DESIGN ENGINEERING OPERATION | 1 | 165 |
| 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 | NS | NS |
| PF | | | |
| 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.

Planned installation start date of 4/17/61, has been postponed, because of higher priority work, by the IOO-AEC.

Firm start date for installation of equipment has been requested from the AEC.

| 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 5-14-61 / ESTIMATED TOTAL COST | $ 2,034 / $ 36,000 |

| STARTING DATES | | | ESTD. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 5-15-61 / CONST. 7-1-71 | DATE AUTHORIZED 12-14-60* | DIR. COMP. DATE 10-15-61 | DESIGN 7-1-61 / CONST. 10-15-61 | |

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. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | 15 | 15 |
| 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.

Design started May 15, 1961.

* Accepted by the General Electric Company 4/17/61.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-914 | Rattlesnake Springs Radioecology Facility | 61-j |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 72,000 | DESIGN $ 3,400* / CONST. $ 68,600 | AEC $ 53,700 / GE $ 18,300 | COST & COMM. TO 5-14-61 / ESTIMATED TOTAL COST | $ 8,857 / $ 72,000 |

| STARTING DATES | | | EST'D. COMPL. DATES | | PERCENT COMPLETE | | | |
|---|---|---|---|---|---|---|---|---|
| DESIGN 3-1-61 / CONST. 7-15-61 | DATE AUTHORIZED 12-22-60 / DIR. COMP. DATE 10-31-61 | | DESIGN 6-15-61 / CONST. 12-1-61 | | | WT'D. | SCHED. | ACTUAL |
| | | | | | DESIGN | 100 | NS* | 95 |
| | | | | | TITLE I | | | |
| | | | | | GE-TIT. II | | | |
| | | | | | AE-TIT. II | 100 | NS* | 95 |
| | | | | | | | | |
| | | | | | CONST. | 100 | | |
| | | | | | PF | | | |
| | | | | | CPFF | | | |
| | | | | | FP | | | |
| | | | | | | | | |

ENGINEER

FEO - OM Lyso

| 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 will allow performance of radioecological studies under local environmental conditions. It consists of constructing field facilities for this purpose.

Title II comment issue of specifications and design were received from the AEC. A meeting was held 5-17-61, and comments were submitted.

* Bovay Engineers. No design schedule is planned for this project.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-916 | Fuels Recycle Pilot Plant | Funds Avail. to Comm. |

| AUTHORIZED FUNDS | | | | |
|---|---|---|---|---|
| $ 50,000 | DESIGN $ 50,000 / CONST. $ | AEC $ / GE $ 50,000 | COST & COMM. TO 5-14-61 / ESTIMATED TOTAL COST | $ 43,700 / $ 5,000,000 |

| STARTING DATES | | | EST'D. COMPL. DATES | | PERCENT COMPLETE | | | |
|---|---|---|---|---|---|---|---|---|
| DESIGN 3-1-61* / CONST. 5-1-62 | DATE AUTHORIZED 2-17-61 / DIR. COMP. DATE | | DESIGN 3-1-62 / CONST. 11-1-63 | | | WT'D. | SCHED. | ACTUAL |
| | | | | | DESIGN | 100 | NS* | 40 |
| | | | | | TITLE I | | NS* | 40 |
| | | | | | GE-TIT. II | | | |
| | | | | | AE-TIT. II | | | |
| | | | | | | | | |
| | | | | | CONST. | 100 | | |
| | | | | | PF | | | |
| | | | | | CPFF | | | |
| | | | | | FP | | | |
| | | | | | | | | |

ENGINEER

FEO - RW Dascenzo

| MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|
| FIXED PRICE | | |
| COST PLUS FIXED FEE | | |
| PLANT FORCES | | |
| ARCHITECT - ENGINEER | | |
| DESIGN ENGINEERING OPERATION | 10 | |
| GE FIELD ENGINEERING | | |

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.

Final building layout is still being determined.

Three drawings have been issued for information: Process Piping Schematic; Ventilation Master Flow Diagram; Waste Piping Diagram.

* Design Scope

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-917 | Field Service Center - Atmospheric Physics | 61-j |

| AUTHORIZED FUNDS $ | DESIGN $ / CONST. $ | AEC $ / GE $ | COST & COMM. TO $ / ESTIMATED TOTAL COST $ |
|---|---|---|---|
| | | | 154,000 |

| STARTING DATES | | DATE AUTHORIZED / DIR. COMP. DATE | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 7-15-61* | | | DESIGN 11-1-61* |
| | CONST. 12-15-61* | | | CONST. 4-1-62* |

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.

The project proposal was held up temporarily by the AEC. A minor revision was made to page 4, at the request of the AEC. The proposal was then approved by the local AEC.

* Based on AEC authorization by 6-15-61.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-918 | Second Whole Body Counter-Cell Addition - 747 Building | 61-j |

| AUTHORIZED FUNDS $ | DESIGN $ / CONST. $ | AEC $ / GE $ | COST & COMM. TO $ / ESTIMATED TOTAL COST |
|---|---|---|---|
| | | | 110,000 |

| STARTING DATES | | DATE AUTHORIZED / DIR. COMP. DATE | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN | | | DESIGN |
| | CONST. | | | CONST. |

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 a second whole body monitoring cell in the 747-A Building to increase the capacity of the Whole Body Counter Facility to meet projected needs.

This project proposal has been returned by the Commission without action, and reporting will not be continued.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-919 | Air Conditioning - 314 Building | 61-j |

| AUTHORIZED FUNDS | | | | COST & COMM. TO 5-14-61 | $ 28,853 |
|---|---|---|---|---|---|
| $ 35,000 | DESIGN $ 3,750 / CONST. $ 28,650 | AEC $ 28,650 | GE $ 6,350 | ESTIMATED TOTAL COST | $ 35,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 5-2-61 | 4-18-61 | DESIGN | 7-5-61 |
| CONST. | 6-15-61 | DIR. COMP. DATE 9-15-61 | CONST. | 9-15-61 |

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 | NS | 60 |
| TITLE I | | | |
| GE-TIT. II | | NS | 60 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| 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 GE Company. Specifications for the cooling units were submitted to J. A. Jones Construction Company on 4-26-61. Bid opening is scheduled for 5-23-61, on the cooling units.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-921 | Geological & Hydrological Wells - FY-61 | 61-j |

| AUTHORIZED FUNDS | | | | COST & COMM. TO 5-14-61 | $ 62,063 |
|---|---|---|---|---|---|
| $ 79,000 | DESIGN $ 1,000 / CONST. $ 62,000 | AEC $ 69,500 | 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 | | |
| 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 | 100 | 0 | 0 |
| GE-TIT. II | | 75 | 75 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | NS | 1.5 |
| PF | 0 | | |
| CPFF | 3 | NS | 50 |
| FP | 97 | 0 | 0 |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

Drilling rig arrived on-site 5/16/61, and set up on Well 299-45-50. Total amount of hole drilled through 5-22-61, is 15 feet.

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-922 | Burst Test Facility for Zirconium Tubes | 61-j |

| AUTHORIZED FUNDS | DESIGN $ | AEC $ | COST & COMM. TO | $ |
|---|---|---|---|---|
| $ | CONST. $ | GE $ | ESTIMATED TOTAL COST | $ 228,000 |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 8-15-61* | | DESIGN 2-15-62* | |
| | CONST. 1-1-62* | DIR. COMP. DATE | CONST. 9-1-62* | |

| ENGINEER | MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|---|
| FEO - H. Radow | 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, which was returned by the Commission without action, has been revised to include supplemental data requested by the Commission.

* Based on AEC authorization by 8-1-61.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-923 | Spectroscopy Laboratory | 0290 |

| AUTHORIZED FUNDS | DESIGN $ 4,500 | AEC $ | COST & COMM. TO 5-7-61 | $ 8,126 |
|---|---|---|---|---|
| $ 95,000 | CONST. $ 90,500 | GE $ 95,000 | ESTIMATED TOTAL COST | $ 95,000 |

| STARTING DATES | | DATE AUTHORIZED 3-9-61 | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| | DESIGN 3-21-61 | | DESIGN 5-24-61 | |
| | CONST. 6-1-61 | DIR. COMP. DATE 11-15-61 | CONST. 11-15-61 | |

| ENGINEER | MANPOWER | AVERAGE | ACCUM MANDAYS |
|---|---|---|---|
| FEO - RC Ingersoll | FIXED PRICE | | |
| | 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 |
| AE-TIT. II | | | |
| | | | |
| CONST. | 100 | | |
| PF | | | |
| CPFF | | | |
| FP | | | |
| | | | |

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for specialized spectroscopy work.

J. A. Jones is preparing a bid package for the block work.

A work order has been issued to FPD Plant Forces to relocate steam and condensate lines in the planned work area.

1252649

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822

DATE 5/31/61

| 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 $ / GE $ | COST & COMM. TO $ | ESTIMATED TOTAL COST $ 80,000 | |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 6-16-61 | CONST. 9-16-61 | DIR. COMP. DATE 3-31-62 | DESIGN 10-16-61 | CONST. 3-31-62 |

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. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | NS | 0 |
| TITLE I | | | |
| GE-TIT. II | | | |
| AE-TIT. II | | | |
| | | | |
| 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.

The AEC Directive No. AEC-194 was issued May 16, 1961. No work authority has been received.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CGH-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 5-7-61 | $ 1,213 | |
| | | | ESTIMATED TOTAL COST | $ 31,000 | |

| STARTING DATES | | DATE AUTHORIZED | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN 5-1-61 | CONST. 6-1-61 | DIR. COMP. DATE 2-28-62 | DESIGN 7-1-61 | CONST. 9-1-61 |

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. | ACTUAL |
|---|---|---|---|
| DESIGN | 100 | NS | 25 |
| TITLE I | | | |
| GE-TIT. II | | NS | 25 |
| 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.

Comment issues of the specifications for work stations are complete.

1252150

# SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69822 E

DATE 5/31/61

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| CAH-932 | 300 Area Retention Waste System Expansion | 61-J |

| AUTHORIZED FUNDS $ | DESIGN $ / CONST. $ | AEC $ / GE $ | COST & COMM. TO $ / ESTIMATED TOTAL COST $ |
|---|---|---|---|
| | | | 70.000 |

| STARTING DATES | | DATE AUTHORIZED / DIR. COMP. DATE | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | 7-1-61* | | DESIGN | 9-15-61* |
| CONST. | 10-15-61* | | CONST. | 2-15-61* |

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 HDO-AEC for authorization on 5-5-61. Review of this project was deferred to 6-1-61, by the HDO-AEC Review Board.

*Based on AEC authorization by 6-1-61.

| PROJ. NO. | TITLE | FUNDING |
|---|---|---|
| | | |

| AUTHORIZED FUNDS $ | DESIGN $ / CONST. $ | AEC $ / GE $ | COST & COMM. TO $ / ESTIMATED TOTAL COST $ |
|---|---|---|---|
| | | | |

| STARTING DATES | | DATE AUTHORIZED / DIR. COMP. DATE | EST'D. COMPL. DATES | |
|---|---|---|---|---|
| DESIGN | | | DESIGN | |
| CONST. | | | CONST. | |

ENGINEER

| 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

# PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

## MONTHLY REPORT

### COMMUNICATIONS

Wrote and filmed a two-minute news film on the completion of the Critical Mass Laboratory. Film editing is now underway.

Prepared press releases on: (1) appointment of Dr. R. C. Thompson to a National Committee on Radiation Protection and Measurements sub-committee, (2) Dr. B. R. Leonard's talk at Rensselaer Polytechnic Institute, (3) Dr. G. Gamow's Science Colloquium presentation. Participated with Relations Operation in preparation of releases on (1) Dr. E. D. Clayton's address before the Symposium on Criticality Control in Chemical Metallurgical Plant at Karlsruhe, Germany, (2) Hanford Laboratories participation in the Pacific Northwest Industrial Waste Conference at Pullman, Washington.

### EMPLOYMENT (Professional)

Advanced Degree - Eight Ph.D. candidates visited HAPO for professional employment interviews. Seven offers were extended; three acceptances and nine rejections were received. Current open offers total 11. For the recruiting year, we have achieved 12 Ph.D. acceptances.

BS/MS - Recruiting activity for the Technical Graduate Program included 19 offers, 17 acceptances and 58 rejections. Six offers remain open. For BS/MS experienced personnel, 17 offers were extended, 5 acceptances and 2 rejections were received with ten offers remaining open.

Technical Graduate Program - Nine Technical Graduates were placed on permanent assignment during the month. Four new members were added to the program rolls and two terminated. Current program members total 41.

### EMPLOYMENT (Non-Professional)

Thirteen requisitions were filled during the month with a total of 31 active requisitions remaining to be filled.

### HEALTH, SAFETY, AND SECURITY

A disabling injury occurred in Fuels Fabrication Development Operation to technologist _____ who severed the tip of his middle finger, right hand, while using a Press Brake and Shear. An investigation has been conducted and the resulting report prepared and distributed.

O E Boston

PRIVACY ACT MATERIAL REMOVED

O. E. Boston, Manager
Professional Placement
and Relations Practices

OEB:lmh 1252152

## TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

### A. Technical Recruiting Activity - HAPO - September 1, 1960 to date

| | Cases Considered | Visits to Richland | | | Offers | | | |
|---|---|---|---|---|---|---|---|---|
| | | Invited | Visited | To Visit | Offered | Accepted | Open | On the Roll |
| PhD | 535 | 168 | 61 | 31 | 46 | 12 | 11 | 6 |
| Exp. BS/MS | 405 | 94 | 63 | - | 78 | 45 | 11 | 26 |
| Prog. BS/MS | 370 | - | - | - | 171 | 65 | 6 | 10 |

### B. Technical Recruiting Activity - HL - September 1, 1960 to date

| | Cases Considered | Visits to Richland | | | Offers | | | |
|---|---|---|---|---|---|---|---|---|
| | | Invited | Visited | To Visit | Offered | Accepted | Open | On the Roll |
| PhD | 535 | 168 | 61 | 31 | 39 | 10 | 11 | 4 |
| Exp. BS/MS | 226 | 46 | 28 | 5 | 23 | 13 | 4 | 5 |

In addition to the above activity, 8 exempt employees have transferred into HL from other HAPO departments and 10 technical graduates have accepted off-program placement in HL to date.

C - Technical Graduate Program
Month ending May 31, 1961

| | |
|---|---|
| Number Personnel on Assignment | 41 |
| (HAPO Tech Grad Program.....38 | |
| (Engineering & Science Program .. 3 | |

Distribution of Assignments by Departments

| | |
|---|---|
| IPD | 12 |
| HL | 17 |
| FPD | 3 |
| CPD | 7 |
| C&AO | 2 |
| CE&UO | 0 |

Distribution of Assignments by Function

| | |
|---|---|
| Research & Development or Engineering | 31 |
| Other | 10 |

# FINANCIAL OPERATION MONTHLY REPORT
## MAY - 1961

### Personnel

There were nc changes during the month of May.

### Activities

#### GENERAL ACCOUNTING OPERATION

The level of travel activity, fiscal year-to-date, paralliels FY 1960 experience but is expected in total to fall slightly below the previous year.

Following is a summary of action on approval letters submitted to the Commission.

| Number | Title | Status |
|---|---|---|
| AT-97 | Cooperative Program for Evaluation of Decontamination Agents | Approved May 26, 1961. |
| AT-104 | Fission Products Dispersal Handbook | Still under consideration by HOO-AEC |
| AT-105 | Symposium on the Biology of Transuranic Elements | Has been forwarded to Washington by HOO-AEC with a recommendation for approval. |
| AT-149 | Recruiting Practices | Approved May 16, 1961. |
| AT-164 | Movement of House Trailer | Approved May 26, 1961. |
| AT-166 | Transfer Expenses -- Nonexempt Employee | Approved May 24, 1961. |

Procedures were revised to improve the quality and issuing date of 3" x 5" reports for management.

During the month preliminary unitization work was performed on the following projects and equipment tagged:

| | |
|---|---|
| CAH-744 | Metallurgical Development Facility, 306 Building |
| CG -785 | In-Reactor Studies Equipment - 105-KW |

Project unitization report was issued during the month on Project CAH-749 - High Level Radiochemistry Facility, 325-A Building - valued at $913,797.

The field count in connection with the physical inventory of movable equipment in custody of Reactor and Fuels R&D is complete and the reconciliation by HLO is in progress.

Reconciliation by C&AO of the physical inventory of fixed property in connection with the Cold Semi-Works, 321 Facility - is complete and a report will be issued in June. Two items valued at $1,000 were not physically located during the count and six unrecorded items valued at $32,897 were found during the count. This inventory included fixed property (buildings, installed equipment and utility systems) valued at $2.4 million.

Heavy water returned to SROO for rework during May amounted to 4,038.250 kgs. valued at $110,287 (Fund) and $85,894 (Non-Fund). Heavy Water generated for return to SROO during May amounted to 1,604.330 kgs. valued at $4,970. A requisition was placed during the month for 3,636.363 kgs. of Heavy Water valued at $113,054.53 for August 1961 delivery.

Sixty-three items valued at $24,674 were received at the Laboratory Equipment Pool during the month. Eighteen items valued at $4,028 were disbursed in lieu of placement of requisitions. Three items valued at $2,573 were withdrawn by custodians. There are currently 599 items valued at $245,689 located in the Pool. Included in the total are 110 uncataloged items valued at $16,038 and 44 items valued at $1,800 held for convenience of others.

Reactor and Other Special Materials on hand at month's end consisted of the following:

| | | |
|---|---|---|
| Beryllium | 1 221 | $ 696 |
| Gold | 2 258 | 3 027 |
| Palladium | 2 219 | 2 530 |
| Platinum | 5 917 | 17 219 |
| Silver | 2 463 | 98 |
| Zirconium | | |
| Inventory Stock | 3 088 | 67 763 |
| R&D Stock | 607 | 9 114 |
| Scrap | 9 643 | -0- |
| | | $100 447 |

Action as indicated occurred on the following projects during the month:

New Money Authorized to HLO

| | | |
|---|---|---|
| CGH-834 | Modification and Additions High Pressure Heat Transfer Apparatus | $45 000 |
| CAH-927 | Waste Treatment Demonstration Facility, 271-CR Building | 17 500 |

Physical Completion Notices Issued

CGH-805 High Temperature Tensile Testing Cell, 327 Building
CAH-885* Geological and Hydrological Wells, FY 1960

*AEM services only.

COST ACCOUNTING OPERATION

The FY 1961 Operating Cost Control Budget was adjusted in May as follows:

1. Increase of $40,000 for Strontium-90 work sponsored by CPD. The increase is funded from 02 Program - Production.

2. Increase of $23,000 for Specific Fuel Cycle Studies as a result of a transfer of 04 Program funds from IPD.

3. Atmospheric Physics funds for sponsored U.S. Air Force Programs adjusted to reflect the current estimate for FY 1961 expenditures as follows:

| | |
|---|---|
| Edwards AFB Work | $ 18 000 |
| Cape Canaveral and Vandenberg AFB Work | 54 000 |
| Current Atmospheric Diffusion Studies | 31 000 |
| Total | $103 000 |

4. Funds added to other special requests as a result of additional authorizations forthcoming in connection with the AEC/AECL Cooperative Program:

| | |
|---|---|
| Non-Destructive Testing of Zircaloy Sheathing | $ 8 000 |
| Magnetic Force Closure Studies | 24 000 |

Financial advice was provided Radiation Protection Operation in connection with a program proposal concerning Columbia River Studies which was subsequently submitted to HOO-AEC at their request.

Information concerning professional recruiting for the first quarter of calendar year 1961 was gathered together from the various HAPO components. Data will be accumulated for a meaningful period of time to develop realistic statistics concerning professional recruiting costs.

## Payroll Statistics

Number of HLO Employees

| Changes During Month | Total | Exempt | Non-Exempt |
|---|---|---|---|
| Employees on Payroll at Beginning of Month | 1 361 | 639 | 722 |
| Additions and Transfers In | 14 | 5 | 9 |
| Removals and Transfers Out | 17 | 11 | 6 |
| Employees on Payroll at End of Month | 1 358 | 633 | 725 |

Overtime Payments During Month

| | May | April |
|---|---|---|
| Exempt | $ 6 607 | $ 6 988 |
| Nonexempt | 25 810 | 18 673 |
| Total | $ 32 417 | $ 25 661 |

| Gross Payroll Paid During Month | May | April |
|---|---|---|
| Exempt | $ 571 486 | $ 572 243 |
| Nonexempt | 406 995 * | 371 529 |
| Total | $ 978 481 | $ 943 772 |

| Participation in Employee Benefits Plans at Month End | May Number | May Percent | April Number | April Percent |
|---|---|---|---|---|
| Pension Plan | 1 226 | 99.1 | 1 213 | 99.3 |
| Insurance Plan | | | | |
| Personal Coverage | 365 ) | 99.9 | 371 ) | 99.9 |
| Dependent Coverage | 982 ) | | 981 ) | |
| U.S. Savings Bonds | | | | |
| Stock Bonus Plan | 66 | 32.7 | 64 | 32.2 |
| Savings Plan | 83 | 6.1 | 83 | 6.1 |
| Savings and Security Plan | 1 038 | 89.9 | 1 046 | 90.0 |

| Insurance Claims | May Number | May Amount | April Number | April Amount |
|---|---|---|---|---|
| Employee Benefits | | | | |
| Life Insurance | 0 | $ 0 | 1 | $ 21 514 |
| Weekly Sickness and Accident | 5 | 344 | 16 | 939 |
| Comprehensive Medical | 71 | 8 433 | 62 | 6 071 |
| Dependent Benefits | | | | |
| Comprehensive Medical | 157 | 17 061 | 129 | 12 185 |
| Total | 233 | $ 25 838 | 208 | $ 40 709 |

| Good Neighbor Fund | May | April |
|---|---|---|
| Number Participating | 924 | 930 |
| Percent Participating | 68.1% | 68.3% |

*Includes retro-active pay.

W. Sale
June 13, 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 |
|---|---|
| R. H. Moore | A Process for Decontamination of Aqueous, Organic, or of Molten Salt Solutions by Reaction Chromatography (HW-69762) |
| R. H. Moore | A Method for Preparing Reactive Absorbants with High Flow Characteristics from Finely Divided Materials (HW-69688) |
| C. H. Bloomster<br>W. T. Ross<br>R. E. Bardsley | Invention Report: An Incremental Loading Process to Accurately Control Plutonium Enrichment in the Mechanically-Mixed Oxide Fuel Systems, May 29, 1961 (HW-69782) |

[redacted]

DECLASSIFIED

DECLASSIFIED

1252660

[redacted]