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HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

SEPTEMBER, 1961

OCTOBER 16, 1961

HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
SEPTEMBER, 1961

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE SEPTEMBER 30, 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	124	117	241	128	123	251	0	4	4	10
Reactor & Fuels Research & Development	200	185	385	205	200	405	2	1	7	16
Physics & Instrument Research & Development	92	59	151	100	63	163	1	0	9	4
Biology Operation	33	48	81	36	49	85	1	0	4	1
Operation Res. & Syn.	18	4	22	19	4	23	1	0	2	0
Radiation Protection	38	96	134	39	95	134	0	3	1	2
Laboratory Auxiliaries	47	186	233	47	184	231	0	3	0	1
Financial	19	15	34	19	16	35	0	0	0	1
Prof. Placement & R. P.	100	10	110	98	11	109	9	1	7	2
Programming	18	4	22	18	4	22	1	0	1	0
General	4	3	7	2	4	6	2	0	0	1
Totals	693	727	1420	711	753	1464	17	12	35	38
Totals excluding internal transfers.	693	727	1420	711	753	1464	16	11	34	37

- 44 people!

BUDGETS AND COSTS

September operating costs totaled $2,472,000; fiscal year-to-date costs are $6,936,000 or 26% of the $26,236,000 control budget. Hanford Laboratories' research and development costs for September, compared with last month and the control budget are as follows:

(Dollars in Thousands)	Cost				
	Current Month	Previous Month	FY To Date	Budget	% Spent
HLO Programs					
02 Program	$ 45	$ 36	$ 116	$ 605	19%
04 Program	1 015	1 134	2 906	9 930	29
05 Program	76	60	196	993	20
06 Program	232	194	624	2 665	23
	1368	1 424	3 842	14 193	27
FPD Sponsored	121	126	352	1 400	25
IPD Sponsored	123	113	336	1 325	25
CPD Sponsored	130	131	369	1 525	24
Total	$1 742	$1 794	$4 899	$18 443	27%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

About 2.8% increase in volume is indicated for NPR fuel irradiated to 2000 MWD/T. Examination of an NPR-type element irradiated to 3600 MWD/T showed ridges or buckling on the inner clad as a result of fuel swelling. In other NPR fuel development work the sixth and seventh in-reactor rupture tests were conducted in ETR, and a test element brazed with an Fe-bearing braze compound showed evidence of an incipient shear-type failure mechanism similar to that observed in unbonded fuel closures when irradiated at high power density.

Preliminary study indicates that a single tube fuel element for N Reactor is feasible. With the high enrichment fuel located in a discreet layer near the outer surface and depleted material near the core, the relative heat fluxes in the inner and outer surfaces can be nearly balanced and operating fuel temperatures can be minimized. Considerable cost reduction appears possible in the replacement of a two-component element with one containing only a single component.

Another alternate metallic fuel element is the fluted element, designed to minimize clad failures due to uranium swelling. A test specimen is nearly ready for reactor charging.

The NPR helium stack gas may require small percentage additions of both CO and H_2 to attain conditions compatible with both the Zircaloy-2 process tubes and the graphite moderator.

Two NPR Zircaloy-2 process tubes have been tested and prepared for installation in KER Loops 3 and 4. Detailed measurements of inside diameter and wall thickness and kinescope records of the inner surfaces will be retained for comparison with future in-reactor monitoring data.

Approximately 60 additional boiling burnout conditions were obtained using an electrically heated test section simulation of the NPR fuel elements. These data and previous data indicate that the tube power required to result in boiling burnout should be 1.7 to 2.0 times the maximum NPR design tube power.

Boiling burnout data applicable to the existing Hanford production reactors were extracted from results of heat transfer experiments performed during the past few years. It was concluded that a reduction in flow of at least 50% or roughly a 100% surge in power level would be necessary to reach boiling burnout in the highest power tubes.

PRTR operation was stable and reliable during the month in marked contrast with numerous "debugging" difficulties encountered during the power testing of July and August. The principal problem was high D_2O losses encountered early in the month. Extensive leak checks and repairs reduced this loss to ca. 50-60 lbs per operating day and further reduction is being sought.

A review of the Critical Facility by the General Electric Technological Hazards Council has resulted in recommendations that include reducing moderator level during fuel loading, providing internal support members in the reactor core for the fuel elements, and adding additional safety features on the crane. Scoping of ways to accomplish the proposed changes has been started.

Wire wrap loosening observed on discharged PRTR Pu-Al spike elements is now believed to be a shutdown phenomenon only. At operating temperature the wires retighten. The cold swaged UO_2 elements in PRTR exhibit no visible changes after exposure to ca. 400 MWD/T.

Electrodeposited UO_2 was cold swaged to approximately 91% theoretical density.

Quantitative data have been obtained which show the relocation of fission fragments during the irradiation of high power density UO_2 fuel elements. Of most interest is a region containing single crystals which is markedly depleted in fission products.

Electrical conductivity of irradiated UO_2 specimens was found to be slightly higher than that of a corresponding non-irradiated specimen. This result is contrary to previous data and as yet is unexplained. The electrical conductivity of single crystals of UO_2 was shown to be substantially higher than that of 96% dense sintered polycrystals.

Eight Pu-Al fuel element clusters have been assembled this month, making a total of 49 Class I Mark I-H clusters fabricated for the PRTR.

The first Phoenix Pu-Al capsule (GEH-21-1) in a series to include various plutonium-240 contents and irradiation exposures was discharged from MTR on September 25. Its reactivity will be measured in the ARMF.

The final five Euratom test fuel rods containing high exposure plutonium oxide (17%-240) have been completed and shipped. Physics test standards of Al-Au, Al-U, Al-Pu, Al-U-B, and Al-Pu-B alloys clad in zirconium are being fabricated for BAPL.

Metallographic examination of a sample of $PuO_{1.83}$ gave indication of a lamellar eutectoid type of structure.

Satisfactory welds of SAP were made in air, helium, and vacuum.

Over-all performance on a current vendor order for over 1000 Zircaloy-4 sheath tubes is the best to date. The tubing is of excellent quality, with reject rates of less than 10% at the vendor's plant, and an additional 17% at Hanford. Correlation between Zyglo dye-penetrant testing and ultrasonic testing of these tubes has been improved.

The onset of Zircaloy hydriding in a dry, hot, hydrogen atmosphere is preceded by a significant drop in the electrical resistance of the ZrO_2 film, suggesting that the hydrogen penetrates the film through oxygen vacancies in the ZrO_2 lattice. This may offer a technique for identifying protective and non-protective ZrO_2 films.

The first in-reactor creep capsule in the third generation series was charged into the reactor late in the month. This capsule contains a 20% cold worked Zircaloy-2 specimen. The capsule appears to be operating in an entirely satisfactory manner. However, insufficient time has elapsed to obtain comparative in-reactor and ex-reactor creep rates.

Burning tests show only marginal reduction in potential burning hazard from coating EGCR graphite fuel sleeves with silicon carbide.

2. Chemical Research and Development

Laboratory tests showed 95% removal of tracer arsenate from synthetic reactor effluent water by high (18-20 ppm) aluminum flocculation treatment. Subsequent

flocculations on the same water sample showed removals of 77, 21 and 4%, respectively. These data contrast sharply with reactor process water treatment findings where the high alum process results in little or no removal of arsenic-76-producing parent material.

The assembled automatic As-76 monitor was placed in continuous operation on a sampling line from the inlet of the 107-F retention basin. Background tests and counter efficiency measurements were satisfactory.

Three parts per million of the complexing agent, EDTA, were added continuously to the cooling water of a chemically decontaminated reactor tube to test its effect on reducing the adsorbability of the radioisotope parent materials. No practical beneficial effect was observed with this agent.

Two fission product release experiments were made using uranium irradiated to about 1300 MWD/T. Heating tests (24 minutes at 1200 C) showed a 13% greater gross metal oxidation than that encountered with lightly irradiated (2×10^{14} nvt) uranium; liberation of fission product xenon as a burst when the metal temperature reached 1000 C; the first detection of cesium evolution at 680 C, followed by a higher but more uniform release of the cesium at 1200 C.

The initial test to determine the feasibility of the in-tank concentration of certain liquid wastes by submerged combustion techniques was made. Although some difficulties were encountered in the burner ignition system, a 4 M sodium carbonate solution was concentrated to about 8 M at which point the tank contents on cooling solidified to a "rigid slush."

The fourth and final run of the current HLO strontium-90 recovery program is in progress and has, in addition to the primary objective of recovering strontium, the secondary objective of exploring the technology required for the recovery of a pure cerium and a cerium-free promethium (rare earth) product by solvent extraction techniques.

The recovery of technetium-99 from alkaline Purex waste supernate was successfully demonstrated on a large scale in the A-Cell ion-exchange equipment; four grams of technetium were recovered from about 450 liters of feed in this preliminary experiment, for an over-all recovery of 80%.

Initial studies to determine the path of technetium in the Redox and Purex processes showed the Redox and Purex final uranium products to contain about one and nine percent of the plant feeds, respectively.

Dipicrylamine in nitrobenzene shows promise of being an effective solvent for the extraction of cesium-137 from Purex neutralized waste.

The presence of air atmospheres and moisture during the electrodeposition of UO_2 from molten chloride salts continues to show detrimental effects on

product quality, namely, product form and high oxygen-to-uranium ratios. Large scale electrodepositions in the absence of air and moisture resulted in the preparation of about 100 pounds of UO_2 with the closely packed rectangular crystal structure and an oxygen-to-uranium ratio of 2.01.

The ion exchange extraction (Duolite C-3) of cesium from high level Purex waste supernate was tested on a substantial scale in the hot cells. The cesium decontamination factor for the first seven column volumes of effluent was greater than 500; 50% breakthrough was reached after 13 column volumes of waste. Greater cesium capacities are expected with wastes at higher pH.

Micro Pilot Plant Run 18, evaluating the decontamination ability of clinoptilolite for radioactive condensate waste, was completed. During the treatment of 5000 liters (20,000 column volumes) of radioactive condensate waste, the Cs-137 and strontium concentrations in the effluent did not exceed their MPC_W until after 15,000 and 5400 column volumes, respectively.

3. Physics and Instrument Research and Development

An increase by 40% in the batch limit in melting crucibles in 234-5 Building will be possible as the result of successful completion of an experiment which mocked up the essential nuclear safety features. As with previous experiments of this type, which are cooperative efforts between CPD and HLO personnel, the critical mass was obtained by extrapolation of subcritical measurements.

In the NPR Program the fuel temperature coefficient of reactivity has been evaluated following earlier PCTR experiments. Data were obtained up to 960° C. The results are needed to provide a basis for control and hazards calculations for the reactor. The results show a non-linear loss in reactivity with increasing temperature.

Precautionary measures to avoid inadvertent introduction of fission products into the NPR coolant system will be based on use of an alpha monitor recently completed and delivered to FPD for detecting surface contamination of fuel elements. No detectable contamination has been found on NPR fuel tested to date.

Nuclear purity of the NPR graphite stack after completion of layup will be measured by methods now being tested in mockup experiments for IPD. Planning and procurement of instrumentation is also under way for IPD.

In support of existing reactors the optical device for measuring process tube distortion has been completed and delivered for use at C reactor. Another instrument of improved design is being fabricated and one suitable for use in the NPR channel geometry is being designed.

The loss in reactivity caused by insertion of poison splines in a K-reator type

lattice was measured in the PCTR. The measurement is to be repeated after irradiation of the splines to determine the burnout rate of the poison material.

The inspection and measurement of weapons components will be improved by a new, special groove-depth microscope developed for and delivered to CPD. Contours of grooves can be measured to an absolute precision of better than 100 microinches.

In the Plutonium Recycle Program, further insight was gained during the month on "Phoenix" fuels application to compact, water moderated power reactors. A preliminary study indicates that highly recycled plutonium does not produce the desired reactivity flatness during reactor life, but plutonium low in Pu-240 ($\sim$10%) compares favorably with the flat reactivity response of self-shielded burnable poisons without the disadvantage of occupying non-fuel bearing core volume.

An improved method for calculating plutonium reaction rates with thermal and near thermal neutrons became available with the coding and debugging of the MWX code during the month. By treating the neutron energy spectrum more rigorously the code achieves results which can be used, for example, to obtain improved results from MELEAGER.

New equipment for the nondestructive testing of fuel core-cladding bond quality by heat transfer tests has been installed in the 314 Building for further development and concurrent testing of AlSi process and NPR fuel elements in small quantities.

Several improved models of the miniature dosimeter with a register readout and the one with an audible alarm are being experimentally fabricated. Prototypes of both designs were successfully demonstrated to several plant organizations.

Knowledge of atmospheric dispersion processes was increased by comparison of recent data obtained at Cape Canaveral with previous Hanford results. Atmospheric stability has less effect upon the horizontal spread of contaminants than previously supposed and other factors such as wind speed and direction shear now appear to be the controlling ones in such dispersion.

4. Biology

A new chelating agent, possibly more effective than DTPA, is TTHA, triethylenetetramine hexaacetic acid. This shows promise for treatment of plutonism, but it appears to be somewhat more toxic than DTPA.

A cooperative study with the State Game Department was developed to study the dispersion of waterfowl from Hanford by obtaining heads of birds killed by hunters.

[redacted]

Some interesting relationships of strontium to calcium and other alkaline earths are being uncovered. It appears that the GI absorption of strontium can be either increased or decreased, depending upon the other alkaline earth present.

Further evidence of the complexity of the "isotopic dilution effect" was obtained. Uptake of I^{131} by bean plants was increased by the addition of carrier iodide.

5. Programming

As uranium-238 spatial concentration in fuel is reduced in order to compensate for the presence of plutonium-240 in recycled plutonium, the computed plutonium value often increases to a peak value and then decreases sharply. This effect complicates the determination of maximum plutonium values when both the amount of plutonium enrichment and the amount of uranium-238 are considered to be variables.

TECHNICAL AND OTHER SERVICES

Presentations of the current status of the input-output model of the Hanford plant were made to several groups. Comments during these presentations indicated interest in comparing the predictions for the model with other forecasts and in further clarification of the effect of research and development on the improvement patterns noted. Additional suggestions were primarily concerned with the effective application of the model rather than its content.

Work on fuel element performance has been concerned primarily with the design of specific production tests in collaboration with feed-site personnel. These tests are designed to clarify relationships between certain onsite and offsite variables and fuel element performance.

Work continued on the reliability analysis of various instances of trip logic of the kind generally known as "majority gate" logic. A reliability algebra for a four-state device has been constructed which will enable, for systems of this type, the simultaneous calculation of the probability of a catastrophic type failure and the probability of a spurious scram.

Revised and improved calibration functions were estimated in connection with the instrumentation of pulse column test facility.

Uncontrolled exposure to a small skin area on the hand of an FPD Maintenance employee occurred in the PRTR discharge pit and resulted in a maximum estimated dose to a small area of the skin of about 300 rads. The average dose to the entire hand was about 5 rads. The dose was estimated from an exposure time of 5 minutes to the small cotter pin source which had a surface dose rate of about 3500 rads/hour.

There were no new cases of plutonium deposition confirmed by bioassay analysis during the month. The total number of plutonium deposition cases that have occurred

at Hanford is 271, of which 198 are currently employed. (One of these employees was re-hired this month.)

Additional laboratory analyses of a construction employee who was contaminated with plutonium oxide during removal of a hood in the 234-5 Building in August indicated inhalation and excretion of significant quantities of the plutonium oxide. Subsequent laboratory analyses continue to indicate that little translocation from the lung to the other organs of the body has taken place.

For the second consecutive time the film dosimeter of a CPD Laboratory Technician at the 234-5 Building indicated an unexplained dose of gamma or X-radiation. The most recent film dosimeter worn by the employee for a four-week period showed a dose of 0.8 r following the previous four-week period where a dose of 2.1 r was indicated. These apparently valid but unexplained exposures when added to the previous accumulated dose for the calendar year result in a total of 3.1 r to date.

There are 18 currently active projects having combined authorized funds in the amount of $5,683,000. The total estimated cost of these projects is $10,664,000. Total expenditures on them through August 31, 1961 were $2,232,000. In addition, project proposals have been submitted requesting authorization of $492,000 total project funds on 3 new projects.

Projects CGH-923 - Spectroscopy Laboratory, and CGH-935 - Metals Storage Building were completed during the month. Completion was ahead of schedule and within the authorized funds.

SUPPORTING FUNCTIONS

Advanced Degree - Six Ph.D. applicants visited HAPO for professional employment interviews. Two offers were extended (one for HL); three acceptances (2 HL) and three rejections were received. Current open offers total two.

BS/MS - Efforts continued on the installation of the new record-keeping system. Plans were made for fall campus visits which begin October 6.

Technical Graduate Program - Two technical graduates were placed on permanent assignment. Six new members were added to program rolls and five terminated. Current program members total 88.

During September, three security violations and 35 medical treatment injuries occurred.

One hundred sixty Laboratories employees are currently enrolled in seven courses offered by the Laboratories. Four of the 7 courses are technically oriented and account for 98 enrollments. In addition, 92 Laboratories employees have submitted tuition refund applications for fall courses, thus making a total of 252 employees engaged in educational pursuits.

Preparations are being made to transfer custodianship of the Hot Semiworks from Hanford Laboratories to Chemical Processing Department during October, 1961.

Notification has been received from Nuclear Materials that Survey 19, Part I, as of the end of October, will consist of verification of HAPO inventories of normal uranium, tritium, deuterium, and enriched lithium.

At the request of the Atomic Energy Commission, the 06 Program supplemental research and development proposals submitted in the Budget for FY 1963 and Revision of Budget for FY 1962 were revised and resubmitted to reflect comments of Washington-AEC personnel on the level and direction of the proposed research.

W. K. Woods

for Manager
Hanford Laboratories

HM Parker:WKW:mlk

[redacted]

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Erosion-Corrosion of Aluminum Alloys. Small areas 0.015-inch wide and 0.500-inch long on samples of X-8001 and 1245 aluminum alloys were exposed to 300 Area tap water at 102 C for 16.5 hours at flow velocities of 43, 59, and 76 ft/sec. Results from duplicate samples were in good agreement except at the highest flow velocity of 76 ft/sec. The corrosion of both alloys at this velocity suggested that cavitation was a major corrosion factor. As additional verification, when the test at 76 ft/sec was repeated except with a 100 psi back-pressure on the system, the resulting corrosion was reduced by a factor of two. This work is continuing to measure the effect of back-pressure at the lower velocities.

Corrosion Resistant Autoclave Coatings for X-8001 Aluminum. The initial phase (sample preparation and accelerated corrosion testing) has been completed for a two-cycle, water - 1% chromic acid autoclave treatment. Correlation of results from accelerated corrosion tests with the autoclaving cycle time and temperature is expected to indicate the optimum over-all cycle. The two separate accelerated tests that form the basis of the evaluation are: (a) one hour in boiling 5% Na_2CO_3, and (b) one hour in boiling 1% HCl, 3% NaCl. The results of the accelerated corrosion tests have been sent to Industrial Statistics for evaluation.

Electrical Resistance Changes in ZrO_2 Films. The "oxygen vacancy" theory of zirconium corrosion predicts a concentration-gradient of oxygen vacancies in the oxide film on the corroding sample, with the number of vacancies increasing toward the oxide-metal surface. If the sample is heated in an oxygen-free system, the number of vacancies should increase with time, since vacancies are continually formed at the metal surface by reaction between zirconium and oxygen present in the film, without a compensating oxygen absorption from the environment. The electrical conductivity of the film should change as the number of oxygen vacancies changes.

A ZrO_2 film was formed on a Zircaloy-2 wire at 450 C in H_2O vapor until the resistance of the film was 70,000 ohms. The system was evacuated, and the resistance slowly dropped over a day to 100 ohms. If water vapor was admitted, the resistance immediately jumped back to 70,000 ohms. This cycle was repeated three times. After evacuating the next time, dry hydrogen gas was admitted. The resistance slowly dropped as before to almost zero over a two-day period. No hydrogen uptake was observed during this interval. However, the sample catastrophically hydrided over a weekend.

[redacted] [redacted]

These results could be interpreted on the basis that some oxygen vacancies must exist for both hydrogen diffusion and electron conductance. In the absence of water, the number of oxygen vacancies increases to the point where hydrogen diffusion can become significant. When water is added, the oxygen vacancies are quickly filled and the resistance increases. It is known from other experiments that water vapor stops hydrogen diffusion, possibly by plugging the vacancies. This also explains why such small amounts of water are effective inhibitors, since only a few molecules are required to fill the vacancies.

The results of this first experiment are considered significant not only because they tend to confirm the oxygen vacancy theory, but also because the resistance of the film may offer a technique for identifying "protective" and "nonprotective" ZrO_2 films.

Zircaloy-2 Sheffield Steel Galvanic Coupons. The possibility of galvanic corrosion between Zircaloy-2 - Sheffield Steel, and low nickel Zircaloy-2 - Sheffield Steel couples in 300 C pH-10 deoxygenated water is being investigated. Following five months of exposure the test couples show no significant effect from galvanic corrosion.

Zircaloy Components for Coextrusion

The quality of the NPR coextruded fuel element would be enhanced if variations in the Zircaloy-2 clad thickness were eliminated. Three initial approaches are being employed to determine whether properties of the Zircaloy components contribute to dimensional variations and whether these variations can be eliminated: (1) the component-forming processes are being analyzed to correct any practices that could cause asymmetric properties, (2) the hardness and grain structure of the components are being characterized in their original condition, after preheating but prior to extrusion, and after extrusion and (3) cladding dimensions are being measured on samples from coextrusions using components from various vendors. The hardness of the components with one exception ranged from 91 to 100 Rockwell B. There were no apparent variations in hardness within individual components. After simulated extrusion preheat treatments, the hardness ranged from 87 to 92 Rockwell B. The one exception, which had lower hardnesses both before and after heat treatment is being rerun. The grain structure of all samples is being determined.

Radiometallurgy Laboratory Studies

Severe bumping was found in the inner bore of two KER single tubes irradiated to 3500 MWD/T. A third element was moderately bumped and the fourth showed no sign of bumping in the inner bore. A silicone rubber replica taken from the inner bore of the most severely bumped element revealed the bumps to be longitudinal ridges (RM-584).

Metallographic examination and replication of NaK swelling capsules GEH-14-96, 97, 101 and 103 revealed that capsule 97, which was irradiated under the highest temperature, exhibited gross swelling and the uranium had recrystallized in the center of the core (RM-565).

The braze bond and end caps at both ends of an NPR inner tube irradiated to 1000 MWD/T at simulated NPR conditions, IP-377-A, are in excellent condition. No heat effects were observed adjacent to the spot welds attaching the support tabs (RM-583).

Metallography of a KER tube-in-tube element irradiated to 1200 MWD/T at high temperature revealed that the Zr-Be-Fe braze was cracked at both ends of the inner tube. The braze at the cooler end of the outer tube was in good condition but was cracked at the hot end (RM-709).

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

Basic Metallurgy Studies

Electron and Optical Microscopy. Damage to metals by neutron and fission fragment bombardment is being investigated by electron microscopy techniques. A new double condenser electron microscope has been installed to permit direct examination of foil specimens at higher resolution than heretofore possible.

Several types of specimens, irradiated in the Hanford Snout Facility, have been received for examination. One group consists of high purity aluminum foils, 0.003" thick containing quenched vacancy clusters. The specimens were irradiated to an exposure of 10^{17} nvt (fast) and will be compared with the high purity annealed and cold worked foils irradiated to the same level. If vacancies rather than interstitial clusters form during irradiation, there should be a marked change in the quenched foils. A second group of high purity aluminum foils, both annealed and cold worked, have sustained an exposure of 10^{20} nvt (fast). This represents the highest level of exposure received to date. A third group of aluminum specimens has been irradiated in close proximity to a carbon coated, UO_2 source. The fission fragment source received an exposure of 10^{18} nvt (thermal). Fission fragment damage regions within the aluminum foils, as well as interaction between these damage regions and dislocations will be studied.

Notch Sensitivity of Zircaloy-2. The mechanical behavior of Zircaloy-2 cladding, in particular, the effects of wall irregularities on the ductility and strength of the cladding, is being investigated with tensile tests at 280 C. Notch geometry, multiple notches, strain rate, and irradiation effects are being studied on rolled 0.020" Zircaloy-2 sheet specimens. In addition, cladding material as extruded on the N-elements will be examined. A roller mechanism to fabricate transverse tensile specimens from the extruded tubes is being built. The preliminary design of a capsule for a one-cycle irradiation of tensile specimens in the ETR is completed.

Zirconium Alloys of Variable Tin and Oxygen Content. A series of Zircaloy-2 melts are being prepared to determine the relationship between extrusion constant, tin content, and oxygen content. Fifteen of the 32 primary ingots and one of the 16 finished ingots have been melted for this program. Melting for this program should be completed by November 15, 1961.

Metallic Fuel Development

Fuel Irradiations. A replica of the inner bore of a KSE-3 single tube fuel element irradiated to 3600 MWD/T has been made in Radiometallurgy. The replica shows that the bumps which developed in the bore during irradiation are ridges that range from two to three inches in length. It is concluded that the bumps are a result of buckling or unstable collapse of the inner clad caused by swelling of the fuel.

Fuel swelling determinations made on five NPR inner tubes irradiated to 2100 MWD/T indicate an average swelling of 2.8 percent. This figure is in good agreement with the average of 2.9 percent swelling obtained on KSE-3's irradiated to 2000 MWD/T.

A full-size NPR tube-in-tube fuel element is being irradiated in the new 6x6 M3 loop in the ETR. Because of minor loop operating difficulties the loop outlet temperature is being maintained below the 271 C temperature requested. During the next cycle, outlet temperature should be raised to the requested value. This fuel element is to be examined and measured after each irradiation cycle.

An NPR inner tube fuel element is being tested in the ETR 3x3 loop. The fuel element has operated for ten days at a specific power of 38 kw/ft and a maximum fuel temperature of 425 C. The exposure is now approximately 120 MWD/T. The element will be measured after each full ETR cycle.

The defected elements from the sixth and seventh ETR rupture tests have been received by Radiometallurgy and a preliminary examination of the element from the seventh rupture test has been made. The fuel element used was an NPR inner tube which had been irradiated to 1700 MWD/T in one of the KER loops before being tested in the ETR. Thirteen minutes after the defect cap was sheared off this element, the loop radioactivity level was high enough that a reactor shutdown was initiated. The nine-minute incubation period observed in this test was the shortest of any of the ETR rupture tests conducted to date.

The cladding of the seventh rupture test element was extensively blistered around the defect. The blister extended about 1-1/4 inches longitudinally on either side of the defect and 90 degrees laterally around the fuel element on either side of the defect. The blister was high enough that it filled the 80-mil annulus between the fuel element and the basket. The cladding was split longitudinally through the center of the blister and was cracked extensively around the base of the blister. The weight of uranium converted to oxide is estimated to be 20 grams.

Radiometallurgical examination has continued on the iron braze elements irradiated in the ETR 6x9 loop. Evidence of the start of a shear-type failure mechanism was observed in the closure of one of the inner tubes. Also, the difference in uranium condition between the reactor midplane and the ends of the fuel element was very marked. The very hot center of the fuel element operated in the beta phase, the cooler ends operated in the high alpha uranium temperature zone. The shear type failure mechanism was observed on the cold end of the upper element. Radiometallurgical examination is continuing.

Twenty-two Zircaloy-2 clad coextruded uranium rods have been irradiated in the MTR in NaK-filled capsules to burnups ranging from 600 to 5000 MWD/T and maximum uranium temperatures from 250 to 700 C. One of the rods, GEH-14-104-1, has a striation on the external surface of the cladding indicating that cladding instability and necking has started.

Prior to this observation, such striations had only been found on capsule irradiated fuel rods with much larger cladding thickness variations than is the case for the 104-1 rod. Metallography and examination on a transverse cross section of this rod is planned.

Single Tube Fuel. Considerable incentive in the area of fuel fabrication costs exists for the development of a single component fuel element for the N Reactor. With proper proportioning of high enrichment in the outer portion and low enrichment in the inner portion of a single tubular element, the relative heat fluxes at the inner and outer surfaces can be controlled and the fuel operating temperature can be minimized. Preliminary calculations indicate that a Zircaloy-2 clad, single tube segregated enrichment fuel element having the same total fuel content as the present tube-tube combination would probably meet the requirements of N Reactor operating conditions.

A single tube fuel element is to be irradiated in the ETR 6x6 M3 loop to evaluate the single fuel tube concept. This element has been designed and fabrication started. The average enrichment for this test element is 1.12 percent, with the outer 46 percent of the volume 1.6 percent enriched, and the inner 54 percent natural uranium. The two coaxial uranium components and Zircaloy-2 cladding material will be coextruded to form a single tube, 2.3-inch OD and 1.25-inch ID.

Fluted Fuel. Several 18-inch long coextrusion clad fuel elements having a non-circular (fluted) cross section are being fabricated for irradiation testing. The use of this geometry may extend the burnup life of the fuel by allowing for uranium swelling; i.e., the volume of the core of these elements can increase nearly fifty percent before the jacket becomes circular.

A cold water irradiation facility will be used to provide most of the 3000 to 4000 MWD/T goal burnup. Final irradiation will be made in a high temperature ETR loop under temperature conditions conducive to uranium swelling.

Thermocouple Fuel. The third thermocoupled fuel rod, which failed in KER Loop 1 after only 6-1/2 hours of reactor operation, has been examined by Radiometallurgy Operation. The cladding was split over the peripheral thermocouples on either side of the rod as well as at the base of the end cap. Considerable uranium corrosion had occurred in the thermocouple holes, particularly in the center hole. The initial point of water entry could not be determined.

Additional thermocoupled fuel rods are now being fabricated. These are one-inch OD rods with 25-mil thick cladding, 1.6 percent enriched uranium, and a 0.45-inch diameter Zircaloy-2 core in the center. A single thermocouple in the Zircaloy-2 core will be used in these rods rather than the three thermocouples used in the previous test rods.

Metallic Fuel Measurement. Methods of numerically analyzing measurements of radial displacements and thicknesses of tubular fuel elements are being developed. The computer program for the circumferential analysis of the data has been debugged. This program gives mean radii, thickness, ovality, radial displacement of the axis, and changes of the mean circumferential curvature. The axial characteristics of the fuel material will be obtained from the radial displacements. Programming is started on this section of the analysis.

Heat Treatment. Several sections of Zircaloy-2 clad, I&E fuel with 0.94 enriched, Fe-Si additive uranium cores were given heat treatments to simulate recycle due to warp and subsequent recycle due to faulty end closure. These recycles result in end sections that have the following thermal treatments: (1) alpha extruded, gamma braze, two beta heat treatments; (2) alpha extruded, gamma braze, three beta heat treatments; and (3) alpha extruded, two beta treatments, gamma braze, and beta treatment. Longitudinal sections through the closure region were examined for effect on uranium grain structure, clad to uranium bond, and braze to uranium bond. No detrimental effect was noted on the uranium grain structure. Pronounced growth of the clad-to-uranium diffusion zone occurs on recycle and particularly upon brazing the double beta heat treated section. No bond cracking was observed. Growth of the braze to uranium bond occurred also, although again no bond failure was found. Considerable porosity was noted in the braze heat affected region and pronounced grain boundary precipitate occurs. This precipitate is presumably U-(Fe-Si) compounds.

Additional samples of the same material are being treated at various alpha temperatures and times before subsequent beta heat treatment to determine the effect of Fe-Si alpha solubility and degree of precipitation on beta treated grain size. Microhardness measurements and high magnification examination are being employed to follow the effect of alpha phase annealing.

A 24-inch long NPR inner tube has been beta heat treated for seven minutes at 730 C, given an air delay of 18 seconds, and quenched into 300 C nitrate salt bath. Eight one-inch long sections were removed from the middle of the tube and are being studied metallographically

and by x-ray. When the texture of sections has been established definitely by x-ray diffraction using the technique of grinding and polishing the specimens as many times as is necessary to obtain sufficient surface area, the samples will be recrystallized and again subjected to the above investigation. The object of the experiment is to determine the effect of recrystallization upon the beta-treated texture with the hopes that more reliable and more economical x-ray data can be obtained using recrystallized samples.

Closure and Joining. A technique for nondestructively testing the quality of bonding at the V-shaped uranium-Zircaloy interface in NPR experimental fuel elements has been developed and evaluated sufficiently to establish reasonable confidence in its reliability. By means of this test, it was revealed that most of the closures heretofore produced by the "self-brazing" process and believed to be sound on the basis of representative metallurgical examinations, were actually incompletely bonded. Dissections of some of the defective specimens showed the poor bonding to be due to a tarnish film on the uranium surface, thus indicating a need for better process control in the surface preparation, assembly, and/or welding operations.

Since cathodic etching in inert gas, followed by assembly and welding in the same chamber, represents the ultimate in surface cleanliness, an experiment embodying this treatment was conducted.

Three specimens having, respectively, no plating on the cap, copper plated cap, and copper-nickel plated cap, were cathodically etched on the faying surfaces, electron beam welded without interim exposure to air, and hot-pressed according to the self-brazing closure process practice. Two of the three appear soundly bonded at the uranium-Zircaloy interface; the third (Cu-Ni plated cap) appears rather spotty. From this it seems that the cathodic etch treatment leads to definite improvement in the consistency of the bond, and with proper placement of copper plating on the side walls of the cap, consistent sound closures should be obtained. Efforts are being devoted to preparation of a group of soundly bonded specimens which can be defected and autoclaved to determine the failure resistance of this type of bond.

Attempts have been made to produce a resistance bonded double closure on Zircaloy-2 clad uranium fuel elements using a combination of resistance and inert arc welding. This closure consists of resistance welding a Zircaloy-2 cap to the inside of the cladding walls next to the uranium to seal the uranium below the final closure area during the cap to uranium bonding step. Small Zircaloy-2 rings wedged against the OD and ID cladding by the wedge-shaped cap act as projections for the resistance weld. Immediately following the resistance weld, the pressure is increased on the cap to seat the cap onto the uranium and the power continued to resistance heat and bond the cap to the uranium. This technique is similar to the projection welded resistance brazed closure. The final closure is a conventional inert arc fusion weld between the cap and the OD and ID cladding at the outer end of the cap.

The closure has been tried only on 1.050-inch OD by 0.500-inch ID tubular elements using the 100KVA resistance welding machine. The resistance weld about the OD of the cap was good and retained the uranium. The weld about the ID was not entirely complete and did not fully retain the uranium. The ID difficulty may be overcome by using a different shaped ring than the 0.030 diameter wire ring which was used. The bond between the cap and uranium appeared to be 100 percent using the 75 degree wedge-shaped cap with copper plate on the wedge section.

Locking Clips. Design was completed on clips that attach to the inside of the outer NPR fuel tube and mechanically resist sliding or rotation of the inner tube with respect to the outer. Positive rotational locking is obtained by bending tabs on the clip around the mating inner tube support. Over fifty fuel assemblies have been subjected to simulated discharge tests, with none of the tube components separating as much as the permissible two-inch maximum. This locking clip will be used on N Reactor fuels.

2. REACTOR PROGRAM

Corrosion and Coolant Systems Development

Diffusion of Water Vapor Through NPR Core Graphite. The rate of transport of water through a thimble of NPR core graphite has been measured in H_2O-He mixtures, H_2O-CO-He mixtures, and H_2O-CO-H_2-He mixtures. Data on the H_2O-He mixtures were reported last month.

The effect of CO additions to a He-H_2O mixture is to stop the diffusion of water vapor through the graphite, probably because the equilibrium $CO + H_2O \rightleftarrows CO + H_2$ removes the water from the system. At 650 C graphite temperatures and 0.5 mm H_2O in the inlet gas, the water transport rate through the graphite dropped to zero when the CO concentration was above three percent. With 800 C graphite no water was passed with 0.2 percent CO added.

The addition of one percent H_2 to a He mixture containing five percent CO and 0.5 mm H_2O partial pressure greatly improved the water transport rate to about double the rate reported last month for He-H_2O (0.5 mm) only.

To date only He-H_2O mixtures and He-CO-H_2-H_2O mixtures have been found to pass water through NPR core graphite in sufficient quantities to maintain zirconium oxidation rates. It is planned to check the effect of a CO-CO_2 mixture on water transport rate.

Present Reactor Decontamination. Three inhibitor materials have been tested in the laboratory as replacements for phenylthiourea in the 0.3 M sulfuric-0.1 M oxalic acid decontaminating mixture. A proprietary inhibitor (No. 5268-1, West Chemical Co.) appears promising as a replacement for phenylthiourea on the basis of these laboratory tests. Rodine-82

only slightly inhibited carbon steel corrosion and apparently catalyzed a catastrophic corrosion of aluminum in the sulfuric-oxalic acid mixture. Sodium dichromate added to the mixture increased the corrosion of carbon steel. Initial testing of Weedac-inhibited sulfuric-oxalic acids in the Pilot Apparatus for Decontamination shows promising decontamination and corrosion results.

Decontamination of Single-Pass Tubes. Two of the single-pass tubes in KE Reactor (4963 KE and 5063 KE) are being used to test effects of chemical additions to the water. The program consists of short operation with a specific chemical added to the water and then discharge, decontamination, reloading, and resumption of the test with another additive. During the past month the tubes were decontaminated with Turco 4306-B. Test samples and control samples are being exposed throughout these tests to measure corrosion rates and decontamination efficiency. Initial decontamination (reported previously) removed the red film from the samples but did not reduce the radioactivity levels of these samples. The second decontamination reduced total radiation levels by factors of 2.4 (Tube 4963) and 3.4 (Tube 5063) with average final gamma radiation levels on the test samples of < 1.5 and 6.0 milliroengtens per hour, respectively. At least one further decontamination, and one more period of chemical addition are scheduled for this test series. Each chemical addition period is two weeks long.

Physical Properties of Decontamination Wastes. Determination of the physical properties of simulated N Reactor decontamination wastes has nearly been completed, and final laboratory reports are expected to be issued within the next two weeks.

Cyclic Testing of Wyandotte Decontaminants. An eight-cycle test to evaluate corrosion by Wyandotte-1113 (alkaline permanganate) and Wyandotte-5061 (sodium bisulfate) has been completed. During the test every effort was made to exclude oxygen. Carbon steel exhibited an average corrosion rate of approximately 0.15 mil per cycle ($\sim$170 hours at 300 C followed by a decontamination). Stainless steel (type 304) corrosion was 0.02 mil per cycle. The stress-relieved carbon steel - stainless steel weld specimens corroded slightly less than plain carbon steel, whereas the as-welded samples corroded at a slightly higher rate. There appeared to be only very minor attack at the weld junction between the stainless and carbon steels. All of the corrosion appeared uniform, with little or no localized attack such as was noted in previous tests when oxygen was present. Samples are being examined metallographically to establish the depth of attack.

Corrosion Rates of Carbon Steel, Stainless Steel, and Zircaloy-2 in 290 C Water at pH 9. A test in TF-5 to determine the uniform corrosion rates of carbon steel, 304 stainless steel, and Zircaloy-2 in pH 9 (LiOH), 290 C, deionized, deoxygenated water is three-fourths completed. A total of 1900 hours of exposure has been accumulated. The corrosion rates of A212 carbon steel, 1031 carbon steel, and 1051 carbon steel are all 0.12 mil/year. Samples in the as-received condition exhibited

slightly higher initial penetration than samples in the polished condition, but all samples are currently corroding at the same rate.

The corrosion rate of both sensitized and nonsensitized 304 stainless steel is 0.057 mil/year. The Zircaloy-2 samples initially exhibited a weight gain of 15 to 20 mg/dm^2 but have not continued to gain weight with increasing exposure.

The corrosion rates of all the alloys listed above are similar to those obtained in previous tests employing similar water conditions, except that the previous tests were run at pH 10. An analysis of the corrosion-product film weights indicates, at least in ex-reactor systems, that the crud release rate is no higher at pH 9 than at pH 10.

NPR Dummy Heat Exchanger Corrosion Test. A test is in progress to determine the susceptibility of the NPR steam generators to deposit formation and stress corrosion cracking. A small dummy heat exchanger tube bundle is being exposed to alternate drying and wetting action in order to promote deposition of water impurities on its surface. After two additional weeks of exposure (3 total) since the last reporting period, no significant deposits have been formed by NPR secondary system water contaminated with five percent filtered Columbia River water.

Corrosion of Materials in NPR Secondary Water. Samples of A212 carbon steel, as-received and sensitized 304 stainless steel, Admiralty metal, 70-30 Cu-Ni alloy, and silicon bronze are being exposed in 160 C, pH 9 (NH_4OH) deionized, deoxygenated water containing 10-50 ppb hydrazine to determine corrosion rates to be expected in the NPR secondary system. Samples are charged in both the stressed and nonstressed conditions. After a two-week exposure all coupons except the carbon steel had tight, adherent corrosion films. The carbon steel had a black smutty film. No weight loss data have been obtained yet.

The hydrazine concentration rose to about 500 ppb for approximately one day, but this did not induce stress cracking of the stressed Admiralty metal. The effect of ammonia and hydrazine on the stress corrosion cracking of Admiralty metal is one of the problems of major concern in the NPR secondary system.

Rupture Testing of Predefected Zircaloy-Clad Fuel Elements. Two KER single tubes which were defected at Radiometallurgy were rupture tested in IRP at 300 C with programmed cooling rates following detection of the rupture. These two tubes were irradiated to 1200 MWD/T in KER-4 at 242 C. They are part of a series of six tubes irradiated to 1200 MWD/T, 2000 MWD/T and 3600 MWD/T for determining the effect of irradiation on the rupture rate and severity. One tube of each pair will be subjected to a scram cooldown, and the other to a slow cooldown, following detection of the rupture.

The first of the 1200 MWD/T tubes exhibited an incubation period of 60 minutes. Following a five-minute hold time at 300 C (five minutes is considered the minimum time before a reactor scram will be initiated at N Reactor after rupture detection), the water was cooled to 160 C in six minutes. The water was then cooled at 1.85 C/minute until the temperature was below 106 C. The loop activity increased from 30 mr/hr to 50 mr/hr during the first four minutes and then climbed to 240 mr/hr after seven minutes. The final total activity was 380 mr/hr.

The second tube exhibited an incubation period of 63 minutes. Following a five-minute hold period, the water temperature was reduced 2.8 C/min until 272 C, and then was reduced 1.85 C/minute to below 106 C. The activity curve was similar to the rapid cool tube after six minutes, but then the activity increased rapidly. After 10 minutes it was 400 mr/hr. The final activity in the loop for the slow cooldown element was 6.3 times higher than for the rapid cooldown element. As the total in-reactor exposure is increased it is expected that this factor will increase because of the increased severity of the core and bond damage. The two tubular elements will be sent to Radiometallurgy for examination and weight loss measurements.

Structural Materials Development

Pre-Post Irradiation Evaluation of Zircaloy Pressure Tubing. Three sections of the Zircaloy-2 pressure tube discharged after 28 months of exposure in KER Loop 3 have been examined with a telescope at the 10-foot level of the KE basin. The outside surfaces of two of the sections from the active zone of the reactor have a black film resembling that produced in a steam autoclave. A third section located within 12 feet of the upstream end of the tube showed interference colors on the surface indicating a thinner oxide film. The film on all sections appeared to be in good condition with no evidence of accelerated corrosion at any point.

Two Zircaloy-2 NPR process tubes have been cut to a length of approximately 48 feet for installation in the KER facility. One tube was produced by Allegheny-Ludlum Steel Corporation (AT-87) and contains about 35 percent cold work. The other (CT-14) was produced by Chase Brass & Copper Company with 18 percent cold work. Each tube contains two butt welds. A Kinescope recording on 16 mm film was made (via borescope examination) of the inside surfaces of both tubes. The welds showed clearly on the film. Little additional surface detail was evident other than minor water stains. The 0°- 180° and the 90°- 270° inside diameters were measured with an air gage, and readings were recorded at carefully measured one-foot intervals. The only unusual measurement was at one of the welds in CT-14 where local conditioning had increased the diameter by 8 to 10 mils. Both the dismater and the wall thickness were within specifications. Wall thickness was measured and recorded by a longitudinal Vidigage trace at the 0°, 90°, 180° and 270° positions. The tubes will be installed in the reactor with the 0° mark in the 12 o'clock position. It will then be possible to refer the in-pile monitoring data to the pre-irradiation measurements.

Nonmetallic Materials Development

Graphite Burnout Monitoring. Monitoring samples in 1889- and 1960-C and in 3478-D have shown high burnout rates recently. In each instance the profile of the burnout rates showed a very sharp peak about 42 inches to 78 inches from the front of the graphite stack; the maximum was 11%/KOD (i.e., 1000 operating days) at C Reactor and 40%/KOD at D Reactor. From the shape of the curve and location of the peak, it is concluded the oxidant was either O_2 and/or H_2O. The partial pressure of CO_2 is large enough so that it would not be depleted in the front of the stack, and the burnout profile, if due to CO_2, would have shown a broad curve with the maximum near the stack center line where the temperature is the highest.

Although no checks on the water inlet dewpoints and the mass spectrometer analyses at C Reactor have been made, data at D Reactor indicate the damage could have resulted either from too much water (average inlet dewpoints approximately -2 F) or too much oxygen (average approximately 0.09%) in the reactor atmosphere.

Graphite Compatibility with Helium Containing Water Vapor. The possibility of adding CO and H_2 to an inert gas stream as an inhibitor for the impurity reaction between C and H_2O is being investigated. Mixtures of approximately three percent CO and three percent H_2 in a helium stream have been found to leave a black deposit on the quartz reaction tube at temperatures of approximately 650 C. Attempts to oxidize the black material in flowing O_2 at 850 C have resulted in the formation of a brown deposit appearing in the cooler regions.

X-ray (powder) lines of the black material showed four d spacings, viz: 2.88, 2.50, 1.76, and 1.50 A. These are consistent with x-ray lines reported by Lind, et al.,(1) for products found in the alpha radiolysis of CO.

A possible sequence of reactions involving carbon sub-oxides is shown below. These have not, however, been reported as occurring solely by thermal stimulation.

$$CO + H_2 \longrightarrow \text{"C"} + H_2O$$

$$x\text{"C"} + xCO \longrightarrow (C_2O)_x \text{ (Black polymer)}$$

$$3y\ C_2O + y/2\ O_2 = 2(C_3O_2)_y \text{ (Brown polymer)}$$

The reactions suggested above are consistent with the experimental observations of deposit formation. Work is continuing on identification of the deposits.

(1) J. Phys. Colloid Chem. 54, 391 (1950)

Graphite-Water Vapor Reaction Under Gamma Irradiation. The first series of rate measurements on the reaction of graphite with He containing 430 ppm H_2O vapor at a gamma radiation intensity of 9.1 x 10^5 r/hr have been completed. The He flow rate was maintained at about 0.5 CFH over a 7.6 g CSF graphite sample. Oxidation rates, as measured by a recording balance, were compared at each temperature with those obtained with dry helium to determine the extent of oxidation resulting from residual oxygen in the system. The oxidation rates at 25 C were too low for accurate measurement by the experimental techniques employed. However, an Arrhenius plot of the data in the 600 to 700 C range yields an activation energy of 9.4 kcal/mole, from which it is concluded that the reaction is predominantly radiation induced. The rate with dry He at 700 C allows an estimate of the oxygen concentration and yields a value of about 5 ppm. A second series of measurements has been initiated using NPR (TSX) graphite. A temperature range of 400 to 700 C will be employed.

Thermal Hydraulic Studies

Thermal Hydraulic Characteristics of the Overbore Fuel Elements for C Reactor. Laboratory experiments were performed to determine the relationship between pressure drop and flow at constant tube powers for C Reactor overbore fuel elements. These data, called hydraulic demand curves, are useful in establishing the flow trip requirements of the process tube pressure gages.

The test section used in these experiments consisted of a 1.991-inch OD by 0.339 inch ID electrically heated rod in a 2.147-inch ID tube. The heater rod was equivalent to a fuel charge of 32 C-VI-N fuel elements and was centered in the process tube by 192 ceramic ribs. The ribs were 0.185 inch wide, 0.625 inch long, and 0.070 inch high.

The mode of experimentation consisted of establishing steady state conditions in the test section at a high flow rate. Then, while the heat generation was held constant, readings of pressures, temperatures, and flow were obtained as the flow was slowly reduced in a stepwise manner. Each run was terminated at boiling burnout conditions as detected by a large temperature surge at some point on the heater rod.

Data were obtained for runs at 700, 1000, 1400, 1800, and 2200 KW. A preliminary analysis of the data for application to the reactor indicated the following for a front header pressure of 400 psig, a Panellit pressure of 200 psig, and a 130 C outlet temperature. (1) Hydraulic instability would only occur at tube powers greater than 1050 KW. (2) The method currently in use to calculate instability limits for the Hanford reactors should be modified slightly for a full charge of C overbore fuel elements. This latter condition appears to result from extra, unexplained pressure losses across the fuel column during the early stages of boiling in the assembly.

Boiling Burnout Conditions for Hanford Production Reactors. During the past several years the maximum operating conditions for the Hanford reactors have been established primarily on the basis of defining and detecting hydraulic instability. However, avoidance of boiling burnout conditions is also important and is one of the safety criteria for the reactors. To show the relation between normal operating conditions of the reactors and the boiling burnout conditions, the available experimental burnout data were gathered together and reported in HW-71074. These data were obtained incidentally to measurements of hydraulic instability, and had been reported only indirectly in documents concerning hydraulic stability.

The data, obtained in electrically heated test sections representing a full charge of fuel elements in a process tube, are presented so as to compare burnout conditions with the normal operating conditions at 130 C outlet temperature and with the conditions at which a reactor scram would be initiated by the Panellit system. These data show that a reduction in flow of at least 50% or an increase in power level of about 100% would be necessary to reach boiling burnout.

Data were also presented to show the effect of displacing the fuel elements toward the wall of the process tube. These data were obtained with a short length test section representing three eccentrically placed fuel elements in a K Reactor process tube. It was found that film boiling conditions would exist if the fuel elements were displaced toward the tube wall by 80 to 90 percent of the normal annulus width. The resulting surface temperatures would not necessarily be high enough to cause aluminum fuel jacket melting, but rapid corrosion could result.

Heat Transfer Characteristics of NPR Fuel Elements. Studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel elements were continued. Approximately 60 additional boiling burnout conditions were obtained in the laboratory with an electrically heated test section equal in cross section to the center hole of the fuel elements. The test section for these runs consisted of a 12-foot long tube, 0.44 inch ID, with flow through the inside. The tube was heated by electrical resistance heating and boiling burnout conditions were detected by noting the temperature excursions as measured by thermocouples attached to the outside wall of the test section.

Since the heat generation is uniform along the length of the test section, it had been expected that boiling burnout would first be reached at the outlet end where the coolant enthalpy was the highest. However, during several of the runs at flow rates of 5, 6, and 7 x 10^6 lb/hr-sq ft boiling burnout was observed at points near the middle of the test section. Plans are made to investigate further this unexplained behavior.

Analyses of all laboratory data obtained to date were compared with NPR design operating conditions to establish the burnout safety margin. Comparisons were made for a given flow rate by calculating heat flux

and coolant enthalpy along the fuel column for various tube powers and comparing these with experimental results of heat flux and enthalpy at burnout. Comparisons have been made for two neutron flux distributions, one for control rods inserted at the front of the reactor and the other for control rods inserted at the middle of the reactor. Both of these configurations produce flux peaking toward the downstream end of the column, where enthalpies are highest.

Comparisons made to date indicate the following:

1. The tube power which would produce burnout is 1.7 to 2 times the maximum design tube power.

2. Film boiling would be reached in the central flow channel at slightly lower powers than those which would produce film boiling on the other fuel surfaces. However, the difference appears to be slight (5 to 10 percent).

In some cases extrapolations of experimental data were necessary for the comparisons. Future test results, which will extend the experimental range, and consideration of the upstream burnout observed on some tests could alter the above conclusions, but the effect of such factors is expected to be minor.

Hydraulic Studies. A question arose as to whether the heavy fuel elements being used in the C Reactor overbore process tubes could be seated by water pressure alone or whether a mechanical means would be required to move the fuel elements to the rear of the tubes. It was found in the hydraulics laboratory that during the time the front nozzle water pressure was increased from 173 to 217 psi, a full charge of 32 fuel elements and 14 perfs moved six feet down the process tube and seated against the rear nozzle cap. It was concluded that the fuel elements would also be flow seated in the reactor since the front nozzle pressure there is approximately 340 psi.

Equipment. Equipment to improve the recording of thermocouple readings from test sections in the heat transfer laboratory was put into effective use. The equipment feeds signals from up to 25 thermocouples through a stepping switch into a retransmitting potentiometer, converts the reading into a frequency, counts the frequency over a short time, and records the final reading in terms of temperature on both a typewriter and punched paper tape. The information on the paper tape is transferred to a magnetic tape and fed into the 7090 computer with a program deck for data analysis.

The equipment has recorded about 18,000 data points without failure of any type. As a result, the equipment has improved the quality and quantity of data and has resulted in considerable cost savings in data analysis.

Shielding Studies

Attenuation Studies. A report describing the experimental data obtained on neutron and gamma attenuation through as-cured barite concrete is complete. (HW-71113, "Shielding Properties of As-cured Barite Concrete") A measured fast neutron removal cross section of 0.089 cm^{-1} was obtained for a concrete density of 3.55 gm/cm^3. This value agrees within about seven percent with the calculated removal cross section of 0.083 cm^{-1}. The variation can be attributed largely to uncertainties in the concrete composition. The barite slabs have been baked at 320 C and placed in the shield facility for irradiation and determination of shielding properties at elevated temperature.

At the request of IPD personnel, shielding calculations have been made for the NPR using the new shielding computer code. A report summarizing the results is being prepared.

B. WEAPONS - 3000 PROGRAM

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

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Project Management and Design

PRTR. The Physical Completion Notice for the project was issued during the month.

The paving and landscaping contract will be closed out upon completion of shrub and tree replanting work and repair of several control valves.

Fuel element examination-equipment testing continued during the month. The viewers are now ready for service. The manipulator mechanical operation is now satisfactory; however, an oil leak in the upper gear head remains to be corrected. Additional work required before the facility can be placed in service is calibration and balancing of the air balance system, performance of the design tests, and the training of operators. No priority for this work has been established. The Operations Manual has been issued.

Plutonium Recycle Critical Facility (Project CAH-842). A review of the Critical Facility by the General Electric Technological Hazards Council has resulted in verbal recommendations that included lowering the moderator level, providing internal support members in the reactor core for fuel elements and adding additional safety features on the crane. Scoping of possible ways of accomplishing the proposed changes has been started.

The over-all project is estimated to be 78% complete. A new schedule will be issued upon approval of a recent project proposal revision. The CPFF contractor is estimated to be 61% complete. Piping installation, delayed two weeks by the pipefitter strike, has been resumed. Electrical installation continued with the installation of the reactor control console.

Fuel Element Rupture Test Facility (Project CAH-867). Over-all construction is estimated to be 24% complete versus 26% scheduled. The water plant holdup tank contract is estimated to be 2% complete versus 5% scheduled. The CPFF equipment installation work is estimated to be 24% complete versus 25% scheduled, and the contractor (Lewis Hopkins Co.) has started excavation. The first concrete pour was made on September 22, 1961, and consisted of lean concrete around the clearwell sump. The contractor is making the 10" raw water plant feed line tie-in to the 24" raw water line during the reactor shutdown at the end of September. Construction work on equipment installation has been delayed by the pipefitter strike and the continuing shortage of qualified welders. The continuing shortage of welders together with increasing gas activity problems in the experimental cell could delay equipment installation

work. Placement of heat exchangers, piping, and other equipment into B Cell are scheduled for the reactor outage at the end of September.

The control console was delivered during the month. The motor control center is presently scheduled for shipment November 8, 1961, versus an original shipping date promise of October 15. The electrical immersion heaters are to be shipped early in October. It is not expected that this will adversely affect the work in B Cell except that the B Cell cover blocks will have to be removed a second time.

The vendor who supplied most of the high pressure control valves - Black, Sivalls, and Bryson - has failed to submit certified material analyses. An effort is being made to get these data, and valve body filings have been obtained for emission spectrograph analyses. It is not planned to install these valves until it is established that all material requirements have been met.

Component Testing and Equipment Development

Primary Loop Mockup. The prototype pump with the self-adjusting mechanical seal assembly operated 744 hours for a total of 10,274 hours with a continual low leakage of approximately 0.26 g/hr. This seal assembly is being considered as a possible replacement for the reactor pump seals.

Second Generation Shim Control. Scope drawings were completed on two proposed arrangements using serviceable drive assemblies located above the top shield and in the C Cell. Three demonstration models of different liquid control systems were fabricated and operated. Scope drawings of one of these types was started.

Critical Facility Components. Adequacy of the source positioner boron-paraffin shielding was tested using a plutonium-beryllium neutron source, and exposure rates were found at be 60 mrem at one foot, and 15 mrem at two feet. Shielding is felt to be adequate.

A combination slip clutch gear reducer for the adjustable weir has been ordered to obtain an operating speed as required by design criteria. Use of a slip clutch will protect the gears in the lower end of the synchro transmitter assembly. The weir has been delivered to construction personnel to allow piping to proceed.

A mockup of the thimble with flexible hoses attached has been completed. Operation of flexible hoses and swivel joints has been satisfactory; however, due to space limitations in the Critical Facility Transfer Lock, additional swivel joints will be required. These swivel joints have been ordered and are scheduled for delivery by October 15. The air purge to remove water from the thimble has been checked with an estimated 150 scfm, and successfully removed all but a one- or two-inch heel in the bottom of the tube. Final testing will be performed in the Critical Facility under actual operating conditions.

Tubing for cadmium plating of the control and safety rods was shipped to the vendor September 18, 1961. Return of this tubing has been promised in four weeks. The components required for the prototype

safety rod drop tests are now being assembled, and initial tests will be performed next week. Although some difficulty has been encountered in sizing the 15-foot long safety rod housings, one of the tubes has been sized and the remaining two tubes are expected to be completed by September 26. Cutting of the guide slot in these long tubes was to be handled by an off-site vendor; however, delivery promises have not been satisfactory, and it is now planned that guide slots be machined on site. Assembly and initial testing of the first prototype safety and control rods is scheduled by October 10. Resolution of all problems encountered to date will not be completed by October 10; however, this will not prevent assembly and initial testing of the prototype rods.

Negotiations with the vendor of the synchro transmitter assemblies have been continued by AEC Purchasing in an effort to resolve the radiation resistance qualities of materials used in some applications.

PRTR Operations

Reactor Operation. Significant improvements were achieved in most phases of PRTR operation during the month of September. The reactor operated a total of 13.5 days during the period of September 1 to September 25, when a week-long scheduled shutdown began. Compared to the 48 scrams occurring in August, only five scrams occurred in September, all from flux monitor instrumentation. This problem is being corrected on the end-of-the-month outage.

Heavy water losses were reduced from the 130-180 pounds per day reported last month to 40-75 pounds per day during the final operating period of September. This reduction was the result of an intensive D_2O and helium leak correction program to be continued on a permanent basis. Helium losses were reduced concurrent with D_2O losses to approximately 3300 scf per day during the last operating period.

Six shutdowns were taken during September. (1) The reactor was shut down on September 2 to repair broken rupture discs on the pressurizer, the result of back-pressure from intermediate pressure helium storage via the waste collection systems. Changes were made to eliminate future back-pressure problems. (2) The reactor was shut down on September 5 for an intensive program of D_2O and helium leak checks and repairs. Significant improvements were made as described above. (3) The reactor was shut down on September 12 due to indications of partial failure of the light water injection system. One light water valve had opened causing failure of the rupture disc separating the H_2O and D_2O systems. The primary system high pressure prevented H_2O injection into the D_2O. A complete mechanical and electrical check failed to show the cause of this failure. Indication was provided to give early warning if the valve should open in the future. (4) The reactor was shut down on September 14 to repair low pressure helium compressor No. 2 which showed evidence of diaphragm failure. The diaphragm was replaced although visual inspection did not reveal a failure. Also, on this outage, the

failure of the seal on primary pump #1 was confirmed. No repairs have been made as yet. (5) The reactor was shut down on September 19 to repair the moderator storage tank level indication system. Repairs could not be completed within the one-hour scram recovery time, and a minimum downtime outage was taken. (6) The reactor was shut down on September 24 on a scheduled week-long outage to examine fuel elements, inspect process tubes, and remove one process tube. Three additional plutonium fuel elements were charged to bring the reactor loading to 36 PuAl and 49 UO_2. This loading is estimated to provide a two-hour scram recovery time.

Reactor Equipment Engineering

Primary Pumps. The high pressure mechanical seal on primary pump No. 1 failed on September 13, 1961, as evidenced by high seal leakage. This seal had previously been damaged on August 24, when seal temperatures increased to 170 F from a normal 100 F during operation with no seal injection. Loss of injection water was observed on another occasion following a system depressurization. The difficulty in maintaining seal injection is caused by drift in the manual setting of the control valve. Equipment for automatic control of the valve setting has just arrived and is expected to be in service for the next reactor operating period.

Both the No. 2 and No. 3 pumps are operating satisfactorily. No instances of loss of seal injection have been observed on these pumps. No. 3 was last overhauled on May 24 and No. 2 on July 13.

D_2O and Helium Losses. A major effort was made to reduce D_2O and helium leaks at reactor shutdowns during the month. One shutdown was devoted almost exclusively to this task. All primary pump check valve lids were seal welded, helium purge valves were dismantled and refinished, and the moderator storage tank relief valve was removed. Other gasketed and packed seals in the D_2O and helium systems were replaced or repaired. Efforts to reduce helium leakage on the top of the reactor were less successful than in other locations. This is probably attributable to dirty sealing surfaces on the top shield.

A significant reduction in D_2O and helium losses was achieved as a result of repairs and modifications, but leakage is still greater than is economically feasible for continuous operation.

Helium System. Repair of a leaking relief valve which relieved from the low pressure discharge line back to the gasometer has resulted in significantly reduced running time on the low pressure compressors. It appears that further progress in reduced compressor running time can still be accomplished by reduced through leakage of other relief and purge valves.

Material has been ordered to install an automatic system for returning to the primary coolant system the condensate removed from gas bled from the primary coolant pressurizer. Detail design of the installation is in progress. This automatic return system will relieve the reactor operators of the bulk of the condensate handling work presently required and should reduce the amount of uncertainty in D_2O inventories.

Helium Compressors. High pressure helium compressor No. 1 developed a large oil leak at the gasketed joint between the second stage head and the piston cylinder. Repair of this leak has been attempted by seal welding rather than gasket replacement. The success of the repair will be determined when the compressor is next run.

The reduced output of high pressure helium compressor No. 2 was traced to a large leak through a gas relief valve which relieved from first stage discharge back to the compressor suction line.

All heads of the low pressure compressors have been equipped with single thickness diaphragms in an attempt to eliminate the galling action experienced between the adjacent surfaces of double diaphragms. There is insufficient operating experience to indicate the success or failure of the single diaphragm approach. Diaphragms in two low pressure compressor heads were replaced during the month. One, with an operating time of 300 hours, did not have a visible failure and is being examined by the dye penetrant method. The other replacement was of the last pair of diaphragms after an estimated running time of up to 500 hours. Failure of these diaphragms was attributed to galling at the two mating surfaces.

Top and Bottom Shield Cooling System. Failure of a mechanical seal on one circulating pump required the installation of a new seal. Excessive vibration of the pump shaft immediately ruined the new mechanical seal and the new secondary seals. A second replacement was required, and the pump is back in service. This is the first installation of the new grease-lubricated secondary seals on a United Pump, and these are apparently operating satisfactorily. The original packing-gland type secondary seals used on the United Pumps in the moderator, reflector, and top and bottom shield coolant systems were not satisfactory.

Fuel Handling Vehicle. A cantilever frame was attached to the upper deck of the Fuel Handling Vehicle in order to suspend the equipment used in process tube inspection. Use of the fueling vehicle for this task will free the reactor hall crane for other uses during reactor shutdowns.

Fuel Element Rupture Detection. A spare process tube cap has been modified for use in fuel element rupture detection tests during shutdown. The cap is equipped with a thermocouple and a coolant sampling tube designed to reach the center of the fuel element.

Inlet Jumper Flange. A new tracing (H-3-11429) has been drawn which combines the flange and sleeve into a single piece, thereby reducing

the number of components from three to two. Also, the material requirement was altered from a highly cold-worked to a hot-worked stainless steel as the cold-working is of dubious advantage due to subsequent welding during installation of the flange.

Neutron Flux Monitoring Instrumentation. Apparent failure of the chamber on high level channel No. 3 and a leak in the chamber for log-N No. 1 during the month reduced the number of chambers in service to five out of ten. Replacement of the startup fission chambers and a galvanometer chamber had previously been planned; additional chamber housings were fabricated to enable replacement of all unserviceable or questionable chambers. At this writing, the fission chambers and galvanometer chamber have been replaced and replacement of damaged log-N chamber housing is in progress.

Returning the startup channels to service should eliminate the need to reposition log-N chambers for reactor startups and low power operation, which in turn should reduce the probability of developing leaks in the chamber housings. The housing leak which occurred this month was caused by frequent movement of the chamber.

Erratic behavior of all three high level channels and frequent single channel safety circuit trips have been experienced during the month, although the number of reactor scrams has been sharply reduced. This behavior is apparently caused by the chamber on channel 3, and this is also the probable cause of trouble on channel 1, although there is no evidence of fault in the chamber. Channel 2 trips were probably caused by a faulty relay.

Wiring of the log-N channels has been revised at one junction box to reduce the possibility of sympathetic trips which have occurred in this instrumentation.

Light Water Injection System. On September 12, during reactor operation at 55 MW, malfunction or leak of the E-17 valve allowed flow of boiler feedwater through the high pressure H_2O injection piping. This resulted in bursting the rupture disc between the H_2O and D_2O sides of the piping and the filling of TKA-6 and 7 with H_2O. Some D_2O in TKA-6 was diluted, but H_2O did not enter the primary system, which was pressurized.

In order to determine the cause of apparent spurious opening of valve E-17, the following steps were taken in an investigation:

1. The valve was leak tested for a two-hour period against full boiler feed pump pressure.

2. All the pneumatic lines supplying air to valves E-7 and E-17 were inspected and connections were leak tested.

3. All electrical connections in the light water injection system were inspected. No condition was found which would account for the apparent opening of the valve. A temporary alarm was installed to monitor valve stem position on E-17.

Design Change 67, providing dual pilot solenoids and dual DC power supply for the light water injection valves, was implemented during the shutdown of September 25-29. This change eliminates the possibility of H_2O injection valves opening as a result of a single fuse failure. Failure of two fuses would now be required for a spurious opening.

DC Power System. A double-ground condition in the DC power system, consisting of a grounding of the positive terminal in a newly installed instrument connected to the alarm annunciator circuit, and a ground at the coil of the "B" dump valve, resulted in failure of the "C" and "D" dump valves to open when the safety circuit was tripped. Design of the safety circuit is being modified to prevent such an occurrence from happening again, and additional ground detection equipment has been ordered for placement in the control room.

Rupture Monitor. Functional testing of the demonstration unit of four gas separators with new water traps was begun on September 19, 1961. The system appears satisfactory except for a slight tendency for condensate to foul the rotameters (one rotameter out of the four plugged after three days of continuous operation). This fouling can be stopped by use of chilled water to further pre-cool the sample flows or by further heating the rotameters. Further tests of the system are planned in order to establish all requirements for redesign of the piping.

Revision of the fuel failure detection system signal terminations was completed. A check of the scintillation probes showed that fourteen were defective and these were being repaired at month's end. A design change was prepared and issued covering elimination of the control room recorder printers and the channel sorting switch. A matrix of lights to be installed in the control room and instrument cell to show which points are being monitored was also designed and approved.

Preventive Maintenance. Thirty-two pieces of major equipment are now set up for preventive maintenance. Preventive maintenance was performed on various reactor system pumps and the chemical feed pump during the month. Lubrication files are being revised.

Training Program. Training classes conducted by Maintenance engineers for Operations personnel began September 12. The primary pump operation class has been presented to all shifts; helium compressor operation has been presented to two shifts.

Reactor Process Engineering

Planning and Procedures. The first review and combining of the PRTR Operating Standards was completed and issuing of the combined standards begun. The total number of standards is being reduced from 102 to 62. Updating of PRTR Operating Procedures has started.

Five written qualification examinations were administered to members of PRTR Operation as part of the program for qualification of personnel to operate the reactor.

Engineering Analyses. Analysis of critical test and power test data continued during the month. A test (PRTR Test No. 6) was conducted to determine the first part of the xenon transient in order to provide better estimates of the xenon decay time and to partially correct the xenon tables.

Three processings of PRTR operating data were completed during the month. Each processing covered a period of approximately two weeks.

PRTR Test No. 2, Increased Steam Generator Surface Blowdown, was completed and showed that the pH in the steam generator remained high even though the surface blowdown was increased from 18 percent to 33 percent. PRTR Test No. 8 is being written to cover the use of monosodium phosphate injection to the steam generator in place of the di-sodium phosphate used at present.

PRTR Test No. 7 was prepared and approved to test the method proposed for locating a defected fuel element by monitoring the I-132 concentration in stagnant water surrounding the suspected fuel element.

A summary report was prepared on the fission product activity in the primary system for release to the Atomic Energy Commission.

Unit motion readings of the top primary shield and calandria were taken during the report period. Preliminary results seem to correspond with the measurements taken last month.

A survey of possible second generation PRTR shim rods utilizing liquid poisons has been completed. Criteria for the control rod are that significant changes in control worth should not occur over short periods of time (several months), that poison concentration changes are precluded, and that the rods be gray to thermal neutrons. The first and second requirements suggested that the poison solution be in equilibrium with the solute. No poison solutions were found which are gray to thermal neutrons at equilibrium conditions. A "black" fluid such as saturated cadmium sulfate appears to provide the characteristics needed. In this case, increased rod lifetime can be achieved through inherent self-shielding of a concentrated "black" solution.

The study of heavy water losses in the PRTR continued. Additional information developed includes:

1. Source of Loss

   With the significant decrease in D_2O loss which has occurred during the month, additional techniques are being used and developed to detect sources of smaller leaks. Tubing has been placed in ten locations in the process cell through which air samples may be drawn during reactor operation to determine D_2O content. The D_2O content is a function of air flow in the particular area being sampled and will influence the interpretation of findings. Significant D_2O concentrations were found near the top of the pressurizer and near the gas balance compressor, both of which are relatively close to ventilation exhaust ducts. The tritium contents of the samples are being determined to pinpoint which systems are contributing the D_2O. Additional monitoring by this technique is planned.

2. D_2O Recovery from Exhaust Air

   Further investigations have been made into the possibility of recovering D_2O of high isotopic content from the containment vessel ventilation system. A D_2O recovery system is feasible; however, preliminary cost estimates are high.

3. D_2O Recovery System

   While the moisture condensing rate of the D_2O recovery system servicing the upper and lower reactor faces has improved significantly, the low isotopic purity (about 60-70 percent) and system temperatures and dew points indicate less than optimum operation. Areas of potential inward and outward air leakages were sealed to improve isotopic purity and there is some indication that it proved beneficial. Inspection of the cooler-condenser revealed what appears to be air channeling, resulting in system temperatures higher than design values. This permits air out-leakage to carry a significantly higher moisture content - increasing D_2O losses. Baffles are being installed in the cooler-condenser to produce additional cooling of the air. However, to date, no conclusion has been reached as to how much the D_2O recovery system contributes to the loss rate of D_2O.

Additional calculations have been performed to determine the reactivity effect of flooding the Plutonium Recycle Critical Facility cell with light water during critical operation. Preliminary results indicate the effect of the additional reflector to be an order of magnitude greater than previously determined, possibly several percent k. The use of a cadmium shroud around the reactor tank to negate the additional neutron reflection is being evaluated.

Critical Facility Operation. Weekly meetings to plan for startup of the facility were initiated. Design, technical planning, experimental physics, hazards analysis, and operations are represented in the planning group. A listing of proposed startup tests covering design and physics tests was issued for comment.

Detailed review of critical facility design from an operating standpoint began during the month.

Thermal Hydraulics Studies

PRTR Critical Facility Hazards Calculations. Preliminary calculations of the consequences of the accidental dropping of a Pu-Al fuel element into the Critical Facility tank at a time when it is nearly critical indicates that fuel element melting may be expected if the safety circuit does not function. The calculations were conservative in several respects, but primarily because no heat transfer from the fuel was considered and the fuel metal temperature behavior of the Doppler effect was the only reactor shutdown mechanism considered. Furthermore, the element insertion rate into the reactor was conservatively calculated to be at the rate of the element fall in free air.

Calculations were made which show that the slowing of the element fall once it enters the D_2O moderator will probably not be significant unless means are provided to increase the water resistance of the falling element.

Evidence from the Borax and Spert experiments show that, in spite of the brevity of a power excursion of the type under consideration, significant heat is transferred to the moderator and steam voids will be formed. These will aid in shutting down the reactor. The PRTR fuel elements which will be investigated in the Critical Facility have a heat transfer surface to heat generating volume ratio less than the elements used in the reactor excursion experiments. Further, the critical facility has a larger moderator to fuel ratio. Both of these effects tend to reduce the heat transfer and hence relative steam void formation. Efforts are being made to devise a valid means of extrapolating the Borax and Spert results to the Critical Facility case.

Plutonium Fuels Development

PRTR Aluminum-Plutonium Fuel Fabrication. Eight fuel element clusters have been assembled this month, making a total of 49 Class I Mark I-H clusters fabricated for the PRTR. Fuel element rods for 13 clusters are ready for assembly and rods for three clusters are awaiting etching and autoclaving. When these 65 Mark I-H 19-rod cluster fuel elements are finished, the low exposure aluminum-plutonium spike fuel element fabrication will be completed.

Six of the aluminum-plutonium elements yet to be assembled will be made up into special monitoring clusters for Applied Physics Operation. A redesign of the existing Mark I-H was necessary to incorporate the required flux monitoring wires and pins. In conjunction with the special clusters, tooling and fixtures must be developed to disassemble the irradiated fuel elements under water in the PRTR basin. A November delivery date for the six special clusters has been proposed.

Fabrication of high-exposure plutonium-aluminum spike fuel elements for the PRTR was begun. Nine kilograms of high exposure PuO_2 were blended to obtain a uniform isotopic concentration. The PuO_2 was divided into six batches from which aluminum-plutonium master alloys were made by the cryolite reduction process. The master alloys will be diluted with aluminum to the proper plutonium composition, alloyed with nickel for corrosion resistance, and cast into extrusion billets.

PRTR Aluminum-Plutonium Fuel Element Inspection. Some loosening of the spirally-wrapped spacing wires has been observed on aluminum-plutonium elements as a result of their operation in the PRTR. During an August outage a plutonium-aluminum fuel element was inspected in the PRTR basin and found to have loose wire wraps on the individual fuel element rods. A one-eighth-inch gap between wire and rod was found in several places along the length of the rods. Calculations showed that the amount of loosening observed could not be explained by plastic deformation of the wire, even if the thermal expansion of the composite fuel rod was the same as the core. On the other hand, if the rods were shortening, the loose wires could be explained. This is contrary to what is expected based on ex-reactor thermal cycling experiments which showed a tendency for the rods to lengthen and the wires to tighten. Loosening of spacing wires was observed on a prototypical 19-rod cluster (GEH-11-2) which was irradiated in the ETR 6x9 loop. It was thought at the time that the loosening of the wires on this element resulted from the method by which they were attached. The method of attaching the wires was changed and no loosening has been observed in irradiation tests conducted since that time until the PRTR experience; however, most of the other tests were conducted at lower surface heat fluxes.

An experiment was conducted in the laboratory which offers a possible explanation of why the wires are loosening on PRTR aluminum-plutonium fuel elements. A 3/16-inch steel pin was placed through a one-half inch diameter, three-foot long, Zircaloy-clad and wire wrapped rod which contained an aluminum core. This, in effect, bonded one end of the aluminum core to the Zircaloy cladding. The rod was heated in a furnace to 400 C and another pin was placed through the other end of the rod while it was at the elevated temperature. After the rod cooled to room temperature, the wire was loose and had a similar appearance to what has been observed on irradiated Al-Pu PRTR elements. The proposed mechanism is that the core and cladding bond to one another while at operating temperature. On cooling to room temperature, the differential contraction of the core and cladding shortens the rod and causes the wire to loosen. If the bond remains intact during subsequent heating,

and there is no reason to believe it does not, the core would expand the cladding until the wire is again tight at operating conditions. Core-to-clad bonding has been observed on various irradiation experiments and primarily those which operated at the higher temperatures. Core-to-clad bonding was observed on GEH-11-2 as a result of its irradiation in the ETR 6x9 loop and rod length measurements taken on the rods from this element showed an average shortening of 0.057-inch on a 35-inch gage length. These data support the proposed mechanism for wire loosening.

The length of the twelve outer rods was measured on irradiated cluster No. 5074 in the PRTR basin. The instrument used for measuring was similar to a tape measure and could be read only to the nearest 1/32 of an inch. From these preliminary data all rods had shortened and the average ΔL was approximately 1/16 of an inch. This also supports the proposed loosening mechanism. If the core-to-clad bond is broken on the cooling cycle, there is some possibility that the wire loosening could be progressive as the fuel rod is heated and cooled in the reactor. PRTR elements will be periodically examined to determine if this is the situation.

An effort will be made to determine the cause and a means to eliminate it before the aluminum-plutonium high exposure fuel element fabrication.

UO_2-PuO_2 PRTR Fuel Element Development. Investigations of the packing of various particle size mixtures of fused UO_2 led to a mixture which gives 82 percent of theoretical density when loaded in a 30-inch long tube and vibrated on a 60-cycle table. A rod loaded with this mixture was given a 15 percent reduction in area by swaging. The resulting density was 88.5 percent of theoretical. The inside surface of the cladding was inspected after longitudinal sectioning of the rod and removal of the oxide. Except for some shallow indentations in a six-inch section, the inside cladding surface was excellent. Internal longitudinal cracking was observed in the Zircaloy cladding of several cold swaged test pieces that were being fabricated to evaluate swagable end caps. Subsequent destructive and nondestructive tests have failed to reveal any further defects in the cladding material. To evaluate the cladding material, three rods were swaged and given ultrasonic examination. Results of the ultrasonic test showed no rejects greater than 0.001 inch along the rod length. Destructive examination of these rods did not reveal any defects along the length.

Four additional rods were then prepared for cladding evaluation. Following each of the four swaging passes, one rod was destructively tested. After removing the oxide, three rings were cut from each tube. These rings were then split and the pieces bent flat. The remaining tubing segments were split longitudinally and examined for cracking. In addition to the above samples, additional rods, primarily swaged for evaluation of the end cap were also sectioned. As mentioned earlier, no defects have been detected in any of these examinations.

It is felt that a piece of scrap reject tubing which is used for other testing was inadvertently used for the swaged pieces in which the cracks were observed.

Development of the swageable end cap for oxide-bearing elements is continuing; a small design change has corrected the weld cracking on the inside of the swaged element. A procedure has been developed to weld the wires to the swaged end caps by the tungsten inert-gas spot welding process. Tests show that the weld strength exceeds the breaking strength of the wire. This weld can be made either before or after autoclaving. This will eliminate the necessity of drilling a wire hole in the end cap.

Work is progressing on UO_2 gas evolution studies. The major portion of effort expended was on apparatus design and procedural development. It is now possible to inductively heat the tantalum crucible in which the specimen is placed to 2000 C. An evolution of 0.002 cubic centimeters of gas at standard temperature and pressure is measurable. It was at first thought that a blank would have to be run prior to each determination to establish the quantity of gas attributable to the crucible. This technique was not found to be feasible due to an undesirable discharge caused by exitation of the evolved gas. The attainment of temperatures above 1000 C was prevented by this discharge. Another technique shows promise of success in which a plot of McLeod pressures squared (pressure due to evolved gas) versus specimen weight is made for each determination. The blank value is found by extrapolating the line to intercept the pressure-squared axis. The total pressure in the system for a given weight of sample is found by determining the slope and making a single calculation.

Essential to the determination of the origin of the gas evolved from UO_2 is its surface area. This will be found by using a commercial gas sorptometer.

As previously reported, a prototypical, nonuniformly enriched, incrementally loaded fuel rod was fabricated. This element contained 63 UO_2 and 63 PuO_2 increments. The fuel distribution pattern was calculated for uniform power generation in the ETR. The rod was swaged and cut for analytical samples. Ten samples were taken along the length of the rod. Eight were within $\pm$ 5 percent of the desired analysis. A small amount of one of the samples was spilled causing a low analysis. Another sample was about 20 percent below the anticipated analysis. This will be reanalyzed for possible analytical error.

Work has resumed on the development of loading and vibrating compaction techniques for the preparation of UO_2-PuO_2 fuel rods. Some difficulty has been encountered in the tamping process. The tamping rod tends to stick in the tube. New tips have been made for this rod and the withdrawal mechanism has been strengthened. The gamma absorptometer is presently being modified both mechanically and electronically to speed up the process of scanning finished rods for density variations.

For a number of applications a regular, dense coating of PuO_2 on the surface of high density UO_2 particles would have unique advantages. These include heat transfer, fuel distribution, reactor temperature coefficient, and fuel fabrication considerations. In an effort to develop such particles, crushed and sized fused UO_2 particles were delivered to the 234-5 Development Laboratory and these particles were used as nucleation centers for the precipitation of plutonium oxalate. This was done on the -200 mesh fraction and the particles were subsequently calcined at 750 C in argon. The results are very encouraging. Microscopic examination shows a thin (0.1-0.2 mil) deposit of PuO_2 on many of the particles. The process will be repeated using larger particles.

A UO_2-20 w/o PuO_2 compact was hot-pressed to a density of 97.3% of T.D. with a 100-ton load on a one-half inch pipe coupling, containing the mixed oxide powders. The coupling contained dry pressed -325 mesh fused UO_2 - 20 w/o PuO_2 powders with stainless plugs welded in the ends. The coupling was heated to $\sim$900 C and upset inside of a steel cylinder. The hot pressing operation was performed twice on this sample. The hot pressed oxide mixture was similar in appearance to fused UO_2. One particle which was used in the density determination was about the size of a one-fourth inch sphere, but irregular in shape.

Fuel Evaluation. Four high-density UO_2-PuO_2 capsules and one low-density capsule are currently being irradiated in the MTR. Five low-density UO_2-PuO_2 capsules were discharged at the end of MTR Cycle 161 (Sept. 5, 1961). Goal exposure for all of the specimens is on the order of 10,000 MWD/T.

The irradiation of a heterogeneously enriched UO_2-PuO_2 seven-rod cluster has been scheduled to start on November 13 in the ETR 3x3 loop. Arc-fused depleted UO_2 will be enriched (0.51 w/o total PuO_2) with as-calcined PuO_2 which contains 16.04 percent Pu-240 as the fuel material. The element will have an over-all length of about 42 inches and will be fabricated by cold swaging in Zircaloy-4 cladding with swageable end caps. The element will operate with a maximum power generation of about 15 kw/ft of rod and an associated maximum heat flux of about 345,000 Btu/hr-ft^2.

Also, four full length (eight feet) UO_2-PuO_2 elements will be fabricated for irradiation in the PRTR starting about January 1, 1962. Two will be fabricated by cold swaging with swageable end caps and two will be fabricated by vibratory compaction. This will be a long-term test of prototypical PRTR elements.

Phoenix Experiment. Irradiation of the first Phoenix capsule (GEH-21-1) has commenced in the MTR. The plutonium in this sample contains 6.25 percent Pu-240 and the capsule is operating at a maximum calculated surface heat flux of about 1,000,000 Btu/hr-ft^2. It is scheduled for discharge on September 25. After an appropriate cooling time of about 100 hours to permit decay of the short half-life fission products so the

reactivity of the sample will be nearly constant as a function of time, its reactivity will be measured in the Advanced Reactivity Measurement Facility (ARMF). The next sample to be irradiated will contain plutonium which has 27.17 percent Pu-240.

An underwater disassembly jig has been designed and is being built that will permit taking the capsule holders apart under ten feet of water.

Euratom Fuel Loading. The last shipment of UO_2 - 1.5 w/o PuO_2 pellets was made to VAL for testing in the VBWR. Final analyses of the sintered product show the plutonium content to be well within the allowable limits. Microscopic and autoradiographic examinations have shown the sintered pellets to be single-phase as was expected. The final report on this work is being prepared.

Long-Life Breeder Type Neutron Detectors. Prior to fabrication of neutron flux monitoring chambers, a series of plutonium-bearing foils will be fabricated for Physics and Instrument Research and Development. The tentative specifications have been received and several approaches to possible fabrication techniques are currently being investigated.

Fabrication of Physics Test Standards for Bettis. Bettis requested the fabrication of Al-Au, Al-U, Al-Pu, Al-U-B, and Al-Pu-B alloys clad in zirconium for physics experiments. The Al-Au alloys have been assembled. The Al-U and Al-Pu alloys have been cast and extruded and are being machined prior to assembly. Fabrication of the boron alloys has been delayed pending startup of the extrusion press which has been relocated. Initial attempts to make accurate boron alloys using amorphous boron were unsuccessful; the boron recoveries in the alloys were very low. However, another series of alloys using an Al-B master alloy additive yielded adequate boron recoveries, but substantial segregation of boron occurred along the length of the rod. The segregation in Al-B alloys is caused by a low-density, high melting Al-B compound which separates during the freezing process and tends to float. In order to obtain a more homogeneous alloy, the mold was modified to permit horizontal casting of the billet which coupled with a slower pouring rate has two advantages in reducing segregation: (1) the vertical height is reduced four-fold, and (2) the rate of cooling is increased and the depth of the solidifying region is kept small.

Although these alloys are primarily of interest to physics research, they have a broader application to fuel fabrication. Boron alloys are of interest, for example, in the fabrication of "longer-lived" spike fuels such as the "Phoenix" fuel concept currently under investigation. Also, the more rigorous tolerances placed on analytical control and fuel distribution by the physics requirements tend to increase the general quality and understanding of similar fuel systems.

UO_2 Fuels Development

Irradiation Tests. The thin-walled (0.008", 0.010", and 0.015" wall) stainless steel clad fuel element (VBWR-2) has accumulated an exposure of ~800 MWD/T_U, with the surface heat flux reaching 280,000 Btu/hr-ft^2.

VBWR-1 test element (swaged UO_2) will be returned to Hanford for examination in the earliest available shipping cask.

A third Hanford defect test element HD-5 (irradiation of HD-3 and HD-4 postponed in favor of HD-5) will be charged during the next KE Reactor outage.

A failed nested tubular ETR test element (Test GEH-12-22) was returned to Hanford for examination.

A document, Erosion Resistance of Swaged UO_2 Following an In-Reactor, Fuel Rod Cladding Failure, HW-70315, was completed and submitted to Technical Information Operation for processing. This document provides detailed information on an ETR irradiation of a prototypical PRTR fuel element.

PRTR Fuel Elements. Swaged UO_2 PRTR Mark I fuel elements have achieved exposures greater than 400 MWD/T_{UO_2} and continue to function as planned.

Hot Swaging. Hot-swaged samples of PWR grade and micronized UO_2 were prepared for HAPO-BMI studies of compaction and pressure bonding of ceramic fuels. The PWR grade UO_2, clad in stainless steel (1.25-inch OD, 0.035-inch wall thickness), was hot-swaged to 79% T.D., with a total reduction in area of 84%. Maximum density (79% T.D.) occurred with an area reduction of 75%. Micronized UO_2, clad in Inconel-X (0.700-inch OD, 0.015-inch wall thickness) was reduced only 50% in area, resulting in 69% of T.D. Vibrational compaction of either type powder, though increasing the tapped density by 5 to 10% of T.D., did not influence the final hot-swaged density.

Immersion plating of thin copper on Zircaloy tubes was unsuccessfully tried as a method for eliminating die marks that occur during swaging. The thin layer of copper (0.0004 inch) was rapidly worn off during swaging. Thicker layers of copper for lubrication and protection during swaging will be tried.

Electrodeposited UO_2. Electrodeposited UO_2 was cold swaged to 91% of T.D. Several batches of electrodeposited UO_2 are being prepared for hot-swaging studies.

Hydriding of Zr-4. Post-irradiation examination of a hot swaged UO_2 fuel element (GEH-4-60) showed no hydride precipitation in the Zr-4 cladding. Metallography showed fuel characteristics similar to those found in cold swaged UO_2 that had generated similar surface heat fluxes.

Corrosion and Materials Studies

Post Transition Hydrogen Pickup for Zircaloy. Hydrogen pickup results for Zircaloy-2 following the first corrosion transition appear to confirm the findings from other sites that, following breakaway, the percent of hydrogen pickup increases.

Zircaloy-2 samples (run in triplicate) show an average hydrogen pickup of 14 percent of the theoretical corrosion product hydrogen after 50 days of exposure to 400 C refreshed steam containing 3-4 ppm O_2. This compares with an average 24 percent for three samples exposed to the same conditions for 170 days. The percent hydrogen pickup in the interval 50 to 170 days is 34 percent. Previous tests show pre-transition corrosion product hydrogen pickup (i.e., prior to 40 days) for Zircaloy-2 exposed to 400 C refreshed oxygenated steam is 10 percent. The percent of hydrogen pickup prior to breakaway was essentially constant for all samples under the test conditions employed.

PRTR Process Tube Corrosion Testing. The effect of fluoride contamination between the top flange internal threads of a PRTR process tube has been investigated. The portion of the tube in question is the threaded joint between the tube and tube flange. The source of F^- contamination might be either the etch solution or fluoride contaminated cooling water. Several segments cut from a process tube upper flange were welded at the cut edges and a 12-mil hole was drilled into the threaded area through the top gasketing surface. The defected samples were etched and autoclaved at 400 C, 1500 psi for 36 hours. Some of the samples were subsequently vacuum loaded with fluoride contaminated water and exposed for 168 hours at 275 C. All samples run, including two blanks, were then sectioned metallographically and examined for corrosion and hydriding. White corrosion product was noted internally - at the threads - when F^- ion was present, but penetration and hydriding were negligible. Only one out of five defected segments showed internal evidence of contamination at the defect.

PRTR Aluminum Corrosion. A simulated calandria gas atmosphere at 315 C was passed over 6061-T6 aluminum coupons in order to evaluate the potential corrosion of aluminum components in the gas space above the D_2O moderator. The gas consisted of argon with 0.6% H_2, 0.3% O_2, and 41% H_2O at atmospheric pressure. An exposure of 6600 hours resulted in 6 mils and 2 mils intergranular penetration for two lots of the same alloy.

The temperature of 315 C is an estimate of the highest temperature expected and is felt to be conservatively high. The test has been started again employing several different alloys and two temperatures (315 C and 260 C).

PRTR Water System Studies. Routine coolant quality control programs are now in effect for the various PRTR coolant systems. All operations including sampling and analysis of the coolant streams and evaluation of the data have been standardized.

PRTR Sheath Tubes. A vendor has shipped 1112, 0.680-inch ID Zircaloy-4 sheath tubes to date. After placement of the order in January, the first 100 pieces were shipped on June 5, and by the end of July (26 weeks after placement of the order), 890 pieces (75% of the total) have been shipped, which is the best delivery to date on any sheath tube order.

On-site Zyglo testing is complete on 904 of these tubes. The reject rate on the first 184 tubes examined was 26 percent, and then fell off to 14 percent on the next 720 for an over-all reject rate of 17 percent. Of these rejects, 76 percent were either one or two tiny spots of impressed material on the inner surface. The remainder generally had more than two indications and approximately 25 had more than five indications in any one tube. The vendor reports that rejects at his plant have consistently run less than 10 percent. Over-all this is the best performance to date on Hanford Zircaloy fuel sheathing orders.

Ultrasonic testing of the above tubes was refined by calibrating the instrument against a one-mil deep by 125-mil long groove instead of the three-mil deep by 500-mil long groove previously used. Since this change, the correlation between the ultrasonic test and the fluorescent penetrant test has greatly improved. One group of 200 tubes had 68 rejects: 38 from Zyglo indications, 21 from both Zyglo and ultrasonic indications in the same locations, and nine with only ultrasonic indications. It is not expected that the two tests show perfect correlation. Extensive destructive analyses performed on Zyglo indications show that this test will detect defects which are less than one mil deep, while the ultrasonic test will detect discontinuities which are the open, smooth-bottomed type which will not retain penetrant.

Two of the 0.680-inch ID tubes which had ultrasonic indications but no indications from the Zyglo test were sectioned and examined microscopically. Transverse sections of the discontinuities showed that one was 3.5 mils deep by 1/2 inch wide, and the other was 2 mils deep by 1/4 inch long and 11 mils wide. Small depressions of this shape do not retain the Zyglo penetrant oil and therefore are not detected by this test. Both of these depressions are acceptable under present tubing specifications.

Wolverine Tube Company has recently installed a complete ultrasonic testing setup patterned after the Canadian G.E. system. They use a double-gated Reflectoscope Model #UR 600 with an RA three-channel monitor recorder attachment. Canadian G.E. personnel helped to set up and standardize the equipment. Two crystals are used, one for longitudinal and one for transverse defects. With two crystals and a double-gated instrument both transverse and longitudinal testing is done at the same time. Their standards are machined notches with a 60° included angle 10 percent of the wall thickness in depth and 1/2 inch long, plus a drilled hole 40 percent of the wall in diameter and 90 percent of the wall in depth. The reject signal is set at 50 percent of the signal height received from the standard groove.

Harvey Aluminum has shipped the first 84 pieces of 0.505-inch ID, Zircaloy-4 sheath tubes. Approximately 600 pieces are essentially finished and about 500 are cut to length and are undergoing tests. The additional material to finish the order has been extruded and is through the first draw. A continuous flow of these tubes is expected until the order is complete.

04 Program Radiometallurgy Studies

Examination of the seven-rod cluster Al-Pu rupture test (GEH-11-5) revealed no swelling on the defected rod. A small cavity had formed in the Al-Pu core under the defect hole (RM-672).

Metallographic examination has been completed on the first of three high power generation UO_2 capsules (GEH-14-231). An extremely fine grained UO_2 structure was found around the outside edge of the core (RM-620).

Composite micrographs of the total transverse cross section of three ceramic fuel elements at 75X were completed this month (RM-635). The microstructure of the 15 w/o Pu - 12 w/o Si aluminum alloy fuel capsule (GEH-14-416) was uniform across the section and no metallurgical bond was observed in any part of the fuel-cladding interface (RM-671).

Metallographic examination and replication for electron microscope studies of the effects of post-irradiation annealing on uranium spheres has been completed as part of the Basic Swelling Studies Program (RM-510). Also, GEH-14-281 and 282 were cathodically etched and replicas were made for electron microscope studies (RM-513).

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

2. PLUTONIUM CERAMICS RESEARCH

A set of five carbon-poor PuC alloys (35 to 46 a/o C calculated) were arc-melted three times each on a water cooled copper hearth in order to check the lattice spacing/composition plot previously found for PuC_{1-x} alloys. Back reflection x-ray patterns showed that the lattice parameters did not conform to the previously found broken curve obtained for arc-melted alloys, but instead, conformed quite closely to the curve found for annealed alloys. The reason for this is presently unknown, but it may be due to the larger sample size of these alloys which permits slower cooling rates, or it may be due to dissolved oxygen resulting from slow oxidation of the plutonium powder used.

PuO and PuN are both isomorphous with PuC and may change the unit cell size of PuC if they are contained in solution. One of the alloys used in the early determination of lattice spacing/composition was analyzed for oxygen, hydrogen, and nitrogen with the values being 28, 30, and 2 ppm, respectively. These values should exhibit a negligible influence on the PuC cell size.

Another sample of PuC was submitted for an impurity analysis. Total impurities were less than 750 ppm with 500 ppm being Fe. The 750 ppm value is quite low considering that the initial hammer-milled alpha-Pu powder contained about 1.5 percent impurities. Apparently arc-melting three times is sufficient to vaporize a considerable quantity of the metallic impurities.

Plutonium Oxides. Metallographic examination on a sample of $PuO_{1.83}$ gave indication of a lamellar eutectoid type of structure. Based on a composition of $PuO_{1.62}$ for the cubic Pu_2O_3 phase, this sample should have shown about 50 percent of cubic "Pu_2O_3". Only 35 percent was seen by x-ray diffraction, however, which is in good agreement with the metallographic observations. The lamellae probably consist of the fluorite PuO_{2-x} ($x \cong 0.03$) and the type C rare earth $PuO_{1.62}$ phases which react eutectoidally during cooling from elevated temperature.

An attempt was made to define this reaction by high temperature-high vacuum x-ray diffraction. In these experiments the disappearance of the second phase "Pu_2O_3" structure was consistently seen between 160 and 200 C under continuous pumping at a pressure of about 2×10^{-5} mm Hg. Further experiments in a hydrogen-argon mixture also indicated the transformation to occur over this range. This temperature appeared to be suspiciously low, and a diffraction check on the oxidation of PuO_{2-x} in air showed oxidation to be complete at about 125 C. It therefore appears that the leak rate during the vacuum operation and the residual O_2 and H_2O impurities in the hydrogen-argon gas gave rise to sample oxidation. This indicates exceptionally poor stability of the "Pu_2O_3" composition especially when a delta Pu sample was heated to 600 C in the same system (2×10^{-5} mm Hg) and showed no sign of oxide formation. This "Pu_2O_3" phase, contained in an operating fuel might be expected to be unstable due to its ease of oxidation, but on the other hand PuO_2 becomes unstable at high temperatures and loses oxygen so that some equilibrium PuO_{2-x} composition might be anticipated. This fact may not be disturbing from a structural point of view since present evidence indicates that the eutectoid transformation occurs below fuel element operating temperatures (less than 1100 C) and that the high temperature oxygen deficient PuO_2 structure is isomorphous with UO_2. Thus, phase relations in the UO_2-PuO_2 system should remain unaltered though there may be an oxygen deficiency. The oxygen deficiency may be beneficial in that built-in fission gas sinks are provided. These sinks may accommodate fission products and gases with little associated lattice strain and may result in reduced fission gas release. It is difficult to speculate on the role of evolved oxygen in the fuel at high temperatures and experiments in and out of reactor are needed to clarify this point. It is expected that the high ambient gas pressure in a sealed capsule will retard total gas evolution so that the equilibrium PuO_{2-x} composition in-reactor will have a greater O/Pu than seen in laboratory experiments.

A series of experiments to define the O/Pu versus temperature relations during heating in vacuum has been initiated. Densities show a uniform increase with temperature and the data indicate that oxygen loss has not started after one hour at 1150 C at 3 x 10^{-5} mm Hg.

Thermal Expansion. Several preliminary experiments on the high temperature expansion of PuO_2 were carried out by x-ray diffraction in order to gain some understanding of the problems associated with the high temperature camera. The diffraction profiles up to 1200 C were very sharp and there was only a slight increase in background and broadening due to thermal diffuse scattering. The instantaneous expansion coefficient at 650 C for $PuO_{2.00}$ was 10.26/C, which is in excellent agreement with dilatometer data extrapolated through the hysteresis normally seen for PuO_{2-x} at this temperature. Recent dilatometer data on $PuO_{2.00}$ supplies justification for this extrapolation since a hysteresis was not observed; however, this point is being checked in greater detail on additional samples of $PuO_{2.00}$. Expansion coefficients determined by diffraction at 1100 and 1200 C were slightly below the extrapolated dilatometer data and are probably the result of temperature measurement errors.

From these experiments it is apparent that accurate temperature measurement and alignment of the sample on the parafocusing circle will present the greatest problems at elevated temperatures. The two techniques used in temperature measurement consisted of mechanically clamping the thermocouple to the heating filament, which introduced considerable error, and measuring the temperature via the change in interplaner spacing of a reference material. The latter method introduces some error due to expansion of the heater from the focusing circle, though this is not severe in the back reflection region; however, a large error may be introduced by choice of the expansion coefficient of the reference material. Calibration of the system for accurate lattice constant versus temperature determinations will continue during the next month.

Plutonium Silicides. A two-phase product was formed by heating a stoichiometric mixture of PuO_2 and alpha SiC II to 1400 C in vacuua for 30 minutes. The product was cooled to room temperature in one hour. There was no evidence of any reaction between the crucible and its contents. X-ray diffraction analyses show the product to be Pu_2Si_3 plus B-Pu_2O_3. A low pellet density, 7.72 g/cc at 25 C, was due to internal porosity probably caused by gas release during the reaction. The melting point of this two-phase product is 1833 C ± 2.11%.

The $PuSi_2$ formed by arc-melting pressed pellets of alpha-plutonium and silicon appears to be quite pure as indicated by x-ray diffraction analyses. Chemical analysis for plutonium will now be performed. The density of this material was determined by immersion in tetrabromoethane. The value is 9.06 g/cc at 25 C. Its melting point as determined in a tungsten ribbon resistance furnace is 1795 C ± 1.28%. Specimens were melted under one atmosphere of argon.

Melting Point Studies. A small sheet of 0.005-inch iridium foil has been received and will permit measurement of melting points and heat treatments in oxidizing atmospheres at temperatures on the order of 2400 C. To date a temperature calibration curve has been obtained on the iridium and its slope differs slightly from the curve determined previously for tungsten strip heaters.

PuO_2-ZrO_2 and PuO_2-MgO Irradiations. Four Zircaloy-clad capsules containing sintered and ground ZrO_2-10.39 w/o PuO_2 fuel pellets have been completed. One of the eight end closures was contaminated with plutonium and the capsule will have to be recanned.

Some difficulty is being experienced in obtaining 90 percent dense ZrO_2-2.18 w/o PuO_2 fuel pellets and a second attempt is being made. Fabrication of the MgO-PuO_2 pellets is continuing.

A capsule was made by swage compacting MgO powder in Zircaloy tubing. The capsule was defected by drilling two 0.035-inch diameter holes through the cladding. It was exposed to 316 C water at 1550 psi for one week with no apparent MgO-water reaction occurring. Also, an unclad MgO pellet was unchanged after being exposed to 310 C water at 1450 psi for 24 hours. It appears that the water reaction would not be a problem in the event of a cladding failure.

In-Reactor Sintering Studies. Four specimens for the irradiation tests in the MTR Hydraulic Rabbit Facility (VH-4) were completed and shipped. The capsules (GEH-21-13, 14, 15, and 16) each contain high density (94% of theoretical), UO_2-0.154 a/o PuO_2 and UO_2 (1.00 a/o U-235) pellets.

3. UO_2 FUELS RESEARCH

Fuel Evaluation

Fission Fragment Distribution in UO_2. Relocation of fission fragments during irradiation of highly rated UO_2 fuel elements was confirmed by radiochemical analyses of micro-samples of UO_2 removed along a diameter of a cross-section of an irradiated fuel rod. The concentrations of plutonium and the fission products zirconium-niobium, ruthenium, cerium, and cesium, were found to be depleted in the cooler regions of columnar grain growth and, in the case of the more refractory elements, concentrated in the hotter regions of columnar grain growth. An unexplained small concentration decrease near the fuel-cladding interface may reflect recoil loss.

Relocation of fission fragments affects the useful life of UO_2 fuel (swelling, loss of crystallinity) that is dependent on fission fragment concentration. Other physical properties such as melting point and thermal conductivity which are also dependent on fission fragment concentration will vary throughout the fuel. Movement of plutonium in mixed UO_2-PuO_2 fuel elements can be troublesome in computing Doppler broadening, particularly in fast oxide breeder fuels.

High Temperature Grain Growth of UO_2. Growth of a 0.1-inch diameter single crystal UO_2 sphere compacted in the center of a half-inch diameter pellet of micronized UO_2 occurred during sintering in 1800 C hydrogen for 66 hours. The bulk density of the sintered pellet was 97% T.D. Metallographic examination revealed that the diameter of the sphere had increased approximately 0.04 inch. Etch pits in the growth layer indicated that its crystal orientation was the same as that of the original fused UO_2 crystal. The concentration of trapped pores in the growth layer was not significantly different from that in surrounding sintered grains of the matrix UO_2.

Similar studies were conducted using spheres of 99% dense HEF UO_2. A sharp transition from normal sized matrix grains to giant grains in the sphere occurred at the sphere-matrix interface. A gradual decrease in grain size from the surface to the center of the sphere was apparent. The same trend has previously been found in sintered, high energy impact formed UO_2 and is presumably caused by air entrapped in the UO_2 during impact forming.

Oxidation of Uranium Inclusions in Fused UO_2. Samples of fused UC_2 containing uranium inclusions were autoclaved 72 hours in 400 C, 1500 psi steam. Four pounds per hour of steam containing 6 ppm O_2 were pumped through the autoclave. Additional stoichiometric and hyper-stoichiometric fused UO_2 samples were included for comparison. The changes in O/U ratio of the samples are shown in the following table. The data suggest a diffusion-limited reaction rate for the steam oxidation of uranium inclusions in fused UO_2.

EFFECT OF STEAM OXIDATION ON O/U RATIO OF FUSED UO_2

	O/U RATIO*			
		After Autoclaving		
	Before	Particle size, Tyler screen series		
UO_2 Purity	Autoclaving	-6+10	-35+65	-200+325
1. Uranium inclusions visible with naked eye	1.938	1.946	1.978	2.029
2. Crystals from same lot as 1, but uranium inclusions not visible under low power microscope.	1.984	1.996	2.006	2.015
3. Crystals not containing uranium inclusions, from separate lot, same vendor as 1 and 2.	2.047	2.051	2.052	2.050
4. Crystals not containing uranium inclusions, from different vendor than samples 1-3.	2.010	2.008	2.010	2.024

*Determined by oxidation to U_3O_8.

Uranium inclusions were eliminated from fused UO_2 by annealing in hydrogen at 1700 C. A sample that had an O/U ratio of 1.953 before annealing was oxidized by the treatment to an O/U ratio of 1.998. Oxidation probably results from traces of moisture in the hydrogen.

Composite photomicrographs (75X) of entire fuel cross-sections were obtained from three irradiated UO_2 fuel cores. The composites are helpful in delineating similarities and dissimilarities in irradiation behavior of various types of UO_2. The three cores presently being examined contain: (1) sintered UO_2 pellets, (2) fused, vibrationally compacted UO_2, and (3) fused, swaged UO_2.

Electron Microscopy

Image intensification in the electron microscope may be possible with an Image Orthicon (I.O.) television chain. Exploratory tests indicate the I.O. chain is capable of producing usable monitor images with object brightness as low as 10^{-7} foot-lambert when the object has a high contrast ratio. Resolution at low light levels can be improved with I.O. target integration. Additional tests will determine the applicability of a fiber optic I.O. tube to the electron microscope.

Thermal and Electrical Conductivity of UO_2

Electrical conductivity of UO_2 with 0.0615 a/o burnup and of single crystal UO_2 was computed from experimental measurements made earlier at BMI. Electrical conductivity of the irradiated specimen was slightly higher than that of a corresponding non-irradiated specimen, reversing the trend shown by previous samples that had received less than one-third the irradiation exposure of the current specimen. The reason for the change has not been determined, but similar phenomena (occurring, however, to lesser extents) in other semi-conductor materials have been reported. For example, a minimum in the conductivity of Ge occurs at the transition from n^- to p^- conduction as the irradiation dose is increased.

Electrical conductivity of single crystal UO_2 (100% theoretical density) was shown to be substantially higher than that of 96% dense sintered polycrystals. This reverses the previously observed, inverse correlation between density and conductivity. The greater conductivity of the single crystal may reflect the lack of resistance by grain boundaries such as are present in polycrystalline material. Similar effects have been reported for other semi-conductors, such as silicon single-crystals and poly-crystals. Inclusions present in the single crystals may also influence the results.

Thermal conductivity of a vibrationally compacted, non-sintered UO_2 specimen in an atmosphere of helium or argon was observed to be 0.020 watts/cm ^oC throughout the temperature range 100 to 1000 C.

Oxygen/uranium ratios of all non-irradiated UO_2 specimens used for conductivity measurements were determined by a controlled potential coulometric method. All ratios are between 2.001 and 2.006; the excess oxygen present is insufficient to significantly affect conductivities. Ratios for the irradiated specimens are being determined.

Materials

High Energy Impact Formed UO_2. A cobalt-bonded tungsten carbide ram for the Dynapak machine was calibrated with strain gauges at static loads to 380,000 psi. High impact pressures available with tungsten carbide tools are expected to simplify procedures for preparing high density UO_2 by high energy impaction.

High energy impact formed UO_2 specimens having densities between 90 and 95% T.D. were sintered 66 hours in 1800 C hydrogen. An average density of 99.5% T.D. resulted. The material will be used in basic studies, where it will be particularly valuable because its density is higher than that of previously available polycrystalline UO_2.

Fused UO_2. An 800-pound lot of fused UO_2 received from a second commercial vendor meets reactor grade fuel material specifications for density, O/U ratio, nitrogen and sorbed gas content. Reactor grade fused UO_2 has previously been available only from one commercial supplier. Properties of the new fused UO_2 are as follows:

O/U ratio (by oxidation to U_3O_8)	2.014
Apparent density (by mercury displacement)	10.86 g/cc
Sorbed gas content (by evacuation at 1000 C, 15 min)	0.067 cc/g UO_2
Nitrogen content (by Kjeldahl method)	0.02 w/o.

4. BASIC SWELLING PROGRAM

Irradiation Program

Irradiation of capsules 7 and 8 is continuing at constant temperatures of 525 C and 575 C, respectively. Each capsule contains three, hollow, split cylinders on which post-irradiation studies will be conducted. Assembly of capsules numbered 11, 12, 13, and 14 also containing three hollow, split cylinders has been completed, bench testing successfully accomplished, and the end caps and fittings installed. These capsules will be charged in tandem, two in each test tube. Another completed capsule, No. 9, is being used in an ex-reactor test tube complete with coolant to check new instrumentation and capsule heater supply circuits. An order has been placed for additional electrical resistance heaters for future capsule assemblies.

Four unmonitored NaK-filled capsules, each containing six cylindrical U-U diffusion specimens have been shipped to the MTR for irradiation.

Post-Irradiation Examination

Two unrestrained spherical specimens of uranium, irradiated to a burnup of 0.05 a/o at 550 C and 0.28 a/o at 575 C, have been annealed for 100 hours at a temperature equal to the irradiation temperature. The specimens have been polished, etched, and replicated to permit microscopic study of pore size-frequency changes due to the thermal treatment. A 3 a/o U-235 spherical specimen irradiated in NaK to a burnup of 0.16 a/o at a temperature of approximately 800 C has also been processed twice for metallography. In both cases extreme heterogeneity in porosity visible at low magnification by optical microscopy was observed. On the two sections through the specimen, a zone free of porosity exists around the periphery of the specimen. Within the specimen interior fine porosity exists but superimposed on this structure is a network of bands about 50 microns in width which are free of fine porosity. However, large pores similar to a string of beads are located along the central region in the band network. Since the network is of a scale similar to the size of grains expected in the gamma phase of uranium, it may be possible that these bands correspond to prior gamma grain boundaries and that gas has diffused to these boundaries. Normal appearing alpha uranium grain and twin boundaries are also in evidence in this specimen. No dependence of one structure on the other was noted. Electron metallographic studies of this structure are in progress.

Pore Size Distribution

Pore diameter data from two hundred 8" x 8" electron micrographs have been programmed through the computor, and pore volume fractions and pore densities have been determined for each micrograph. The data were obtained from five replicates of each combination of the following parameters associated with ex-reactor induced swelling of irradiated uranium: (1) two burnup levels, 0.29 a/o and 0.41 a/o; (2) two regions of the specimen, the core and the periphery; (3) five temperatures of annealing, 400 C, 500 C, 600 C, 650 C, and 700 C; (4) two holding times for the anneals, one hour and one-hundred hours. A statistical analysis of the variance associated with the calculated pore void fraction and density values has been made to determine the importance of the variables on the final swelling state. Although final interpretation is not complete, the following general conclusions have been drawn. The change in pore void fraction (increase in swelling) is approximately a linear function of temperature of annealing and increases with increase in burnup. Time of annealing and position within the specimen play only a minor interacting role. The pore void density, number of pores per unit volume of uranium, approximates a decreasing linear function of temperature. Burnup, position in the specimen, and time of annealing have little effect. Analysis of the data is continuing.

Fission Product Mobility

Efforts are continuing to determine the mobility of inert fission gases in uranium. The "glow discharge" release work has been temporarily interrupted, but the feasibility study of U-U diffusion couples that have a large concentration of fission products in one-half of the couple is continuing. Replicas of enriched-depleted U-U diffusion couples, GEH-14-281 and 282, after polishing and etching have been prepared for microscopic studies. The enriched (3 a/o U-235) outer shell of these cylindrical couples had attained a nominal 0.3 a/o burnup, whereas the core (0.15 a/o U-235) had attained 0.015 a/o burnup. The temperature of irradiation was $<$ 200 C. Optical examination of the replica of these specimens shows that the U-U interface is intact, even though considerable change in the microstructure of the enriched layer has occurred. No pores with diameters greater than three microns (limit of resolution) were detected in the enriched layer. Porosity in the specimens will now be studied in the electron microscope, and the specimen will be annealed to induce gas mobility and agglomeration into pores.

Restrained Irradiations

Swelling experiments of Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and burnup are being conducted employing NaK-filled temperature monitored capsules. The density was measured on eight rods irradiated in the MTR. Two of these rods which had maximum center uranium temperatures of 300 C during irradiation to 0.24 a/o burnup differ in density decrease by a factor of three. To determine if the difference can be accounted for by fission gas pores, replicas of the uranium from both rods are being prepared. Electron micrographs from the rod with the larger density change, -1.8%, shows no fission gas pores. The appearance of the uranium surface in the electron micrograph hints that the etching may have been inadequate. Another replication of this sample is planned if the uranium with the lower density change shows gas pores.

Optical metallography on a cathodically etched sample from a rod irradiated at a maximum uranium temperature slightly greater than 660 C to a burnup of 0.38 a/o reveals extensive trans and intergranular cracking. A well defined grain structure is present in the central zone of the uranium, and the normal highly distorted structure characteristic of uranium irradiated at lower temperature is found in the edge zones.

A composite of photomicrographs along a radius has been made to investigate the change in grain structure of uranium irradiated with a temperature gradient from low beta to low alpha. Electron micrographs of this sample reveal gas pores from 0.1 micron to 4 microns in diameter.

5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

A capsule of the third generation series was installed in the reactor. The third generation capsule, designated as III-2, contains a 20 percent cold worked Zircaloy-2 specimen and is the first of this design to be tested in the reactor. Insufficient time has elapsed to obtain creep data; however, the operating characteristics of the capsule are a considerable improvement over previous models. A complete series of tests were made on the capsule before charging and in the reactor before reactor startup. In each case the capsule responded as predicted. As the reactor started up, the transducers responded properly, the mechanical positioner was operated and used to recalibrate the variable permeance transducer. The thermocouples held and the heaters maintained a uniform temperature without any adjustment between reactor off and reactor on. As the gamma heating approached the set temperature, the electrical power was turned off to check the thermal balance within the capsule. The temperature gradient on the specimen, with only gamma heating, was less than 20 C; the central thermocouple was low while the two ends were within 5 C of each other. Power was again applied to maintain the maximum temperature the capsule would see with the combination of minimum electrical power and maximum gamma heating. As the reactor approached maximum operating conditions, the specimen temperature approached 400 C. This temperature of 400 C is approximately 150 degrees higher than predicted but is within the planned range of test temperatures for 20 percent cold worked specimens. This temperature is being maintained on the specimen until the reactor comes to level operational conditions, at which time the stress will be applied, and the creep test will begin.

Capsule and Instrument Development

A third generation series capsule, designated as III-3, is being readied for the next charging. The capsule contains a 20 percent cold worked specimen. The operating characteristics of the capsule now working in the reactor revealed that all aspects are within the design limits although the temperature is on the high side. The thermal barrier is being removed from the next capsule to permit better heat transfer. The barrier was intended to maintain a more uniform temperature gradient on the specimen by suppressing heat flow. The removal of the barrier will reduce the specimen temperature towards the lower limit of the design.

Tests have now begun on a thermal mockup of the capsules to check their thermal characteristics by simulating gamma heating in all components of the capsule. It has been found that neither laboratory measurements on the capsule before charging nor calculations can accurately predict the exact temperature of the capsule when in the reactor. Therefore, the entire capsule has been mocked up with small heaters inserted in each component with power proportional to component weight to simulate and measure the effect of gamma heating.

Pre-Irradiation Material Characterization. The study of the activation energies for creep of annealed Zircaloy-2 between 50 C and 200 C has been continued. The activation energy in this temperature range has been shown to be a function of creep rate and temperature. Values determined at 50 C range from 14,000 cal/mole to 21,500 cal/mole; the high value corresponding to a creep rate of 1×10^{-4}/min; the low value corresponding to a creep rate of 3×10^{-4}/min. At 125 C the activation energies range from 19,500 cal/mole to 32,700 cal/mole at creep rates of 4×10^{-4}/min and 1×10^{-4}/min, respectively. At 200 C values from 45,000 cal/mole to 35,500 cal/mole were found corresponding to creep rates of 2×10^{-4}/min and 4×10^{-4}/min.

6. GAS-GRAPHITE STUDIES

EGCR Graphite Irradiations

The H-3-3 capsule containing EGCR graphite continues to operate successfully in the GETR. It has received approximately 60 effective days of exposure. The total maximum exposure received by the samples which were irradiated in both H-3-1 and H-3-2 now totals approximately 250 effective days (estimated dose of 7×10^{21} nvt, $E > 0.18$ Mev). All thermocouples are operating satisfactorily.

EGCR Burning Rig Experiments

Burning rig experiments were conducted to determine the degree of protection which refractory coated fuel sleeves would provide to the EGCR. Two series of tests were run, the first with Si-C coated sleeves and the second with uncoated fuel sleeves. Initial conditions were repeated as closely as possible for corresponding tests in each series. On the basis of these tests there is no apparent advantage from employing the coated sleeves since the assembly actually appeared to be more stable towards combustion with the uncoated sleeves.

In-Reactor Creep Experiments

Five 300 psi compression test boats which were irradiated at about 600 C have been disassembled, and length measurements have been completed for the samples. Analysis of the data is not complete, but in general there is a noticeable reduction of initial growth for the loaded samples as compared with the unloaded samples.

Tensile test boats are being designed for loads of 150 psi on samples of the same graphite types as used in the compression test (TSX, AGOT-LS, EGCR, TSGBF and CSF).

Ex-Reactor Creep Experiments

The first tensile creep machine is now working. The first sample is EGCR graphite with an effective gage length of three inches. The equipment has been in operation at a temperature of 590 C and at a load of 1000 psi

for 11 days. After an initial change of 0.0002 inch which occurred in the first hour of operation, no significant change has been noted. This test is scheduled to continue for 100 days.

In-Reactor Gas-Graphite Reaction

Several quartz capsules containing CO_2 and graphite have been exposed in-reactor in the pressure range 200 to 500 psi and at approximately 575 C. There has been very little evidence of reaction. On the other hand, every capsule that was loaded with CO and graphite under these conditions has given indications of chemical reaction. A loss in CO and a gain in CO_2 as well as a deposit of black material uniformly deposited on the inside capsule walls has been observed. Electron micrographs show a lampblack structure for the deposit. X-ray powder patterns reveal several lines:

Relative Intensity	d Spacing Å
1	2.864
2	2.468
3	1.492
4	1.748
5	3.173

The first four of the lines are very close to those obtained by R. C. Giberson in ex-reactor $CO-H_2$ experiments and are believed due to the presence of carbon sub-oxides.

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

The gas loop installation and construction is 92% complete versus 100% scheduled as of September 30, 1961. Delivery date of the main blowers remains indefinite. A recent progress report indicates that some improvement has been made, and if proposed modifications now being incorporated are approved, two blowers could be delivered by December 31, 1961. The General Electric Technological Hazards Council considers the NaK-filled preheater unacceptable from over-all safety considerations; therefore, the preheater is being removed from the containment vessel. Replacement of the NaK with a suitable heat transfer medium, such as solid graphite, is being considered. Preliminary heat transfer calculations and metallurgical considerations indicate that the NaK replacement by graphite is feasible. A revised project proposal requesting an extension of time and an increase in authorized funds for this work will be submitted when formal estimates have been prepared. Preparation of electrical, instrument, and operational design tests are in progress.

Component Testing. Operation of the diaphragm compressor prototype to date has shown that one of the main causes of trouble is air on the oil side of the diaphragms. To eliminate this problem, the following changes have been made.

1. The oil suction check valves have been relocated below the oil level in the crank case. This prevents oil from draining out of the suction lines when the compressor is not running.

2. A pigtail, which is below the oil level in the crank case, has been added to the discharge line from the oil relief valves. This keeps the discharge line full of oil and prevents air from being drawn into the oil side of the diaphragms on the suction stroke if the oil relief valves are not seating properly.

Operation of the compressor has also shown that mounting the oil relief valves in the vertical position instead of the horizontal position increases the life of the valve considerably. To facilitate startup of the compressor after an extended outage or maintenance work, a by-pass line with valve has been installed around the oil relief valves so that the oil side of the compressor can be unloaded. These modifications will be required on the gas loop compressor also to permit unattended operation.

7. GRAPHITE IRRADIATION DAMAGE STUDIES

Reactor Graphite Irradiations

The GEH-13-6 capsule containing special graphites was disassembled in the MTR hot cell. These are CSF graphite; "A" grade, a raw coke graphite; ZT, a hot worked graphite; ARF-3, a furfural alochol bonded graphite; and 901S, a special isotropic graphite. The capsule interior had suffered some damage as a result of a leak in the lead tubing which necessitated removal of the capsule from the reactor. The alundum cement used for spacers and as insulation over the flat platinum heaters had eroded away and broken up quite badly. This was apparently caused by reaction with water vapor in the capsule. However, the molybdenum springs held each assembly in place so that there was no major displacement of capsule parts. All seven graphite sample cups were recovered intact. There was no evidence of reaction on the external surfaces of the cups. One cup inadvertently fell open so the samples were examined under the hot cell periscope; there was no apparent damage to the sample surfaces. Consequently, it is assumed that the samples suffered no adverse damage. However, this cannot be confirmed until they are received at HAPO, weighed, and measured.

Fifty-three of the 56 flux monitors contained in the capsule were recovered. Three of the manganese monitors had reacted to form a compacted material which could not be readily removed from the hole in the base plate.

Flux Monitoring

Initial results on the use of Fe as a fast neutron flux monitor in the Hanford reactors were received. During two short-term irradiations,

relative activations were consistent within 5 percent with Ni foils. These irradiations were short enough so that no correction to the Ni results for Co-58 burnout was needed. Using 92 mb as the Ni-58 (n,p) cross section along with a calculated fast neutron spectrum; a value of 45 mb was derived as the effective cross section for the Fe-54 (n,p) Mn-54 reaction in an unmodified fission spectrum. The currently accepted value is 53 ± 4 mb, and, in view of the many assumptions necessary for the calculation of the effective cross section, the agreement is considered satisfactory.

For these short irradiations, the empirical correlation with Ni yielded the following factor for the computation of fast fluxes from Fe activation in Hanford reactors:

$$\phi t = \frac{ZA\, e^{-\lambda t_o}}{1 - e^{-\lambda t_i}}$$

where: $Z = 2 \times 10^{15}$ (nvt > 1 Mev/(dis/sec-mg Fe))

λ = decay constant - $0.693/(\text{half-life})^{\frac{1}{2}}$

t_o = decay time after discharge

t_i = irradiation time

A = Mn-54 activity of the foil in (d/sec mg).

Longer irradiations have been completed to determine the importance of thermal neutron burnout effect on Mn-54.

Electron Microscopy

Three samples are being prepared for irradiation at 700 C in the GEH-13-8 capsule in the ETR for approximately 10,000 MWD/AT. Electron micrographs at 5000X are being made of the cathodically etched surface of TSX graphite and a natural flake graphite having a coal tar pitch binder. A sample of CSF graphite which was oxidized after cathodic vacuum etching to enhance structural detail will also be included. The photomicrographs at 5000X will be assembled in mosaics of an area representing approximately 0.1 square millimeter for comparison with the same areas after irradiation.

The samples are threaded and will be screwed into a graphite cup for protection of the polished surface during irradiation. A thermocouple mounted in the cup will monitor the irradiation temperature.

Thermal Diffusivity of Graphite.

Construction of an apparatus to measure the thermal diffusivity of irradiated graphite was completed. A 500 microsecond light pulse is absorbed on the front surface of a 0.5 inch diameter sample. The

resulting rear surface temperature increase is detected by a thermocouple, amplified, and observed on an oscilloscope.

In this apparatus the measured thermal diffusivity of copper and aluminum were within 20 percent of the accepted values at room temperature. Further calibration data at room temperature will be obtained before high temperature graphite thermal diffusivity measurements are started.

8. ALUMINUM CORROSION AND ALLOY DEVELOPMENT STUDIES

Corrosion in Molybdate Systems

Testing was terminated on the corrosion of X-8001, Zircaloy-2, and sensitized 304 stainless steel at 300 C in water adjusted to a pH of 4.5 with H_2MoO_4. The coupon data are now being analyzed to determine corrosion rates.

9. USAEC-AECL COOPERATIVE PROGRAM

Ultrasonic Testing

To study the response of the ultrasonic equipment to notch defects of different widths but with the same length and depth, notches 3 mils deep by 119 mils long and varying from 2.25 to 17.5 mils wide were machined on both inside and outside surfaces of 0.680-inch ID low-nickel Zircaloy-2 sheath tubing. The responses from identical inside and outside surface notches were balanced by varying the entry angle of the ultrasound into the tube. This response was then compared with the other inside and outside surface notches of different widths. No significant difference in ultrasonic response was obtained from notches varying from 2.25 mils to 17.25 mils in width (with depth and length held constant), using a spot focused lithium sulfate crystal at 10 megacycles. The notch depths in the experimental defect samples are measured nondestructively by using a thermal-setting Vinyl Plastisol Plastic to replicate the notches. The height of the notch-replicate is then measured on a microscope with a calibrated stage. To demonstrate the reliability of this technique, twelve samples were first replicated and then sectioned, and both the replicates and the transverse sections were measured. The differences between all but two of the measurements made by the two techniques proved to be no larger than the precision of measurement, $\pm$ 0.2 mil. In the case of the two exceptions the replica measured 0.5 mil deeper than the measurement of the transverse section of the actual groove. It is concluded that the replicating technique is sufficiently accurate for measuring ultrasonic standards.

Heat Transfer and Fluid Flow Studies

The design has been completed for the steam generator and the test sections to be used for determination of two-phase pressure drops through valves, orifices and pipe fittings. Pump capabilities and

the heat generating capacity of the steam generator will permit studies up to steam qualities of 20 w/o at mass flow rates of 4×10^6 lbs/hr-ft^2 through two-inch pipe and fittings.

Following the demonstration last Spring that steam generation might be feasible using 19-rod fuel elements in a horizontal position, plans were made for more extensive experimentation using an electrically heated test section with CANDU dimensions. Fabrication of the tubing for the 19 rods has been completed by the vendor and is waiting for inspection prior to shipment. Fabrication of the copper end clamps which will supply the electrical current and provide the 0.050-inch spacing between rods is 75% complete. The process tube was finished and is ready for installation.

Magnetic Force Welding SAP

Welding parameters for closure of SAP fuel element cladding were evaluated. An optimum initial weld joint pressure was established to be approximately 11,000 psi. The Magnetic Force welder armature-to-core air gap controls forging force and timing. An air gap of 0.625 inch was shown to be optimum for welding 0.551 inch OD x 0.022 wall thickness M-257 material. A welding current of approximately 1.5×10^6 amperes per square inch was employed, using either RWMA Class 3 or Class 10 electrode materials. Satisfactory welds were made in air, helium, and vacuum.

10. IRRADIATION EFFECTS IN STRUCTURAL MATERIALS

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

Beneficial use of the modified ETR 6x9 hot water loop began with cycle 39 of the ETR. A total of 504 Zircaloy-2 tensile specimens are now under irradiation. Valve difficulties have prevented attainment of the proposed 300 C operating temperature; consequently, the specimens scheduled for discharge at the end of cycle 39 will not be discharged until the end of cycle 40.

Interpretation of the extensive tensile data obtained in this program will be aided by means of a computer program. Programming is now completed; input data will be extracted from load-strain charts as continuously recorded by the testing machine. Several machine runs have been made on control specimens. Computer output consists of engineering stress-strain and true stress-strain values, in addition to the normal tensile parameters. A considerable time savings will result from machine calculation on raw data.

Six quadrants containing a total of 108 stainless steel specimens (types 304 and 348) have been assembled and shipped to NRTS. These are scheduled for irradiation during cycle 41 of the ETR.

A remotely operated tensile machine has been calibrated and installed in a shielded testing facility. Air operated remote specimen grips have been designed for use with this machine.

Testing is in progress on Zircaloy-2 tensile specimens irradiated in the F-6 position to exposures of 10^{19} and 10^{20} nvt (fast). The data obtained have not yet been programmed into the computer.

11. REACTOR STUDIES PROGRAM

In addition to the three reactor types reported last month to be under consideration for possible conceptual design and economic evaluation, three other concepts suggested by the Evaluation and Planning Branch, Division of Reactor Development, are being considered. These include reactors utilizing regenerative fuel cells, MASER principle energy conversion, and fission energies to promote chemical reactions. These initial investigations will be carried to the point of determining whether the technology in support of the basic concept warrants the conceptual design of the reactor exploiting it. As previously indicated, a proposed program for conceptual design of one or more of the reactor types will be developed prior to committing significant amounts of manpower or funds.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

The objective of this program is to develop a model which accurately describes the nature of neutron damage in pure metals, to determine how controlled impurity additions alter this damage state, and to establish the mechanisms of damage recovery. High-purity molybdenum has been selected as a suitable metal for initial study because a large proportion of damage is retained at room temperature, and transmutations and residual radioactivity are minimal. A number of single crystal and polycrystalline specimens with known carbon contents will be irradiated at temperatures of 40-75 C.

The crystallographic orientations of molybdenum single crystals containing 10-30 ppm carbon have been determined. In most cases the rod axes of the crystals lie in or very near the (100) plane, with no consistent orientation in this plane. Stress-axis rotations in molybdenum crystals under load are expected to fall into four groups, depending on the initial orientation: (1) rotation toward the $[\bar{0}01]$ pole, (2) rotation toward the $[\bar{1}12]$ pole, (3) rotation toward the $[\bar{1}11]$ pole, and (4) formation of deformation bands rotating toward the $[\bar{1}11]$ pole, with the matrix rotating toward the $[\bar{0}01]$ pole. The low-carbon crystals are expected to exhibit all rotations except group (2).

[redacted]

Single crystal tensile specimens are now being prepared. Flat faces are being ground on the specimens such that a low-order plane, either (110) or (001) is parallel to the surface. After the specimens are ground, the worked layer will be removed by electrolytic polishing. The condition of the surface will be determined by three x-ray techniques: (1) Laue asterism and Laue spot size, (2) x-ray extinction, and (3) line width. The third method has been used in determining the depth to which disturbed metal persists in polycrystalline molybdenum after grinding and milling. It was found that the depth of highly distorted material was larger after grinding than after milling, but the total depth of distorted material is about the same for both methods.

A series of cold worked and annealed, high-purity (99.99%) molybdenum foils have been discharged from the KW Snout facility after an exposure of 1×10^{17} nvt (fast). These foils will be thinned for transmission electron microscopy studies of clustered defects and dislocation structures. Integrated intensity measurements on Al single crystals irradiated to 10^{19} nvt have been made. The crystals originally less perfect (grown by a rapid cooling method) were unaffected by this level of irradiation. The highly perfect crystal showed a definite decrease in x-ray extinction, indicating that some type of defect was induced by the irradiation. No change in lattice parameter was detected.

E. CUSTOMER WORK

Radiometallurgy Service

Examination has been started on two overbore elements from C Reactor to determine the cause of support damage on one, and the severity of cladding corrosion on the other (RM-433).

A maze of cracks was observed on the outer surface of a transversely cracked fuel element from tube 2485 F. Microscopic examination revealed considerable uranium hydride (RM-432).

The suspect male weld on a production element irradiated in 4159 KW was found to be in good condition when it was examined (RM-430). Oriented diameter measurements of two overbore fuel elements were obtained to determine their profiles. One was "bottle" shaped and the other "barrel" shaped (RM-431).

X-ray diffraction studies have been completed on Vallecitos uranium dioxide samples, and the data have been forwarded to the customer. Fourteen uranium or uranium dioxide samples have been dissolved for burnup analyses; two uranium samples have been declad for density measurement; fission gas has been collected from one element (GEH-4-61), and densities have been determined for four samples. Two samples were fractured at liquid nitrogen temperature and replicated, and microhardness tests were completed on sample A-2 (RM-667).

Equipment for handling a waste sludge sample from the Purex Tank Farm has been modified to facilitate disassembly of a new rotary core drill sample holder. Equipment has been prepared for measuring densities and solubilities of sludge samples.

Metallography Service

Since the adoption of metallographic polishing with Syntron Vibratory polishers, a need has been apparent to speed up the preliminary polishing step for samples of large cross-sectional area. A device has been designed and shop-made which will space specimens on the Syntron properly and allow a heavy, large diameter weight to be placed on them. In this way samples are given heavy individual pressure and remain flat during polishing. Initial trials with four test samples have shown that it is possible to polish specimens in about 1/2 to 1 hour whereas several hours were required previously. Present drawbacks to this setup are: (1) the samples must be of the same height, and (2) the polishing face and the face opposite must be parallel. Methods are being considered to accomplish this without undue difficulty.

Electron microscopy of 12 compounds in the form of powder that were later added to experimental graphites has been completed. These graphites were prepared by Speer Carbon Company for Nonmetallic Materials under Contract DDR-118, "Chemical Additives to Graphite". The compounds examined were commercial purity Fe_2O_3, highly purified Fe_2O_3, FeO, Fe_3O_4, FeS, $FeSiO_3$, 325 mesh Fe, Cr_2O_3, CuO, ZnO, Ni_2O_3, and Al_4C_3. A knowledge of particle size and shape is expected to assist in identifying these additives and their distribution in the mix at various stages in the manufacture of the graphite. Replicas of polished graphite specimens from the green and baked stages of manufacture are currently being examined.

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	495
Replicas	19

Photographs

Micrographs	595
Macrographs	47
Electron Micrographs	200
	842

NPR Charging Machine

The main frame was removed from the cross travel frame so that these assemblies could be weighed and some mechanical modifications performed. The vertical lift drive shafts and mitre boxes have been replaced. Dust covers have been installed over the jack screws. Modification to the jack screw support points have been finished. Wiring of the machine is estimated to be 90% complete. Charging machine design test (CMDT) No. 1 (weight of machine) was completed.

J. W. Woodfield

For Manager, Reactor and Fuels Research
and Development

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

SEPTEMBER 1961

FISSIONABLE MATERIALS - 02 PROGRAM

FUELS

Kinetics Calculations for HTR

At the request of personnel in Fuels Preparation Department, some calculations were made of the consequences of a postulated step reactivity increment of $1 in the HTR, at normal power level, but with all control and safety mechanisms inoperative. It was assumed in the calculations that the fuel and moderator temperature coefficients were both negative, and equal to the reported value for HTR. It was further assumed that there was no explicit heat transfer between fuel and moderator or between moderator and environs, though transfer between fuel and moderator was implicitly included by adjustment of the proportion of fission heat dissipation between the two media. Calculations for cases with parameters bracketing reasonable limits of uncertainty indicated that the excursion would peak in about 13 sec., with several hundred degrees rise in the fuel temperature, but no melting. Total fissions would range around 3×10^{19}. It should be pointed out that these results are mathematical consequences only. There is no allowance made for the fact that, because the excess reactivity of HTR is insufficient, additional fuel would be required to effect the postulated reactivity increase; whether or not the present calculations are applicable thus depends on the characteristics of this additional fuel.

REACTOR

Optimization of C-Pile Retubed Lattice

Optimization of the C-Pile lattice with overbored process channels is highly dependent on the vertical safety system strength. An exponential pile mockup is in use to measure the strength of safety rods in several configurations with standard and overbore size I and E fuel, both wet and dry. The first measurement was the change in buckling caused by insertion of six safety rods into the exponential loaded with dry C-II-N fuel. The change in buckling was $150 \pm 3 \times 10^{-6}$ cm^{-2}. A correction for the small size of the exponential is needed to allow comparison to the local control strength in C-Reactor of 120×10^{-6} cm^{-2}. The correction has not yet been made, but the magnitude and sign of the difference (150-120) indicate reasonable agreement between the exponential and the reactor values of the local control strength. The most pertinent comparison will be the VSR strength in the exponential for the present fuel versus the overbore fuel (both dry), since this determines the effect of overbore fuel on the disaster case of total water loss.

Measurement of the Strength of Control Splines in the K-Lattice

The strength of control splines has been measured with the K-lattice in the PCTR. The spline is a dispersion of 12.5 w/o B_4C in Al. The mixture is formed into a flat strip which is then inserted between the process tube ribs for supplemental control in the production reactors. At present the burnout rate for the splines is not well known, so they are used only once and discarded. Some of the measured spline pieces will be returned to IPD for irradiation and then brought back to the PCTR to determine the fractional burnout.

The reactivity worth of the spline material was measured at the edge of the K-pile lattice, at the surface of the K-IV slug, and at the center of the K-IV slug. The physical dimensions of the cell are given in Table I. The worth of the spline was determined for seven samples: one was bent to fit the center hole in the K-IV slug; two will be kept as standards; and four will be sent to IPD for irradiation. Calculations needed to interpret the measurements in terms of Δk are not complete.

TABLE I

Region	Diameter cm		Length cm	Mass Grams
	Inside	Outside		
Water	0	0.9728	45.029	33.47
Cladding	0.9728	1.2217	45.029	52.16
Fuel	1.2217	3.4688	42.291	6612.
Cladding	3.4688	3.7059	45.029	163.30
Water	3.7059	4.2564	45.029	144.03
Process Tube	4.2564	4.5872	45.029	313.7
Graphite	4.6838	21.4954		
End Cap	1.2217	3.4688	2.7381	23.18

$$\rho_{H_2O} = 1.0 \text{ gm/cm}^3$$

$$\rho_u = 18.887 \text{ gm/cm}^3$$

$$\rho_{al} = 2.7 \text{ gm/cm}^3$$

Lattice Parameters for Large Diameter Fuels

The lattice parameters k_∞ and f have been measured for a 1.66 inch solid fuel element in a 6.5 inch lattice. The fuel was natural uranium, the moderator was graphite, and the coolant was air.

The parameters were measured to obtain flux traverse and cadmium ratio data for a very hard neutron energy spectrum. The flux traverse will be fitted with P_3 calculations to derive an effective neutron temperature for the smallest C/U ratio normally encountered in lattice analysis. The measured values will also be used in a comparison of exponential and PCTR results for a wide range of C/U ratios.

The values for the flux match are given in Table II for gold foils 5 mils thick and 0.5 inch diameter. The physical dimensions of the cell components are

given in Table III. The values of k_∞ and f are $k_\infty = 0.944 \pm .002$ and $f = 0.959 \pm .001$.

TABLE II

Material in Flux Adjusting Region	Measured Cadmium Ratio: Center Cell	Side Buffer	Corner Buffer	$M_{1/v}$
1) Graphite	2.99	3.56	3.83	
2) 98 - 0.5-inch U-rods	2.65	2.75	2.78	- 240.3
3) 130 - 0.5 inch U-rods	2.58	2.55	2.65	- 242.9

TABLE III

Region	Radii cm: Inside	Outside	Density g/cm^3
Fuel	0	2.102	18.887
Cladding	2.133	2.205	2.7
Process Tube	2.540	2.705	2.7
Graphite	3.048	9.303	1.61

Study of Flux Matching in the PCTR

Additional reactivity and gold cadmium-ratio measurements have been made in the to study the technique of matching the neutron flux ratio and/or the int flux ratio at the center cell and at an adjacent buffer cell of a sample lattice by means of reactivity measurements alone.

Four different spectral conditions have been investigated by using an oxide-fueled graphite lattice and adjusting the fuel loading in the buffer zone between the lattice boundary and the PCTR driving fuel. From foil irradiation measurements the four cases yield, at the buffer cell position, flux ratios which, when compared to the same ratios at the central cell position, indicate that the spectra at the buffer position are seven percent too slow, one percent too slow, exactly matched, and four percent too fast.

Data obtained from reactivity measurements of cell, copper, U^{235}-aluminum alloy, and graphite worths at the two cell positions are being analyzed to determine how they vary with the spectral mismatches obtained from the foils.

Exponential Studies for N-Reactor

The effect of a column of samarium oxide balls in the NPR mockup has been determined. The change in buckling was $63 \pm 5 \times 10^{-6}$ cm^{-2}. As a comparison the change in buckling for an NPR control rod (previously reported) was 96×10^{-6} cm^{-2}. These measurements were taken for the wet lattice loaded with 0.946 percent enriched fuel.

N-Reactor Fuel Temperature Coefficient

The change in k_∞ due to a uniform change in the fuel temperature in the NPR mockup lattice has been measured by reactivity methods using the PCTR. These measurements were performed to provide the basis for control and hazards calculations involving the prompt fuel coefficient of the NPR. The complete results of these experiments are contained in a formal document, HW-71112, entitled, The Variation of k_∞ with Fuel Temperature for a Uranium Fuel Element, and only the major items will be summarized here.

The change in k_∞ was found to be non-linear with a change in fuel temperature and could be represented by the relation:

$$\Delta k_\infty(T) = -(10^{-3})\left[1.836(T_V^{\frac{1}{2}}-T_O^{\frac{1}{2}}) + 0.81\ U(T_V - 940) + 0.57\ U(T_V - 1045)\right]$$

for a uniform temperature distribution in the fuel.

The change in k_∞ for a non-uniform temperature distribution in the fuel was also measured. These measurements allowed the change in k_∞ to be separated into terms proportional to the surface temperature and the average volume temperature as shown below.

$$\Delta k_\infty(T) = -(10^{-3})\left|\left[1.43 + 0.4\ R\right](T_V^{\frac{1}{2}}-T_V^{\frac{1}{2}}) + 0.81\ U(T_V-940) + 0.57\ U(T_V-1045)\right|$$

$$R = (T_{surface}^{\frac{1}{2}} - T_O^{\frac{1}{2}})/(T_u^{\frac{1}{2}} - T_O^{\frac{1}{2}})$$

The temperature span of these experiments was from room temperature to 960°C. This large span and the good fit of the experimental data to the theoretical model allows extrapolation of the results to the melting point of uranium metal.

A summary of these experiments was presented at the meeting of the Reactor Physics Advisory Committee in September.

Transport Theory Development Work

The S_n analysis method for solving the multi-energy transport equation has been extended to the more versatile double-S_n generalization, which provides the additional angular distribution flexibility needed to handle physically admissible flux discontinuities perpendicular to flux direction. The work was motivated by eigenvalue inconsistency and neutron imbalance encountered in applying the S_n method to analysis of fine structure effects in a well-moderated fuel cell. The double-S_n representation has markedly improved both convergence rate and firmness of convergence, in addition to providing satisfactory neutron balance and satisfactory coalescence of reactivity eigenvalues computed by five

alternative methods (successive-free-flight fission production ratio, successive-free-flight adjoint fission production ratio, flux balance, adjoint balance, and action balance).

The double-S_n analysis has been programmed for the IBM-7090, and is now available for general use as an option in GE-HAPO program S-X (Neutron and Photon Transport Theory). Judging from significance comparisons formulated for the test cell as theory improvement work proceeded, double-S_n angular distribution flexibility appears to be necessary for successful cell fine structure analysis with the S_n method, because of the sensitivity of cell reactivity to neutron angular distribution detail within a mean free path of the fuel surface.

Digital Computer Programs for Reactor Analysis

An informal document(1) describing the generalized input routine used with HFN has been released and distributed to the people who use the computer for scientific calculations.

A rough draft of the HFN descriptive document is being typed.

A short program, which reads a 9-Zoom(2) cross section library tape in order to calculate and punch cross section HFN library input was written and debugged. Using this program, an HFN data tape was generated from the 18-group tape being used by personnel of Critical Mass Physics. This short program has saved a considerable amount of data recording and keypunching.

Three bugs were discovered in HFN during attempts to calculate the reactivity effect of an internally cooled control rod. Removal of the bugs did not yield a satisfactory answer because of slow convergence in the iterative solution of the group equations. This problem is being studied.

Green's Function Treatment of Exponential Piles in the Small Source Approximation

Since the fuel region of an exponential pile consists of a lattice of fuel rods placed in moderating material, small source theory would be expected to give a more exact representation of the flux in such a pile than the two-region approach reported on last month. However, in small source theory the source strength depends on the magnitude of the flux at the location of the source, so that one is forced to consider an integral equation. Such equations are commonly solved by iteration, the success of such a scheme depending on the accuracy of the first approximation to the solution. The two-region results provide a reasonable first approximation, provided that one can relate the parameters of small source theory to an effective material buckling. This has been accomplished, and a solution is being derived for a pile with vertical rods.

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

(2) Stone, S. P., et al, "9-ZOOM - A One-Dimensional, Multi-Group Neutron Diffusion Theory Reactor Code for the IBM 709," UCRL-5682, August 25, 1959.

Computational Programming Services

An informal document, HW-70823, describing INELASCAT, the code which processes inelastic scattering data from the three-axis neutron spectrometer, has been issued. INELASCAT itself is undergoing a number of minor revisions to smooth out certain undesirable features. Also issued were an informal document, HW-70611, describing WTBX/RTBX, the binary intput-output routines, and an addendum to HW-68807, the COFIT2 program description.

TRIP, a specialized version of the reactor kinetics code HAIREK, is being prepared at the request of IPD personnel. Coding is completed and debugging has begun.

A contribution was made to FORTRANSLATIONS of September 15, 1961, detailing a method of preparing tables for use with Fortran.

Instrumentation

The detailed report for the NPR backup Fast Scan Scintillation Fuel Failure Monitor was nearly completed in rough form. All experiments are completed within the limitations of the present prototype system.

Agreements were reached with IPD concerning participation in the forthcoming NPR graphite stack "purity" and diffusion length measurements. Nucleonic Instrumentation is responsible for mockup tests, necessary instrument procurement, detector design and assembly, and will provide consultation to IPD Instrument and Electrical Development concerning final assembly, testing, and use of the complete system. A number of experimental tests were completed using several detectors and poison concentrations to determine the effects of both detector and neutron source movement on readout counting rates. The experiments indicated a need for very close control of source-to-detector separation.

Considerable consultation was provided IPD and CE&UO concerning the N reactor nuclear instrumentation being designed and fabricated by GE-APED to meet the system requirements determined by HAPO. Several tests were made on various types of coaxial cable for system DC amplifier use. All vendor-supplied blueprints for the instrumentation were reviewed, and in addition, several types of low noise preamplifiers were tested to determine the best solution for use with fission counters. One satisfactory preamplifier was found and will be recommended.

Discussions were held with GE-APED, CE&UO, and IPD personnel concerning the specified requirements of instrumentation for the Slow-Scan portion of the NPR Fuel Failure Monitor. All questions were resolved.

The scintillation surface uranium contamination monitor for NPR fuel elements was completed, tested, delivered, and is in constant use by Testing Methods Engineering, FPD. In addition, advice was rendered concerning two additional special scintillation alpha probes for element end-cap and inside-of-element checks for surface uranium. These probes will be fabricated by Testing Methods Engineering.

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Development of instrumentation for measuring distortion of reactor process channels continued. Modifications were made in one borescope head to permit viewing the traversing mechanism target at a higher magnification. A series of test traverse runs were made on the test process tubes in the Optical Shop to calibrate the mechanism. Some of these runs were made by four people from Irradiation Testing Operation for the added purpose of training them in the use of the equipment. This Mark I traversing mechanism has been delivered to Irradiation Testing Operation and it is expected that traverses of C Reactor process tubes will be made in mid-October.

Work has begun on another traversing mechanism of similar but improved design. The improvements permit greater ease of fabrication, assembly, and maintenance. Preliminary calculations and estimates have been made to determine the feasibility of replacing the optical readout with a transducer (LVDT) readout in the recently-developed production-reactor traversing mechanism. Preliminary results indicate that a transducer system can fulfill the necessary requirements, improve the operating convenience, and provide an output for direct recording or printout for subsequent computer processing.

Design drawings are being prepared for a traversing mechanism suitable for use in the NPR reactor. Access to the traverse channels is complicated by the fact that for the first 45 inches, the access hole is only two inches high, while the traverse channel is three inches high. This expansion is too great to be accommodated by the mechanism, but a solution has been found which involves inserting shoes into the channel first, followed by a two-inch-square traverse mechanism which engages the shoes within the channel.

Experimental evaluation of the possible use of microwave techniques for in-reactor creep measurements on metallurgical specimens has been delayed for a number of months by slow delivery of ordered components. The Hewlett-Packard microwave frequency doubler finally arrived and was placed in operation. The Q-factor and transmission loss were measured on a resonant cavity built on plant for evaluation of the cavity's use as a linear motion transducer. The motion to be measured changes the size of the cavity, causing a shift in resonant frequency. This type of transducer is especially suited to extreme environmental conditions. The cavity Q factor is about 4000, with a transmission loss of ten decibels. The cavity walls are machined brass. It is expected that a polished, silver-plated cavity will have a Q in the range of 10,000 to 12,000, and would allow a linear motion sensitivity of less than ten microinches. This would be of value for in-reactor creep measurements on metallurgical specimens.

Planning of experimental instrumentation for the PRTR Rupture Test Loop continued with IPD. This facility will be used for proof-testing components of the NPR fuel rupture monitor, for developing technical criteria for operation of the NPR monitor, and for basic studies on fuel failure detection.

Systems Studies

The reactor speed-of-control study, using the sectionalized reactor model, has been completed for the present, and the result forwarded to Reactor Physics, IPD. The simulated reactor was divided into horizontal and vertical sections for representation of both horizontal and vertical diffusion. A document defining

the problem has been prepared and will be published soon. It is expected that further speed-of-control studies will be initiated later this year.

Work was begun on a simulation of a Hanford production reactor under cold startup conditions. This study will serve to aid in updating the bases for standards governing the rate of VSR (vertical safety rod) removal. In particular, it is desired to determine what reactor power and fuel temperature transients would result if the pile were to go critical before all of the VSR's were withdrawn.

The NPR secondary loop is presently being studied on the EASE and GEDA analog computers. The circuit has been debugged and a number of runs have been completed. Scram transients and load loss transients will be studied. A study will be made to determine the possibility of using a modified form of this circuit in a plant simulator.

The NPR primary loop will be simulated in the near future. This simulation will include the kinetics, temperature feedback loop and the reactor scram initiated by various types of trip signals. The initial work of collecting the necessary data was begun this month.

Two points, in particular, concerning the NPR simulation by GEL have been studied in more detail. One is whether the temperature rise in the heat exchanger was properly represented, since boiling takes place. The other is whether the reactor kinetics should not have been considered as space dependent, since the temperature distribution was so considered (the reactor was divided in five sections, front to rear, for temperature distribution, but in only one section for neutron generation). Physicists have differences of opinion on the necessity of treating the reactor as space dependent (except for xenon oscillation). All agreed that, in a large reactor, a reactivity disturbance in one part would not be felt immediately in all parts, but opinions varied as to whether the time of propagation was milliseconds or minutes. The majority leaned towards the latter, particularly since the Dresden reactor has been observed to start up on two different periods, on two sides, for times in the order of twenty minutes. It has not yet been decided whether a more accurate reactor kinetics simulation would be worthwhile for the NPR studies which have been made, since the primary purpose was for secondary loop behavior, but discussions with IPD on both these points continued.

The space dependent reactor kinetics simulation would be worthwhile, perhaps essential, for other NPR studies, such as the proposed permanent simulator.

Preparations for the 100-D automatic control experiment continued. IPD Instrument Development Operation is in the process of procuring control equipment. The production test required to authorize installation of the rod position readout devices for 100-KW was prepared by Operational Physics Operation during the month. This test procedure was reviewed and comments forwarded to the author. Approval is expected by October 1. The sensitive Visicorder galvanometers for recording in-core flux levels have arrived. The bucking current circuits to be used with these galvanometers will be fabricated, and it is expected that all necessary recording equipment will be ready for use as soon as the chambers are installed in the reactor.

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The final equations for a spatial model of a reactor were obtained, and a rough draft of a report is complete. An analog model was developed to investigate reactor dynamics. An error was made in this simulation and the results were invalid. Even though the model could be proved incorrect, the error in the simulation could not be located.

Several frequency response runs were made on the xenon equation simulation during the month. It was found that good results could be obtained at the low frequencies which are normally of interest in xenon studies, but that at frequencies where the effects of the metastable isomer should occur, the system gain was too low to yield repeatable results. A new simulation, which will improve the accuracy at the higher frequencies, has been developed and scaled. Frequency response runs are scheduled to be made soon.

Specifications for the experimental process control computer are being revised and will be submitted to Purchasing upon approval of the Appropriation Request for the Chemical Development input-output equipment. Meetings were held with a representative of Information Systems, Inc., to discuss their Model 609 computer, and with representatives of Minneapolis-Honeywell to discuss application of their Model 290 to our program.

SEPARATIONS

Critical Mass Experiments with Plutonium Solutions

Since the control rod for the critical assemblies has been inoperative, subcritical multiplication measurements were made with plutonium nitrate solutions in the 14-inch stainless steel sphere. The critical volume and mass were determined from extrapolation of the multiplication curves. The measurements were directed toward evaluating the effect of nitrate on criticality. The results of recent measurements are presented in the following table. The data, when compared with previous results, indicate the importance of nitrate on critical volume and mass, and the necessity for having good chemical analyses of the solutions. The chemical analyses for total nitrate have not been completed, but qualitatively the data imply that in the 14-inch sphere (reflected with $\frac{1}{2}$-inch paraffin) for a Pu concentration of about 100 gm/l a difference in acid molarity of about two (changing from $\sim$ 2 - 4 in molarity) will cause the critical volume and mass to increase by about 15 percent. The effect of nitrate will be accurately evaluated in subsequent critical experiments.

The control rod was reassembled, decontaminated, and reinstalled by personnel of Critical Mass Physics. The magnet drive appeared to work satisfactorily, but would not pick up the control rod because of an open circuit in the magnet coil; work is now being done to repair this unit. Design has also been completed for a new, much simpler and less costly control rod mechanism, which will be used as replacement for the existing unit.

Difficulties were encountered in the operation of the servo manometer used for liquid level measurements in the critical assembly vessels. Since it is not certain that the troubles have been corrected, a sight tube was installed to serve as a check on the manometer operation. The sight tube and scale will be read by means of the closed circuit TV system.

MULTIPLICATION MEASUREMENTS WITH PLUTONIUM SOLUTIONS IN 14-INCH DIAMETER STAINLESS STEEL SPHERE

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

Date	Experiment Number	Pu Concentration (gm/l)	Acid Molarity*	Sp. Gr.	H_2O (gm/l)	H/Pu (Atom Ratio)	Reflector Condition	Estimated Critical Volume (liters)	Estimated Critical Mass (Kg Pu)
9- 1-61	1141016	68.4	2.24	1.19	892	354	Bare	25.5	1.74
9-15-61	1141015 (Rerun)	191.2	3.84	1.44	845	122	½-inch Paraffin	24.2	4.63
9-18-61	1141017	62.9	4.40	1.25	917	404	½-inch Paraffin	25.6	1.61
9-20-61	1141018	96.7	4.35	1.30	916	262	½-inch Paraffin	23.5	2.27
9-21-61	1141019	164.6	3.88	1.41	839	141	½-inch Paraffin	23.6	2.28

* Final chemical analyses for total nitrate were not completed at time of this report.

Full critical experiments will again be undertaken with plutonium solutions as soon as the control rod assembly is correctly performing its intended functions.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

Monte Carlo Calculations of k_∞ for Homogeneous Systems of Three Percent Enriched UO_3

A quantity of special interest in nuclear safety is the value of k_∞ for unmoderated, slightly enriched UO_3 - and if the value is greater or less than unity, i.e., if criticality is possible with dry salt. A series of calculations were begun with the HISMC Monte Carlo code for calculating the measured values of k_∞ in the PCTR for homogeneous moderated mixtures of three percent enriched UO_3[1]. These calculations will be compared with the measured values and then the code used to evaluate k_∞ for dry UO_3; the smallest H/U ratio in the experiments was 3.58. The first system investigated was one having a hydrogen-to-uranium ratio of 43.87 for which the measured k_∞ was approximately unity. The results of an initial tracing of 1,000 neutron histories were reported in the July report.[2] It was evident from these results that the resonance capture in U-238 greatly exceeded the expected value. Also, it should be noted that the flux spectrum reported in the July report was in error due to a subscripting error in the code that has since been corrected. An investigation showed that the U-238 and U-235 resonance integrals, as determined from the data on the HISMC data tape, were in very poor agreement with quoted values. The data tape has since been revised and the resonance capture integrals for U-238 and U-235 were calculated to be 292 and 170 barns, respectively. These values are in good agreement with the quoted values of 281[3] and 166[4] barns, respectively. The resonance fission integral for U-235 is 311 barns as compared to the quoted value of 315 barns.[4]

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(1) Neeley, V. I., Measurements of k_∞ for Three Percent UO_3-Hydrogen Moderated Homogeneous Systems, Nuclear Physics Research Quarterly Report for July, August, and September 1959, HW-62727.

(2) Gast, P. F., Physics and Instrument Research and Development Operation Monthly Report - July 1961.

(3) Progress in Nuclear Energy, Series I, Vol. II, Pergamon Press, 1958.

(4) Goodjohn, A. J. and N. F. Wikner, Suggested Values for the Partial Cross Sections of U-235 for Use in the Neutronic Analyses of Thermal and Intermediate Reactors, GA-2151, July 1961.

The results of the calculation for the system having a hydrogen-to-uranium ratio of 43.87 are given below:

Run	No. of Histories	k_∞	Fermi Age (cm^2)	Migration Area (cm^2)	Mean Life of the Neutron (μ sec)	Mean Slowing Down Time (μ sec)
1	1000	0.9736	91.33	107.29	135.19	2.71
2	1000	1.0125	89.43	105.46	134.08	2.67
3	2000	0.9996	91.34	107.20	135.04	2.71
Weighted mean value and mean square error		0.99957±.0152	90.78±.87	106.72±.81	134.80±.47	2.71±.03

The calculated k_∞ of 0.9957 ± 0.0152 is in excellent agreement with the experimentally determined value of 0.996±0.006 reported by V. I. Neeley.(1)

Quantity of Boron Required to Render Plutonium Solutions Safe from Criticality

A calculation to determine the amount of B^{10} required to reduce k_∞ to unity for a variety of hypothetical plutonium-water mixtures has been performed. The results are of interest in connection with plans for more extensive use of neutron absorbers in criticality control (boron impregnated raschig rings).

The thermal group constants were calculated for the mixtures by the "Tempest" code and used with the current "Zoom" 18-group library to determine k_∞. The results, together with the pertinent thermal group constants, are summarized in Table IV.

The ratio of the number of boron atoms to plutonium atoms (N^B/N^{Pu}) is considered reliable up to 800 gm/l Pu; above this concentration extrapolations were used in evaluating the safe ratio. The results above 800 gm/l are probably not accurate to better than 20-50% (becoming worse as the H/Pu atom ratio gets smaller). The values for N^B/N^{Pu} are too small by larger amounts as the H/Pu ratio decreases. No extrapolations were involved in obtaining the amount of boron in solutions below 600 gm Pu/l.

The "thermal" group constants are averages taken from zero to 0.625, e.v., to conform to the Zoom 18-group library. They are included to show the strong dependence of the effective cross sections upon the amount of absorber present.

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TABLE IV

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

H/Pu	Pu(gm/cc)	N^B(atoms/cc) (10^{24})	N^B/N^{Pu}	Thermal Group Constants - Barns σ_c^B	σ_f^{239}	$\sigma_a^{239}(1-\bar{\mu})$	σ_{tr}^H
12	2	1.85×10^{-2}	3.70				
25	1	4.2×10^{-3}	1.67				
32	0.8	2.46×10^{-3}	1.22	1260	610	1000	12.0
43	0.6	1.78×10^{-4}	1.18	1290	621	1010	12.2
65	0.4	9.15×10^{-4}	0.908	1501	647	1050	14.4
131	0.2	3.18×10^{-4}	0.631	1840	694	1118	17.9
264	0.1	1.1×10^{-4}	0.437	2324	715	1119	22.8
529	0.05	4.05×10^{-5}	0.321	2800	711	1070	27.5
872	0.03	1.88×10^{-5}	0.249	2960	708	1030	29.5
1270	0.02	0.95×10^{-5}	0.189	3209	694	998	31.7
2600	0.01	2.10×10^{-6}	0.0833	3365	685	965	33.2
3500	0.0075	4.0×10^{-7}	0.0212	3383	684	961	33.4

Effect of Pu-240 on the Criticality of Plutonium

Additional calculations on the Pu-H_2O systems have extended the earlier results to higher Pu-240 content (15 and 20 percent) for bare spheres and to infinite cylinders for 0, 5, 10, 15, and 20% Pu-240. A summary of all the bare sphere calculations to date is given in Table V. The infinite length cylinder calculations are summarized in Table VI. In all the calculations the thermal group constants were calculated with the Tempest Code and used with the 18-group Zoom library and code.

Calculated Material Bucklings for Al - 1.8 w/o Pu Alloy, 0.5-inch Rods in Light Water

Material buckling calculations were made for Al - 1.8 w/o Pu alloy rods of 0.5-inch diameter in light water. These buckling estimates are to be used as a guide for planning critical approach and exponential measurements with these size rods.(1) The calculated values are given below:

(1) Letter from C. L. Brown to L. C. Schmid and W. P. Stinson, Al - 1.8 w/o Pu Alloy Measurements, September 6, 1961.

TABLE V

CALCULATED CRITICAL RADII AND MASSES FOR UNREFLECTED Pu-H_2O SPHERES

(Mass Values are for Pu-239)

Total* Pu Density (gm/cc)	H/Pu Atom Ratio	Atoms Pu (10^{24}/cc) **	0%-240 R_c (cm)	0%-240 M_c (Kg)	5%-240 R_c (cm)	5%-240 M_c (Kg)	10%-240 R_c (cm)	10%-240 M_c (Kg)	15%-240 R_c (cm)	15%-240 M_c (Kg)	20%-240 R_c (cm)	20%-240 M_c (Kg)
10	1.3	2.52 (-2)	7.62	18.5	7.81	18.95	7.98	19.15	8.2	19.63	8.4	19.
8	2.0	2.016(-2)	8.45	20.26	8.68	20.81	8.92	21.40	9.14	21.74	9.4	21.
6	3.1	1.512(-2)	9.44	21.14	9.75	22.12	10.01	22.68	10.3	23.34	10.6	24.
4	5.3	1.008(-2)	10.62	20.70	11.10	21.77	11.50	22.93	11.9	24.12	12.1	25.
2	11.9	5.040(-3)	12.31	17.36	13.27	18.60	13.92	20.34	14.6	22.20	15.4	24.
1	25.2	2.52 (-3)	13.62	10.54	14.97	13.35	15.83	14.95	16.8	17.00	17.7	18.
0.8	31.8	2.016(-3)	14.00	9.16	15.38	11.58	16.27	12.99	17.2	14.49	18.2	16.
0.6	42.9	1.512(-3)	14.40	7.44	15.84	9.49	16.75	10.63	17.7	11.81	18.7	13.
0.4	65	1.008(-3)	14.85	5.53	16.17	6.73	16.96	7.35	18.0	8.30	19.0	9.
0.2	131	5.04 (-4)	15.45	3.09	16.50	3.57	17.40	3.97	18.2	4.27	19.0	4.
0.1	264	2.52 (-4)	16.10	1.75	17.08	1.98	17.75	2.11	18.5	2.27	19.3	2.
0.075	349	1.89 (-4)	16.53	1.42	17.43	1.58	18.18	1.70	18.9	1.81	19.8	1.
0.05	529	1.26 (-4)	17.40	1.10	18.30	1.22	19.15	1.32	20.0	1.42	21.0	1.
0.04	662	1.008(-4)	18.20	1.01	19.09	1.10	20.02	1.21	21.1	1.30	22.1	1.
0.03	872	7.562(-5)	19.54	0.94	20.57	1.03	21.62	1.14	22.7	1.25	24.2	1.
0.027	981	6.804(-5)	20.18	0.93	21.26	1.03	22.43	1.15	23.7	1.28	25.2	1.
0.023	1152	5.796(-5)	21.45	0.95	22.60	1.05	23.87	1.18	25.4	1.33	27.2	1.
0.02	1325	5.040(-5)	22.71	0.98	24.05	1.10	25.54	1.25	27.4	1.46	28.2	1.
0.015	1768	3.78 (-5)	26.70	1.20	28.82	1.42	30.61	1.62	34.4	2.17	38.4	2.
0.01	2652	2.52 (-5)	41.95	3.09	47.30	4.21	57.80	7.27				
0.0087	3049	2.192(-5)	54.40	5.87	71.1	12.44						

* Pu metal at full density assumed to be 19.7 gm/cc.

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

TABLE VI

CALCULATED CRITICAL RADII FOR INFINITE BARE CYLINDERS

Pu-H_2O Mixtures Homogeneous

Total Pu* Density (g/cc)	H/Pu	Atoms Pu (10^{24}/cc) **	0% Pu-240 Crit R (cm)	5% Pu-240 Crit R (cm)	10% Pu-240 Crit R (cm)	15% Pu-240 Crit R (cm)	20% Pu-240 Crit R (cm)
10	1.3	2.520 (-2)	5.52	5.64	5.82	5.91	6.12
8	2.0	2.016 (-2)	6.10	6.28	6.47	6.65	6.80
6	3.1	1.512 (-2)	6.85	7.06	7.25	7.52	7.78
4	5.3	1.008 (-2)	7.74	8.08	8.49	8.75	9.20
2	11.9	5.0402(-3)	8.98	9.67	10.15	10.75	11.28
1	25.2	2.5201(-3)	9.99	10.95	11.64	12.45	13.05
.8	31.8	2.0161(-3)	10.25	11.27	11.99	12.66	13.45
.6	42.9	1.5120(-3)	10.55	11.61	12.34	13.10	13.80
.4	65.0	1.0080(-3)	10.91	11.92	12.50	13.36	14.05
.2	131.0	5.0402(-4)	11.36	12.18	12.85	13.55	14.20
.1	264.0	2.5201(-4)	11.86	12.57	13.25	13.75	14.32
.075	349.2	1.8899(-4)	12.16	12.86	13.46	14.00	14.70
.050	529.0	1.2600(-4)	12.87	13.57	14.25	14.90	15.56
.040	661.9	1.0080(-4)	13.46	14.15	14.92	15.50	16.43
.030	872.0	7.5622(-5)	14.50	15.25	16.10	16.95	17.99
.027	981.3	6.8037(-5)	14.99	15.80	16.66	17.71	18.85
.023	1152.2	5.7958(-5)	15.90	16.80	17.80	18.85	20.35
.020	1325.0	5.0402(-5)	16.93	17.93	19.15	20.30	22.00
.015	1767.5	3.7798(-5)	19.97	21.58	23.40	25.85	29.17
.010	2652.0	2.5201(-5)	31.75	35.70			
.0087	3048.9	2.1920(-5)	41.13				

* Pu metal at full density assumed to be 19.7 gm/l.

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

V_w/V_{alloy}	Buckling (10^{-6} cm^{-2})
0.7	7450
0.9	7750
1.1	7800
1.3	7700
1.5	7500
1.6	7100
2.0	6700

The maximum buckling of 7800 microbucks occurs at a water-to-alloy volume ratio of 1.1. The calculated minimum critical mass (water reflected spherical geometry) is 106 Kg of alloy at a water-to-alloy volume ratio of 1.57. These measurements are being made to supplement the data on Al - 5 w/o Pu alloy rods so that a more complete comparison can be made between theory and experiment. The results will be used in nuclear safety specifications relative to handling and storage of Pu-Al alloy fuel elements in PRTR operations.

Criticality Hazards Specifications

Nuclear Safety in FPD

The nuclear safety of processing three special 1.6% U-235 enriched uranium billets in the 333 Building was reviewed and approved.(1) The billets were 1 - in. ID x 5.5-in. OD x 18-in. long and weighed about 260 lb. each. The billets together represented less than 25% of a minimum critical mass.

Nuclear Safety in HLO

The nuclear safety specification (No. I-1) for the Radiological Development and Calibrations Operations was revised and reissued to include the handling and storage of a 488 g plutonium metal source. The two large plutonium sources now used in the 3745 Building are 488 g of plutonium as metal and 760 g of plutonium as PuF_4.

A shipment containing 6.8 Kg of 93% enriched UNH solution was received from Atomics International for experimental work in Critical Mass Physics. The UNH solution is in two four-inch-diameter bottles, 6.1 liters - 558 g U-235/l in each. A nuclear safety specification covering the handling and storage of this material is being prepared.

Miscellaneous Experiments for Nuclear Safety Specifications

In Situ Multiplication Measurement with Plutonium Metal

On Saturday, September 16, a further in situ critical approach experiment was made with Pu metal in Hood 19B2 of the 234-5 Building.(2) Personnel of CPD

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(1) Letter from P. F. Gast to S. M. Gill, Nuclear Safety of 1.6% U-235 Enriched Uranium Billets, September 19, 1961.

(2) R. E. Isaacson, In-Plant Neutron Multiplication Test No. 2, HW-70842.

[redacted]

made the arrangements for the experiments, and performed the measurements with instrumentation borrowed from Critical Mass Physics. E. D. Clayton served as technical director during the conduct of the experiment. The purpose of the experiment was to determine if the "safe mass" or batch limit for the melting crucible could be increased to 3.5 Kg of Pu (the current limit is 2.6 Kg).

A cylindrical array of Pu was built up from Pu metal disks, 3.5 inches in diameter, positioned in a 3/8-inch thick Si_3N_4 crucible. The crucible was further reflected by a complex array of materials of the furnace, a 3/8-inch thick quartz heat shield, glass jar, coils for induction heating, with graphite at the base of the assembly, etc. The experiment was conducted because of the difficulty in determining the effect of these reflectors on the criticality of the Pu by theoretic methods.

A total of 7.67 Kg of α phase Pu were used in the assembly; the estimated critical mass for the melting furnace was $\sim$9.2 Kg.

The experiment proceeded very smoothly, with a fair estimate being obtained for criticality in the furnace, since the final assembly contained about 84 percent of the critical mass. The experiment was successful in that the objectives were met in all respects, and the desired increase in the "safe mass" may now be permitted.

Mass Spectrometry

The heavy element mass spectrometer for this program provided isotopic analyses on twenty-four plutonium samples for CPD and six plutonium samples for Critical Mass Physics during the month.

Some operating difficulties were encountered with the spectrometer. The most important of these was a reoccurrence of the problem of improper ion intensity peak shapes at the collector. Conditions could be found to obtain tolerable peak shapes and routine analyses were performed. It is suspected that a possible cause of the improper peak shapes is the movement of collimating slits in the source. Design has been started on a more rigid mount for these slits to attempt to eliminate this recurring problem.

Instrumentation

Additional study of the CPD tracer lathe control systems resulted in the conclusion that the performance is limited by flexing and vibrations in the tracer cylinder supporting mechanism. The study is continuing with investigation of methods to apply mechanical damping and electrical compensation.

About 50% of the instrument engineering time at the Critical Mass Laboratory is still being spent on instrument maintenance. Present problems not involving maintenance that have been worked on during the month include the following: 1. A pulse generator was fabricated to drive the multichannel analyzer for the pulsed neutron tests; 2. Work has started on the development of a log n-period meter utilizing a scintillation probe as the detector element; 3. Design of a modified control rod drive assembly has been almost completed by Nucleonics Instrument Operation.

Questionable reliability of the servo-balanced reactor liquid level indicator at the Critical Mass Lab has prompted a study to determine the best alternate level measuring system. The system must satisfy the following criteria: 1. Accuracy - plus or minus 0.01 inches; 2. Reliability - excellent; 3. Range - zero to about 25 inches; 4. Liquid - plutonium-nitric acid solution; 5. Indication - remote, 200 feet away; and 6. Response speed - zero to full scale in one minute or less. The system may use a float to detect the level but no mechanical device may be used to couple the float to the measuring system since the fluid to be measured must remain completely sealed. This study has been started and is expected to be completed in a few weeks.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Cross Sections

The faulty step plug in the beam hole facility for the 105-DR neutron crystal spectrometer was successfully replaced during the month. No cross section measurements have been performed since the facility was repaired because the fission counting channels are inoperative awaiting a replacement part.

Slow Neutron Scattering Cross Sections

A new series of measurements of inelastic scattering of neutrons of an initial energy of 0.3 ev from room temperature water has been started. These experiments will give scattering law information for large energy changes corresponding to values of $\beta = \Delta E/kT$ in the range of 6 to 8. Two energy analysis runs have been made at 10° and 40° scattering angles and angular distributions have been obtained for 0.10, 0.115, and 0.125 final energies.

Analysis of the spectrometer resolution function from measurements completed last month is in progress.

Attempts to obtain quantitative fits to the data obtained on the quasi-elastic scattering of neutrons from water has continued. During the month it was discovered that the fit of a Gaussian function to a Lorentz broadened Gaussian (ψ) function by the method of least squares yielded values of Gaussian parameters which were systematically in error by a significant amount. As a result a new program was written which fits the data with an expansion in Hermite orthogonal functions. The program named GLOCKE, which is a subroutine to be used with the generalized least squares program GLEX, includes Hermite functions through the sixth. Fits made to tabulated ψ functions with this program show very adequate fitting in the region of the peak. The fitting of the quasi-elastic scattering data with the new program is in progress.

Fast Neutron Cross Sections

The detection of high energy neutrons for neutron cross section measurements by time-of-flight requires a neutron detector which is efficient and which has a fast response in time and a good pulse height spectrum. In addition, it is very desirable that the detector be relatively inefficient for the detection of gamma rays since events due to gammas constitute a background which must be subtracted from the neutron measurement. A low gamma detection efficiency is a particularly important requirement for fast neutron measurements using the 2 Mev Van de Graaff since it is necessary to use deuteron reactions to

produce neutrons for most measurements because of the low machine energy. Most of these reactions produce large quantities of gamma rays. Some organic crystals used as fast neutron detectors produce pulses of different shape for gammas and neutrons because of the different ionization densities produced by the two radiations. Measurements at Hanford to date have used a stilbene crystal and a circuit which electronically differentiates between gamma and neutron pulses as a fast neutron detector. Stilbene, however, has a slow response and other properties which are not desirable. One vendor now markets special liquid and plastic scintillators which are also advertised to possess the properties which allow pulse shape discrimination of gammas while retaining the most desirable properties of a fast neutron detector. Quantities of these liquid and plastic scintillators have been subjected to performance tests during the month. Tests which were made on a sample of plastic scintillator showed that any pulse shape discrimination properties that this sample might possess were very slight.

Our greatest interest is in the liquid scintillator. The liquid is difficult to handle as it must be kept free of undesirable contaminants which destroy its properties and it must be deoxygenated prior to use. A cell to contain the scintillator plus auxiliary equipment to deoxygenate the liquid with argon gas and transfer the liquid into the cell was designed and fabricated. The scintillation cell was mounted on a two inch diameter 56AVP photomultiplier which is reported to have most excellent qualities as a fast pulse detector. The procedure of deoxygenation and transfer has worked quite satisfactorily. The performance tests showed that the liquid scintillator had good pulse shape discrimination properties but that the pulse height spectrum was of poor quality. This latter defect was shown to be due to the poor optical properties of the flame sprayed Al_2O_3 interior surface of the cell which is used as a reflector of light but whose properties seemed to change in contact with the liquid scintillator. Tests which are in progress using an aluminum foil as a light reflector show much improved pulse height characteristics and indicate that the liquid scintillator will be a satisfactory detector for this application.

For fast neutron total cross section measurements by time-of-flight it is planned to place the fast neutron detector in the heavily shielded room originally provided for use with the undeflected particle beam from the Van de Graaff. Designs were completed of bulk shielding which will shield the doorway to this room while allowing access to the room and which provides the flight path for the desired fast neutrons.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Lattice Parameters for High Exposure Pu-Al Fuels

Experiments are being planned which will measure the flux distributions and effective cross sections of core materials in graphite moderated, Pu-Al fueled lattices, using the PCTR. These experiments will provide check points for various computational methods which will then be used for reactor calculations on systems fueled with plutonium. These experiments will be continuations of the measurements which have been made using low exposure plutonium in aluminum.

[redacted]

The first set of elements containing high exposure plutonium have been ordered from Plutonium Metallurgy Operation. The plutonium is nominally 20.6% Pu^{240} and will be made into a 2.2 w/o Plutonium-Aluminum alloy. The alloy will be fabricated into PRTR-type rods which will be assembled into 19-rod clusters for the experiments. The criteria of maintaining $(\nu\Sigma_f)_{LX} = (\nu\Sigma_f)_{Hx}$ has been established to provide a connecting link between the Lx and Hx experiments.

The Critical Facility of the PRP

Detailed planning of the tests which will be conducted at the startup of the PRP-CF has begun. These tests can be divided into two categories, design tests and physics tests.

A series of design tests are being planned by personnel of Design Development Operation and PRP-CF Operation. These tests are of a functional nature and will determine the satisfactory operation of the facility from a design standpoint.

A series of physics tests are being planned by Nuclear Physics Research personnel and the physics personnel of the PRTR Operation. The physics tests which will be done during startup will be kept to a minimum and will be followed by experiments such as proposed in HW-67725, "Proposed Studies for the PRP Critical Facility." In general tests will be conducted during startup to determine the sensitivity of the facility and to evaluate the hazards analyses.

The physics tests will be accomplished for a reactor loading similar to Figure 1 in HW-67725. With this loading, void, temperature, and pressure coefficients, control and safety rod calibrations, moderator level sensitivity, power level calibration and the ratio β/ℓ will be determined. In addition, the effect of light water substitution in the test region of the core, the effectiveness of the poison injection system, the effect of a light water reflector and the maximum worth of a Pu-Al element will be measured.

Instruments are being designed for obtaining horizontal and vertical flux plots in the PRP-CF.

The effect on the experimental program of using aluminum cladding for PRP-CF fuel instead of Zircaloy has been investigated. The main disadvantage is the larger corrosion rate of aluminum and subsequent bubble formation on the fuel. These bubbles could change in size and quantity during a reactivity measurement and thus introduce additional error in the measurement.

Spectral Variation of $(1 + \alpha)$ for Pu^{239}

Work has continued during the month on determining the change in $(1 + \alpha)^{239}$ which occurs upon poisoning a plutonium fueled lattice in the PCTR. The detector normalizations reported last month were used in conjunction with foil activity data obtained in the 6½-inch Pu-Al lattice experiments to obtain a preliminary set of coefficients for the Maxwellian and Hurwitz spectra and absorption spectra. These first results do not appear to be realistic, and further work is in progress on the problem.

Neutron Rethermalization in a Strong Absorbing Rod

The counting data on the Lu, Cu, and Eu foils which were activated in these experiments have been processed using the IBM 7090 codes APDAC-I and Lulu. The decay corrected data shows that the counter drifts were not severe and the APDAC code has corrected the data satisfactorily. Curves of the Lu and Eu data show non-uniformities of approximately 10% due to variation in Lu and Eu concentrations in the resin matrix. Calibration of the foils in the TTR central column will be necessary to correct for this non-uniformity.

Some progress has been made in fitting the thermal activity of Cu(1/v) with the "absorption spectrum model". The best results have been obtained with an approximate analytical solution using a spatially flat source of thermal neutrons. The source actually has some spatial dependence. Work is being done using this source, as determined from traverses of the epicadmium activity of Cu^{63}.

Attempts are being made to use FIT-1 which until recently has had convergence difficulties with the "absorption spectrum model." This problem was partially resolved through the use of "self-coupling" cross sections. Study of the convergence problem and fitting of the traverses of the thermal activity of Cu is in progress.

Plutonium Fuel Temperature Coefficient

Dummy fuel rods, which have pure aluminum cores, have been delivered by Plutonium Fuels Development Operation. These rods will be used in testing the heater assembly and in determining temperature distributions throughout the 19-rod cluster during heating. They will also be used to attempt to determine the effect of the neutrons which are heated in the aluminum upon the reactivity of the PCTR, without the additional complication of fissionable material.

The low exposure fuel rods and the 16% Pu^{240} fuel rods for this experiment are being fabricated and should be available in about a week. These elements will be heated to 600°C for several hours and then tested for leaks, before being delivered by PFDO. This additional testing should insure no contamination problems during the course of these experiments.

Pu^{240} Effective Resonance Integral

Plutonium Fuels Development Operation has started fabrication of the Pu-Al rods for the Pu^{240} effective resonance integral experiment.

Specifications have been drawn up for the cadmium tube and supporting equipment which will be used in the experiment.

PuO_2-UO_2 Lattice Studies

An estimate for the construction of a PCTR core loading of PuO_2-UO_2 fuel in 19-rod clusters is being prepared by Plutonium Fuels Development Operation. Plutonium with a Pu^{240} content of about 8% will be used with depleted uranium.

The work on PuO_2-UO_2 lattice systems will supplement the work which is in progress on Pu-Al lattice systems, and increase the scope of our research effort on plutonium fueled lattices. The mixed oxide systems are somewhat more complicated than the low exposure Pu-Al systems in that additional materials are present in the lattice which have a cross section with a large amount of resonance structure.

A study is underway to determine both the amount of plutonium enrichment which shall be used and the most desirable graphite lattice spacing for the experiment.

Uranium Oxide Reactivity

Final analysis of the data collected in the PCTR in August with the 2.6 w/o enrichment, EGCR lattice has been completed. This measurement was made in order to check the results obtained in 1960 with this same lattice since the original experimental data did not appear to be internally consistent. The results, along with the previously measured values, are:

New Measurement	1960 Measurement
$k_\infty = 1.256 \pm 0.009$	$k_\infty = 1.264 \pm 0.008$
$f = 0.845 \pm 0.006$	$f = 0.850 \pm 0.005$

The lower value of f is due to an improved determination of the absorption rate in the stainless steel cladding of the outer fuel rods of the seven-rod cluster. The lower value of k_∞ is a consequence of the lower f and a correction made in the value of the 1/v flux in the copper poison. The agreement in the two measurements, in view of the above modifications, is good. The new data are considered accurate.

The error quoted in the recent measurement of k_∞ is due principally to an uncertainty in ratio of average flux in the copper poison to average flux in the fuel. This ratio was remeasured and the variation is slightly larger than expected but within the quoted error.

Copper Resonance Integral

The discrepancy between the Swedish value of the activation resonance integral of Cu^{63} (Dahlberg, et al, J.N.E. 14, 53, 1961) and the HLO value (Bennett, HW-68389) has not been resolved. Dr. Sher (BNL) has forwarded his result which is in almost perfect agreement with the Swedish result. He has further suggested that self-shielding corrections for the resonances of Cu^{63} are significant. Such corrections have not been made to the Hanford data. This point is being investigated, using the new resonance paramter data in the Supplement to BNL-325.

Critical Mass Studies

A series of critical approach measurements is being planned for 1.8 w/o Pu-Al fuel. The purpose of these experiments is to provide data for comparison of experiment with theory and for establishing basic nuclear safety parameters for

this type of fuel. The measurements will be made in the exponential tank in the reactor room of the TTR. The fuel is being prepared from PRTR rods and later will be used in the PRP-CF experiments which use light water moderator. Plastic tubes which will contain the fuel have been ordered.

Experiments will be conducted at lattice spacings of 0.75, 0.85, 0.95, 1.00, and 1.05 inches.

PRTR Startup

The final set of results and summaries of the PRTR Critical Tests has been distributed. Assistance is being given in preparing the formal presentation of the results.

High-Exposure Pu in Fast Spectrum Reactors

The use of high exposure Pu in fast reactor spectra appears to be advantageous since Pu-241 may be a more desirable fissile isotope than Pu-239, and the fissioning of Pu-240 and Pu-242 could be taken advantage of in a fast spectrum reactor.

To obtain some quantitative idea of what could be achieved by such a procedure we have made use of the diffusion calculations of Yiftah and Okrent for various Pu reactors(1) and the procedures of Greebler, Aline and Sueoka(2) to estimate power extractions from various oxide breeders.

We have selected the fast oxide breeder as one of the more promising breeder concepts. It is envisioned that such a reactor would be sodium cooled and would employ a pin-type, steel fuel element filled with a mixture of uranium oxide and plutonium oxide. Elements of this type have been subjected to radiation testing(3) and promise to result in a simple and potentially economical fuel processing cycle.

Since only very limited data were available, reactors were compared on the basis of their so-called "value," V defined by:

$$V = (\text{Breeding Ratio}) \times (\text{Specific Power})$$

This ratio, the product of power delivered per unit fuel inventory and the amount of plutonium produced per unit fuel destroyed has an important effect on power costs.

For a range of power levels from about 400 to 900 MW it was found that V increases markedly as more highly exposed Pu is used. On the other hand, V does

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(1) Yiftah, S. and D. Okrent, "Some Physics Calculations on the Performance of Large Fast Breeder Reactors," ANL-6212, December 1960.

(2) Greebler, P., P. Aline, and J. Sueoka, "Fast Oxide Breeder-Reactor Physics, Part I, Parameter Study of 300(e) MW Reactor Core," GEAP-3287, Dec. 15, 1959.

(3) [redacted] W. M., "The Fast Oxide Breeder-Fuel Irradiation Experiments," KAPL-1784, August 26, 1957.

not appear to be a strong function of reactor power level and, hence, reactor size - at least over the range examined. These conclusions could be changed if the fuel loading in the calculation of specific power were to include Pu-240 and Pu-242. In that case, for very "dirty" Pu, the specific power would drop rapidly and so would V.

To pursue this line of investigation further would require burnup studies of Pu in fast spectra and the possible recycling of this Pu into thermal spectrum reactors. It is planned at present to couple the fuel cycle code MELEAGER and the multi-group code HFN for the purpose of conducting some preliminary burnup studies.

C-6 Nuclear Data Tape

A 100-group cross section data tape for the C-6 program has been generated from the RBU basic library. During the generation of this tape, absorption and fission integrals are computed and written out with the cross section information. Some of the resulting integrals compare quite favorably with other tabulations of calculated and measured absorption integrals. A more significant check of this sort will be made upon completion of the updating of the basic library.

SPECTRUM

Improvements have been made in the input and output of the General Atomics thermal spectrum code, SPECTRUM. To facilitate preparation of data for SPECTRUM, a code has been written which will obtain cross sections from the RBU basic library and punch them in a form acceptable to SPECTRUM.

RBU

Checking of the Monte Carlo portion of the code continued using test cases. Analyses of plutonium and uranium water solutions are planned to be performed before analyzing the PRTR.

The basic library was revised and corrected for an accumulation of changes during the last few months. An improved resonance treatment for use in RBU has been completed for U-233, U-235, U-238, Pu-239, Pu-241. Also, an improved Simpson's numerical integration technique is being inserted in the input code.

MXW

Coding and debugging of the MXW code was completed during the month. The code calculates "g" and "s" factors based on a Hurwitz spectrum for the Westcott cross section notation. These factors have been obtained as a function of temperature for Xe-135, U-235 and Pu-239. The MXW code uses cross section data from the RBU library. The "g" and "s" factors may now be calculated for the MELEAGER burnup code.

SPECIFIC FUEL CYCLE

MELEAGER

Testing is now under way to find the response in the economics results to increasing Rungge-Kutta time steps. A factor 10 increases in time step limit resulted in a 40 percent reduction in time with a decrease in accuracy of 0.601 percent in minimum fuel cost. The cases run varied from 1,300 to 35,000 MWD/T exposure; longer runs would allow a greater reduction in time, but would also be more inaccurate. Work is continuing to speed up MELEAGER.

A special SETZ subroutine for MELEAGER has been written which selects an SDPV in order to give a desired k_∞. All other input is held constant. This routine may be used as a first order approximation to a "Spectral Shift Reactor." The spectral index may be shifted step-wise at any frequency during burnup. This change was made to satisfy a request from the AEC for fuel cycle analyses on the Babcock & Wilcox's Spectral Shift Reactor.

Minor additions to the MELEAGER code include a test for reactivity humping during burnup, this is essential if curves of exposure vs. enrichment are to be fixed with a polynomial then used in fuel cost calculations. The humps usually occur at low enrichment and effect the aforementioned curve so that it does not pass through the 0,0 point. The result is that for zero enrichment there is some apparent exposure, hence, nearly zero fuel cost at that point.

Another addition is an internal calculation of conversion ratio defined as follows:

$$C.R. = \frac{\Sigma_a^{28} + \Sigma_a^{40}}{\Sigma_a^{25} + \Sigma_a^{49} + \Sigma_a^{41}} = \frac{\text{Production of fissile atoms}}{\text{Destruction of fissile atoms}}$$

this may be a useful figure of merit when one wishes to recycle plutonium in a system where both density and enrichment level may be varied to produce minimum fuel cost.

WESSEX II

Correlation between MELEAGER and WESSEX II is still under way; however, programming to provide proper output for the QUICK code is continuing.

Non-Destructive Evaluation of $\nu\Sigma_f$ of a PuO_2-UO_2 PRTR Fuel Rod

The Plutonium Fuel Development Operation desires a non-destructive, routine method of determining the uniformity of PuO_2 distribution in PuO_2-UO_2 fuel rods. It is their objective to fabricate rods with a PuO_2 concentration of approximately 0.14 gm ± 5% per inch of length. The minimum acceptable precision of the non-destructive test method has tentatively been set at ± 20% of the allowable ± 5% variation in PuO_2.

It is the general opinion in Reactor Lattice Physics Operation that the most important parameter to control and evaluate is the total $\nu\Sigma_f$ of the mixture.

Preliminary evaluation of this problem has shown that relative reactivity measurements of 1 to 2 inch sections of the fuel rods could possibly meet the above specification. It has also been shown that variations in PuO_2 content will not appreciably alter the UO_2 content (PuO_2 content is 0.5% by weight) hence a reactivity or fission product activity method would yield the variation in PuO_2.

Static and dynamic reactivity methods are being considered for testing a U^{235} mockup rod with variations in U^{235} enrichments. The static method will be evaluated first in the TTR.

The static method consists of measuring relative worths of equal segments of the fuel rod. The rod segment will be exposed to the reactor flux in a window of a cadmium tube which extends through the TTR central column, along the vertical axis. The standard operating precision of TTR (± 0.01¢) is not expected to be adequate. It is felt, however, that the addition of strong shutter control rod of the "in or out" variety will increase the precision by perhaps an order of magnitude, which should be sufficient.

If this method fails or is marginal a dynamic method will be employed which is essentially an oscillator technique. The physical arrangement is similar to that in the static method except that each segment of the rods would be exposed to the reactor periodically over a short period of time. This is expected to produce a pulsating neutron density in the system. The current from a thermal neutron monitor would be measured with a DC amplifier.

Work on the apparatus for the static method is in progress. A sample cadmium tube has been fabricated from a Zr II inner tube, a 0.040" cadmium layer, and an aluminum outer tube. The entire assembly was swaged in a single operation by PFDO and appears quite satisfactory. The sample tube will be tested for thermal neutron leaks. Further details of the evaluation of the static method are being studied at present.

Instrumentation and Systems Studies

The prototype one-megacycle scaler built for the PRCF counting channels has been on test all month with no apparent failures. Tests are continuing.

A special tritium monitor was ordered for modification and eventual use at PRTR. The tritium monitoring requirements are quite stringent considering the general gamma background level variations at PRTR. The tritium-in-air monitor will be the double ion chamber type with gamma compensation provided with one chamber. Heavy shielding will be used around the detector head to attempt to alleviate the high gamma background conditions. The problem is extremely difficult considering the situation and the requirements.

Improved methods are being sought for measuring plutonium segregation in PuO_2-UO_2 fuel rods. The gamma scanning technique previously developed has insufficient sensitivity for "production-type" use. Experimental Physics is considering a reactivity type measurement in the TTR. This may give the desired accuracy, but will likely be very slow. Other possible methods are under study.

PRTR Operations were assisted with recommendations concerning adjustment of the sensitivity of a water vapor leak detector and its application.

Fabrication of the four-transducer, ultrasonic probe assembly for measuring wall thicknesses of PRTR process tubes has been completed. The normal amount of pre-assembly checking will be required before final assembly and testing can be accomplished.

The design and fabrication of the mechanical portions of the Mark-II Gas Annulus Gauge for the PRTR will be accomplished by Structural Materials Operation with advice and electronic development support furnished by Physical Measurements. This support will include developmental testing of mockups (as required), final assembly, and final performance and calibration testing. Tests were completed demonstrating that possible errors due to coil tilting are negligible when using a pair of coils in a self-compensating arrangement. Other tests define the least acceptable spacing between coils compatible with the new mechanical design which must accommodate a coaxially inserted borescope.

Preparations are being made to measure the PRTR zero-power frequency response by noise analysis techniques. A previous attempt indicated that large extraneous noise signals were present in the recorded signal, resulting in a distorted frequency response curve. An attempt will be made to determine the origin of these extraneous signals and to devise a method of cancelling out their effects on the desired signal. The ion chamber preamplifier circuit was changed to allow operation of the ion chamber shell at ground potential. It is expected that this change will reduce extraneous pickup and make the chamber shell insulation problem easier. In addition, the linearity of the tape recorder mechanism and the bandpass and gain characteristics of the Krohn-Hite filter have been carefully checked. The recorder is linear to within the accuracy of the available measuring instruments (better than 1%) over the input range of ± one volt. The filter was found to have a variation in center-frequency gain near the high end of each range but the percentage bandwidth was very uniform. This effect had been noticed before and corrected for, empirically. An accurate correction factor is difficult to obtain at low frequencies because of the time required to obtain accurate frequency response characteristics for a large number of dial settings. However, an approximate correction factor has been determined at a number of frequencies.

The PRTR deaerator problem was essentially finished with issuance of Systems Research Memorandum 61-31. Startup difficulties are most likely due to the low operating level of the water control valve. The most important parameter in the system is the time constant of the steam control valve. Further improvements would most likely demand additional information and possible improvements in the steam control valve.

The PRTR Critical Facility has been simulated several times on the analog computers. In each case, additional runs designed to gain further information on the hazards have been made and satisfactorily completed. Initially, the assumption was made that, due to the extreme rapidity of the power transients, it was not necessary to include the effect of heat transfer to the moderator. However, the G. E. Technical Hazards Council has requested that new analog runs be made including this effect. Work is now proceeding to develop the necessary heat transfer equations.

PHOENIX FUEL

ARMF-MTR Experiments with Plutonium Fuel

Studies to obtain Pu-Al samples which contain a uniform dispersion of boron have continued. The current attempt has not been evaluated. When uniform samples are available, they will be used to determine the sensitivity of the ARMF to nonfissionable material.

A special sample has been prepared to accept various foils. This sample will be used to study the neutron spectrum in a fuel sample in the ARMF.

The first irradiation in the MTR is nearly completed and the reactivity measurements in the ARMF are scheduled for the first part of October. These measurements will be compared with other measurements made in the ARMF for the same sample but for different exposure times in the MTR.

Use of Phoenix Fuel for Compact Power Reactors

The investigation of the possible use of Phoenix fuel for compact, water moderated power reactors is continuing. A series of MELEAGER calculations have been performed for U-235 - B-10 systems, U-235 - recycle Pu systems and Pu-239 - Pu-240 systems. Some tentative conclusions might be drawn at this time:

1. The use of highly recycled Pu - that is a plutonium mix rich in Pu-240 - does not seem to solve the problem of reactivity mismatches in long-endurance, high power density compact reactors. Such reactors require high initial k_∞ and, hence, U-235 must be added to offset the poisoning effects of Pu-240. The resulting reactivity-time behavior of such cores is very similar to that of U-235, unshielded B-10 systems characterized by pronounced reactivity mismatches.

2. The possibility of using Pu-239, Pu-240 systems with relatively low Pu-240 content does seem promising from a nuclear viewpoint, and would seem to warrant further investigation. Such systems display a very favorable (i.e., flat) reactivity behavior with time and it would appear that they offer an alternative to the use of fully enriched uranium, self-shielded burnable poison systems.

NEUTRON FLUX MONITORS

An interim report is being prepared concerning progress to date and experimental testing methods planned. Comparisons were made of both 1/v and non-1/v detectors with considerable effort devoted to the plutonium nuclide Phoenix detector using various $Pu^{239-240-241}$ composition ratios. Investigations, calculations, and computer studies were also made concerning analysis of the characteristics of the various detectors, and various optimal compositions were determined for several in-core locations such as in the graphite and in water cooling tubes.

Preparations were made for the irradiation testing of various plutonium nuclide foils and quartz ampules containing plutonium nuclide compositions. Foil and ampule fabrication was started, and arrangements were made with Plutonium

Metallurgy personnel for calibration and irradiation damage measurements. The various methods being considered and tested for plutonium foil fabrication include: 1) PuO_2 surface fused to a zirconium disk with an intermediate zirconium alloy layer; 2) Precipitation onto a base metal of plutonium oxalate with PuO_2 formation by hydrogen sintering; 3) Electrophoretic coating of PuO_2 on a suitable base material; and 4) Coating of PuO_2-wax mixture onto metal and baking. The actual foil fabrication will be done by Plutonium Fuels Development Operation, who also formulated the fabrication methods.

Calculations and computer studies to date indicate that, for the same exposure conditions such as flux density, spectrum hardness, and graphite temperature, the $Pu^{239-240}$ Phoenix detector method will have from five to ten times the useful life of a pure U^{235} detector.

With the delivery of ordered equipment, active development was initiated on several possible microwave techniques for in-core neutron flux monitors. The principal objective was to determine if these might lead to a rugged in-reactor system suitable for use at high temperature in a high flux. Experimental and theoretical limitations of the present equipment are being found and the expected effects are being calculated. The lowest power reliably detectable with the present 26.5-40 Gc(kMc) equipment is about 10^{-6} watts. If the detector is used as a mixer (e.g., mixing 60 Mc as an i.f. frequency), the sensitivity may be increased to 10^{-12} to 10^{-14} watt.

Microwave detection of neutrons is based either on ionization or a nuclear reaction in a gas in the waveguide. Ionization is equivalent to a change in the dielectric constant. This may be looked for through a change in attenuation, reflection, phase angle, polarization in a magnetic field, noise, or through a MASER effect. Nuclear effects are manifested as a change in molecular mass or production of a new nuclide. These may be measurable with microwave spectroscopy, electron paramagnetic resonance (EPR), or MASER techniques.

Some of the possible measurements were mocked up for estimates of the expected effects. It appears that the present detector will be marginal in some applications, so higher sensitivity mixer equipment is being designed.

NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

A series of measurements made with the equipment assembled for checking the theory of the proposed multiple parameter eddy current device for detecting small individual parameter excursions revealed the need for several equipment modifications. These have been made and additional measurements are in progress. Means are being explored to take into account the effect of the nonlinear relationships between parameter values and eddy current signal components, with the objective of extending the range over which parameters may be identified.

The measurements of orthogonal components of the signal as a function of simulating circuit resistance values gave anomalous results which were found to be caused by variations in the inductances of the plug-in resistors being used. New resistors in the one-to-eight-ohm range have been made having low and nearly equal inductance values. Additional controls were added in the balance circuits

to obtain a finer null so that greater sensitivity can be used. Drift of the 100 kilocycle Wien bridge oscillator caused undesired variations in measurement. This oscillator has now been stabilized by synchronizing it with a quartz crystal controlled oscillator.

The present work is planned to result in the development of an instrument which will identify several eddy current test parameters which have small excursions from initial or nominal values. The range of parameter excursions which can be handled in typical test situations will be determined experimentally. In the proposed equipment, this range will be limited due to the known nonlinear relationships existing between general parameter variations and the eddy current test signals. Several proposed methods to partially compensate for the effect of these nonlinearities are under study.

Heat Transfer Testing

A new 40-kilowatt plasma arc jet heat source for use in heat transfer testing fuel elements has been installed in the 314 Building Physical Testing Laboratory. An improved flame control unit consisting of a water-cooled, solenoid-operated, copper shutter has been installed and tested. The newly developed heat transfer mapping system has been rigidly mounted in a cabinet for field application, and the recorder used in this system has been connected to the fuel element scanning lathe. Heat transfer maps of fuel elements containing known defects appeared satisfactory.

Heat transfer testing of AlSi bonded fuel elements in an attempt to detect brittle bonds has been requested by the Fuels Preparation Department. Also, approximately 50 selected ultrasonic reject fuel elements are to be heat transfer tested in an attempt to differentiate between those having voids or separated bonds, and those having non-wets or fractured bonds in close contact. This information will be of value in process optimization studies. It will be possible to provide limited heat transfer testing services concurrently with further development of the test.

Zirconium Hydride Detection

An eddy current method using balanced probes to detect localized differences in hydride concentrations in Zircaloy-2 by detecting local differences in resistivity was attempted. Although differences between resistivities of Zircaloy-2, aluminum, brass, and steel were readily detected, the equipment was not sensitive enough to detect the resistivity difference between Zircaloy-2 samples containing 50 and 15,000 ppm(weight) hydrogen. Previous measurements by an a-c potential probe method indicated the resistivities of these two samples to be 73.2 and 81.6 micro-ohm-cm, respectively.

An informal report, Resistivity Variations in Zircaloy-2 for Low Hydrogen Concentrations, HW-70977, by W. G. Magnuson, has been issued.

Ultrasonic attenuation tests are being made by Testing Methods, FPD, on Zircaloy-2 samples containing various amounts of hydride. Frequencies of 20, 25, and 60 Mc were used in the initial tests. However, no attenuation has yet been detected.

Several mechanisms can cause ultrasonic attenuation. Background scattering, which generally increases with increasing frequencies, is caused by nearly all discontinuities in the metal. In addition, peaks in vibration absorption can occur at certain oscillation frequencies due to grain boundary absorption, twin boundaries, atomic diffusion, dislocation movement, thermal current generation, and dynamic hysteresis due to a combination of non-linearity of the stress-strain curve of some metals, and dislocation movement. Although helpful conclusions can be made by examination of the theory, actual conditions under which these absorption peaks will occur are not readily calculable. Therefore, an attempt to ultrasonically analyze Zircaloy-2 samples over a wide range of frequencies is under way.

Calculations indicate that the frequency at which maximum absorption of vibrational energy due to hydrogen diffusion in Zircaloy-2 occurs should vary over a wide range when the temperature is changed from -129°C to + 25°C. On this basis, some investigation on the effect of changing temperature on ultrasonic attenuation appears worthwhile.

USAEC/AECL COOPERATIVE PROGRAM

Nondestructive Testing of Sheath Tubing

Design work on the mechanical apparatus for experimental ultrasonic work is complete. The part which will clamp and rotate flat and curved plates has been received. The remainder of this device will be sent off site for fabrication. A HAPO production testing tank was obtained for some experimental work with tubing. Though accurate ultrasonic measurements are difficult when using this tank, experiments can be made which will be indicative of trends during the time that other, more precise equipment is being fabricated. The production tank transducer holder was modified to incorporate a commercial crystal manipulator which allows more freedom for mechanical alignment.

The production testing tank discussed above was used to conduct initial studies to determine the ultrasonic effects of width variations that may occur in prepared notch type discontinuities. Longitudinal notches were electro-machined in the O.D. and I.D. surfaces of a 0.680-inch-I.D. Zircaloy-2 sheath tube. The notches were about three mils deep and about 120 mils long, and had widths ranging from about two mils to about 17 mils. The ultrasonic test was aligned by the longitudinal test procedure described in Physical Testing Memorandum 61-8. As the procedure describes, equal signals were obtained from one set of nearly equal-sized I.D. and O.D. notches. In this case the tester was aligned using the two-mil-wide notches as a reference case with which the wider O.D. and I.D. notch signals were compared. The signals obtained from all notches were identical in amplitude within ± 10 percent of the average. The differences that occurred did not appear to be a function of notch widths.

Preliminary work indicates the Immerscope will be capable of driving two crystals in parallel with little or no loss in gain. Laboratory test equipment which will be used to evaluate the ultrasonic and electronic limitations of the Immerscope is being checked against primary frequency, amplitude, and other standards. This work is about 50 percent complete. Evaluation tests will be conducted according to I.R.E. standards wherever applicable.

Some mechanical equipment which will be used to evaluate the response variations of crystals has been obtained. Accurate mechanical positioning will be provided by machinist lathe compound rests now on order. Reproducibility of mechanical positioning should be better than plus or minus one-half mil.

PHYSICAL RESEARCH - 05 PROGRAM

Mechanism of Graphite Damage

A new measurement of the energy loss in thin specimens of material was completed. Calorimetric equipment was used that was thought to be an improvement over previous equipment. The results, however, were not as good as those obtained previously. A possible reason for this is heat leakage up the drift tube of the electron Van de Graaff.

BIOLOGY AND MEDICINE - 06 PROGRAM

Atmospheric Physics

Analysis of measurements obtained during atmospheric diffusion field trials continued. Data accumulated from 28 field tests in 1959 and 15 in 1960 at Hanford and 23 tests conducted off-site at Cape Canaveral, Florida, in 1961 in most ways have similar characteristics, but differ significantly in some of the diffusion properties. All of the experiments were conducted using the Hanford Fluorescent Tracer Technique with the source located near ground level. In a statistical sense, data from the two Hanford series are samples obtained from the same population. This is true in spite of the fact that data from the second series (1960) included measurements in six experiments conducted during unstable daytime conditions, whereas the earlier 1959 series comprised only stable experiments. The independent sample (1960) in a sense verified the earlier estimates of dosage and plume growth observed in 1959, and supports the finding that neither dosage nor plume growth are simply related to atmospheric thermal stability.

Data from the Cape Canaveral tests differ from the Hanford data in two major respects. First, the peak exposure at any point downwind is more simply related to atmospheric stability, showing a reduction in peak exposure as the stability decreases. Secondly, the maximum exposure decreases more rapidly with distance and the average horizontal growth of the plume is greater than at Hanford.

Assembly of all data obtained during the first series of diffusion experiments at Vandenberg Air Force Base, California, neared completion. Determinations of the mass of zinc sulfide tracer material were completed for all of the 52 field releases. Careful editing of the data tabulations for pertinent remarks to identify samples affected by topography, trees, built-up areas, and construction activity as valid, required nearly the full month of effort. Samples affected by operating failure were also identified. At month end, all data were being key-punched in preparation for calculating the first four moments of the arcwise mass distribution, the modal value along the arc, and the position of the mode, utilizing the IBM 7090 computer. Copies of the counting sheets and field records were forwarded to the Air Force Geophysics Research Laboratories.

In work on atmospheric tracer technology, comparison was made between the particle size distributions of various lots of zinc sulfide tracer material received from the manufacturer. The size distributions for three lots are summarized in the following table:

PARTICLE SIZE DISTRIBUTION OF FLUORESCENT PIGMENT

Cumulative percent less than (microns)	Lot Number			
	1	2		3
.93	5.6	12.3	6.6	11.0
1.86	23.8	46.6	40.8	43.9
2.64	52.4	73.2	71.4	70.8
3.73	83.8	92.0	91.4	91.6
5.27	95.0	98.2	98.0	97.8
7.46	98.8	99.8	99.7	99.3

Although 95 percent of the pigment particles for all lots are less than 5.27 microns, the question arises as to how differences in size distribution might affect the calibration of the Rankin Counters. Lot 1 shows a slightly larger distribution than Lots 2 and 3. Since some 20 months elapsed between the sizing of Lots 1 and 2, the size distribution of Lot 1 will be redone with the techniques used for Lots 2 and 3, to see if the distributions are truly different.

Dosimetry

Studies continued of the in vivo detection of P-32 bremsstrahlung with the counter placed over the head. The results were better than when counting over the chest but were still not satisfactory. It was found that about half the counts received over the head were due to radiation from outside the body that was reflected into the counter from the head. This makes the results dependent on head size.

The carriage for moving the whole body counter when used in scanning measurements was altered so that the counter now makes two parallel scans slightly displaced from one another. The object of this was to reduce dependence on subject width. Preliminary tests indicate the technique will be successful.

Other activities in whole body counting included: A chain drive was attached to the bed in the shadow shield so it could be motor driven. A subject known to have a body burden of plutonium and who was counted two years ago was counted again and the continued presence of Am-241 in his body was confirmed. Radiation Protection Operation and Instrument Maintenance personnel were assisted in dealing with difficulties with the tape punch at the whole body counter.

The positive ion Van de Graaff operated satisfactorily during the month. Annual and semi-annual maintenance was started. With the help of a factory representative the multichannel analyzer was put back in operation after

more than three months of faulty operation. Apparatus was completed that permits use of twice as many BF_3 counters in the large moderator.

Studies of target contamination continued. Time-of-flight studies with a deuterium-titanium target showed the presence of carbon contamination. A gas target was installed on the accelerator. Time-of-flight studies showed no contamination of this target. The foil window of the target ruptured at a beam current of 5 microamperes. Better foils are being sought.

The new automatic source and instrument positioner began to yield results. The double moderator was used to obtain measurements indicative that the average energy of neutrons coming from the end of the source have higher average energy than neutrons coming from the side. The statistical accuracy obtainable with the new position led to the removal of a discrepancy between some neutron source calibrations by the National Bureau of Standards and by our own long counter work.

A slight lack of reproducibility was found in certain precision long counter measurements. It was first suspected that the addition of the grating floor in the accelerator laboratory might have increased the number of scattered neutrons. This was shown not to be the case. Indirect comparisons with other BF_3 counter tubes indicate that the tube in the counter may be at fault. Another precision long counter was completed. It will be used in intercomparisons with other laboratories.

The calorimetric measurement of the half life of Sb-124 is in progress. The estimated uncertainty in our measurements is already less than any quoted in the literature but will be still further reduced as we continue our measurements.

Radiation Instruments

The complete prototype experimental alpha coincident-count air monitor operated correctly for the month after one minor high voltage supply change and after minor discriminator level adjustments to provide better balancing and uniform airborne plutonium sensitivity under very high background (radon-thoron) conditions. The system remains in operation, and test data are being obtained to accurately determine the true performance characteristics. Essentially, this project is nearly complete with only final evaluation testing remaining.

The experimental work on a combination transistor and tunnel diode pulse height analyzer circuit was completed and all tests were satisfactory. A report was prepared concerning the circuit.

Experimental fabrication was started on two more of the pocket-size ionization-chamber register-indicating dosimeters. The register-indicating unit and the alternate type, which employs an ion (pencil) chamber with an illuminated-fiber, CdS-cell light detector, temperature compensation, and a transistorized amplifier and annunciator circuit, were both successfully demonstrated to HLO, IPD, and CPD personnel during the month.

Several more experimental units of both types will be fabricated, with care taken to insure proper ionization chamber response by judicious assembly, and with a strong effort to further miniaturize both types. Careful cost estimates of both types indicate that, in lots of 200 fabricated offsite, the cost per unit will be about $125 each, and in lots of 1000, the unit cost should be less than $100 for either type. The register-indicating unit is easily adapted to the proposed telemetry system with all dose information radioed back to a central receiving location for recording purposes. Since the information in the personally carried unit is already in the form of accumulated dose, the telemetry system can be relatively simple and no elaborate integrators need be used at the central receiving-recording station. In addition, at any time desired, the alarming-type model can be read out on a standard HAPO pulse-type charger-reader.

These two types of dosimeters are potentially much less expensive per man monitored than are dose-rate type instruments such as a portable C-P which must telemeter the dose rate information for integration at a central station. As another point of interest, any standard type "pencil" ionization chamber can be easily adapted for use in either the register-indicating or selectable alarm dosimeters. Gamma pencil dosimeters are available with ranges from 0-200 mr up to 0-600 r. Such a coverage should satisfy all HAPO needs, even including disaster monitoring. A report was issued on the selectable alarm level dosimeter, and a report was started on the register indicating dosimeter.

The experimental prototype background suppression beta-gamma combined hand and shoe monitor, clothing monitor, and background recording system operated successfully for the month in the 105-D Building. Field personnel acceptance of the unit seemed to be excellent. The unit, of the scintillation transistorized type, will be moved to Purex for the next demonstration. Other than for minor front-panel changes for data presentation as desired by IPD personnel, no modifications seem to be necessary.

Both experimental prototype scintillation transistorized building-area monitors with both logarithmic and multi-decade linear ranges continued to perform satisfactorily. One unit was simply and easily adapted, by a change of scintillator, to experimental use as a reactor poison spline checker at 105-D, and the second remains as a regular building dose-rate monitor. A third unit will be fabricated to incorporate special alarming and range features as desired by IPD personnel for building monitoring.

Efforts to improve energy dependence characteristics of the CaF_2:Mn thermoluminescent dosimeters continued. In addition, a number of tests were made using LiF dosimeter material. The observed peak reading for the LiF unit occurred at a much lower temperature (inductively heated to cause readout via light emission) than for CaF_2:Mn. A theoretical model was formulated to explain the observed reduced fading, or loss of dose information with time, for the LiF type.

The Automatic Film Badge Densitometer, modified and redesigned considerably for Radiation Protection Operation, operated most of the month. Several marginal diodes were replaced by higher peak inverse voltage units for better reliability. In addition, at the request of RPO, a zero suppression network was installed to simplify output reading. The IBM drum contacts continue to

require periodic readjustment. Basically, the system is nearly ready for routine operation.

Extensive effort was made during the month on modifications to the Atmospheric Physics Radiotelemetry System. A new type of wind-driven battery charger was ordered to replace all of the original units which proved to be unsatisfactory and unreliable.

Two experimental prototype "palm size" alpha monitors, using solid state surface barrier diode detectors and a transistorized, highly audible annunciator circuit, were completed and are being tested. These will be quite useful at the glove box lines in the 234-5 Building and other similar locations.

Fourteen more experimental silicon surface barrier diode detectors of various sizes were completed and regular tests commenced. Initial tests indicate excellent performance on all units with a very high forward-to-reverse current ratio. Plans were formulated to start using some of the units, in cooperation with Radiological Physics personnel, for neutron dosimetry investigations. In addition, several commercial diodes, of both surface-barrier and diffused-junction types, with boron, lithium, and uranium coatings were ordered for the same work.

A completely transistorized circuit, including the highly audible annunicator, was supplied to RPO for use in a simple, easily maintained, portable scintillation alpha Poppy. The new circuitry will replace the obsolete vacuum tube circuitry used in 90 such units since 1954. The old model is the standard HAPO Scintillation Portable Poppy. The transistorized version, although costing more per unit, should have lower maintenance costs because of the considerably lower battery replacement costs.

Because certain 234-5 Building operations require the use of air-proportional alpha detector probes, due to contamination problems associated with probe repair costs, a new completely transistorized circuit, using an amplifier and an audible annunciator, was developed for direct use with the alpha air-proportional probes. The audio signal can be distinctly heard under extremely high ambient noise conditions. The experimental unit has operated, without sensitivity change, for one continuous month without any necessity for probe or circuit adjustments of any kind. This performance is markedly superior to the present HAPO Vacuum Tube Cart Poppies which must be frequently adjusted because of either probe voltage breakdown or complete loss of response. One prototype unit is now being fabricated for direct field test use at the 234-5 Building.

Investigations continued concerning a special 4π beta scintillation detection system for Biology and on some miniature freezer units (Peltier effect) to be used with the Biology Microtome unit.

Experimental noise suppression work for use with low energy photon and X-ray detection continued with the development of a combined clipper inverter circuit for testing.

Other semiconductor circuitry development and testing work included a fast discriminator circuit and a start on a logarithmic response pulse amplifier. Considerable design work remains to be done.

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Work continued on the spectrum data storage system for the Whole Body Counter. The read/write circuits for the LFE magnetic storage disc were developed and are being fabricated. A test of the circuits included the reading and writing alternately of thirty billion bits of information with no dropouts. This test simulated (except for aging effects) about six years' operation in the intended installation.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis

The results of several uranium standards analyses made last month indicated a change in the systematic bias of the ion detection system of the mass spectrometer for this program. A series of analyses were performed on uranium standard samples which indicate a zero bias for samples containing up to 50 atom percent 235. Because of the time lost in processing the necessary standard samples the analysis of program samples was about 50 percent of goal schedules.

Four operating days were used for instrument repair and maintenance.

Two uranium samples were isotopically analyzed for FPD.

TEST REACTOR OPERATIONS

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

A series of experiments designed to allow theoretical analysis of the PCTR technique was completed. This work was done by D. D. Lanning, a consultant on the staff of the Massachusetts Institute of Technology.

A preliminary experiment to investigate flux spectrum matching in the test core was completed. The technique compares reactivities when different cells are removed instead of irradiating foils. Its advantages are in increased speed in presentation of data and in reduced radiation exposure.

The effectiveness of poison splines was investigated in a $7\frac{1}{2}$-inch graphite lattice.

The measurement of k_∞ and other parameters of tube-in-tube fuel in a 14-inch graphite lattice was begun.

There was a three-day scheduled outage for maintenance items. Installation of the coarse face position indicator equipment was nearly completed as was installation of the equipment to reactivate the rear face inner leveling slug drive system.

Operation of the TTR was limited to three sets of foil irradiations. There was one unscheduled shutdown caused by instrument failure.

CUSTOMER WORK

Weather Forecasting and Meteorological Service

Consultation service was rendered on meteorological and climatological aspects of 1) NPR emergency systems, 2) expected arrival time of fallout from Russian weapons tests, 3) freezing of large water storage tanks, 4) plant emergency procedures, and 5) NPR Safeguards analysis. Wind direction and speed frequency distributions at the meteorology tower were prepared for the period 1951 through 1959.

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	86.6
24-Hour General	60	88.0
Special	145	84.1

Temperatures during the past month averaged below normal for the first time since May. There was no measurable precipitation. A high wind with gusts to 50 mph blew on the 28th. However, it lacked the intense dust which accompanied the storm in the Tri-City area.

Instrumentation and Systems Studies

Tests on the Columbia River Radiation Monitor show that controlling the probe temperature with water cooling does not provide sufficient stability for use at the low (0-50 microroentgens/hour) dose rate levels being monitored. Day-to-night temperature fluctuations are still reflected by the chart recorder. Recommendations have been made to replace the present current measuring system with a more stable pulse-type count-rate-meter system. This will also require a larger terphenyl-in-polyvinyltoluene detector.

The experimental rechargeable battery Field Analyzer Instrument, designed for Biology for field use and Project Chariot in Alaska, was completed in all minor modifications and was tested satisfactorily. It is scheduled for delivery shortly.

Two experimental prototype portable transistorized G.M. instruments with both count-rate-meter and audible annunciator circuits were completed by the 328 Building Electronics Shop. Tests are scheduled after which the units will be given to RPO to prepare drawings and specifications so that a number may be purchased for plant portable-instrument "pool" use.

The combined alpha and beta-gamma air monitor, designed specifically for use in the Cell Exhaust system of the 325-A Building, operated correctly for the month. A report is being prepared.

Most of the alpha and beta-gamma scintillation probes and a number of the transistorized circuits for the Automatic-Conveyor System Laundry Monitor, designed for the Laundry Operation, HLO, have been satisfactorily checked. Of the detection and circuitry portions, only the rest of the fabrication and general system assembly remain to be done. Special mechanical load and unload assemblies are being fabricated for the conveyor portion, and in addition, the complete electrical control chassis was fabricated and satisfac[redacted]ested.

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Fabrication was completed on two prototype "palm-size" alpha monitors, using solid state alpha detectors and transistorized circuitry, for Finished Products Chemical Technology, CPD.

A work order was received from Fuels Development Operation for development and fabrication of an instrument to punch on paper tape the readings of a device which automatically measures the dimensions of NPR fuel elements. The readout system will comprise a digital shaft encoder connected to the present penumatic servo chart recorder, a decoding matrix to translate the encoder closures to a Friden eight-channel code, and a sequencing network to effect the punching of the three-digit numbers on paper tape. The tape will be punched in a code compatible with the tape-to-tape converting equipment at the 713 Building computing facility.

Calibration of micro-displacement readout systems to be used by Physical Metallurgy Operation for in-reactor creep measurements has continued during September. The readout system for the third generation (0.030 inch) transducers was received the latter part of the month, and the actual calibration of these transducers is expected to begin early in October, and should be completed about six weeks later. The calibration data for the second generation transducer (three-range) has been given to Operations Research and Synthesis for statistical analysis.

Installation of the hydrogen detectors on the 333 Building autoclaves was completed in June. At that time there was some doubt that the hydrogen monitoring system would detect a fuel element rupture. No information, other than calculations, was available as to the background hydrogen concentration in the autoclaves. A recent fuel element rupture has demonstrated the system satisfactorily. Although on this occasion the autoclave was not full, a very large increase in hydrogen emission after the rupture indicated detection in a full autoclave will not be difficult.

The completed prototype model of the Panellit-Heise gage readout device has been delivered to the Contract and Accounting Operation. Revised requirements by the Data Processing Operation necessitated changes to the circuitry to provide beginning-of-record, beginning-of-field and end-of-tape characters on the punched tape. Changes in the location of the correction symbol also required wiring alterations. The device will be tested by Office Procedures Operation in the 700 Area and then sent to 100-DR Area for use by operations.

Optics

The Mark II corner radius measuring microscope for CPD was fabricated and tested. The unit gives a fine image of the corners of a groove and illuminates the groove corner with the required fine line of light. It has been necessary to redesign and refabricate the nose piece in order to bring the line of light into the center of the field of view at the proper object distance. This new nose piece will be ready for testing within the next week.

The groove depth microscope has been delivered to Finished Products Technology, CPD. It will be used to measure and inspect shallow grooves approximately 0.010 inch deep in weapons components. A contour of the groove is

obtained by optical sectioning. Features of the contour can be measured with an absolute precision of at least 100 microinches. These features may be machine tool chatter marks, inclusions, scratches, burrs, or dirt. The unit was demonstrated to the customer and was enthusiastically received. An appropriate manipulator is now being designed by the customer so that the components being inspected may be properly positioned in the field of view.

Revisions in the design of the NPR periscopes which satisfy all comments have been completed. The specifications of the portable periscope have been revised to correspond to the new design.

A total of 456 man hours of shop work was performed during the four-week period (September 3 to October 1) included in this report. The work included:

1. Final assembly of the corner radius measuring microscope for Finished Products Operation.
2. Evaporation of gold on silicon diodes.
3. Evaporation of lithium fluoride on tantalum targets for Health Physics.
4. Modification of a theodolite for use in optical traverses for Maintenance Engineering Operation, IPD.
5. Fabrication of right angle eyepieces for radiometers in 303 Bldg.
6. Servicing of 105-DR basin viewer.
7. Complete cleanup and regasketing of the shop vacuum system.
8. Fabrication of six glass bearings for CPD.
9. Cutting six silicon and three germanium resistivity specimens.
10. Miscellaneous fabrication of small quartz components for dilatometer apparatus, furnace windows, etc.

Physical Testing

Testing work was sustained at a high level with tubular components receiving major emphasis. A total of 10,944 tests were made on 9,633 items, totaling 140,028 feet in length. The greater part of this footage consisted of NPR reactor pressure tubing.

Test work included: autoclaving; borescoping; dimensional measurements (micrometric); eddy current; magnetic particle; penetrant (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, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements). Work was done for 32 organizational components representing most of the operating departments and service organizations at HAPO. Advice was given on 39 different occasions on general testing theory and applications.

Work proceeded routinely on the remaining NPR pressure tubes. In line with new reactor schedules, completion date for testing and treatment of the tubes has been extended from October 15 to December 1, 1961. Provided the remaining tubes on the order are shipped on schedule, there should be no difficulty in meeting this new deadline.

Of the 33 spare PRTR pressure tubes being tested, pre-autoclave testing has been completed on all tubes, eleven have been pickled and autoclaved, an

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additional 18 are ready for pickling and autoclaving, and four are held for further conditioning work before releasing for pickling and autoclaving. Evaluation has not been completed on all of the eleven autoclaved tubes, but so far one is acceptable and one will have to be locally conditioned and re-autoclaved due to a handling mar after autoclaving. The post-autoclaving tests will be completed immediately after autoclave film evaluation of the remaining tubes has been finished.

An additional five tubes are being tested for the rupture loop facility. These pressure tubes are similar to the regular PRTR tube except that the reduction to the small diameter is accomplished by utilizing a relatively short reducer section instead of the gradual taper. The rather marked reduction will cause a restriction in the pickling process and will require a flushing adapter on the existing NPR pickling hoist. Arrangements are currently being made with Kaiser Engineers for installing the adapter and doing the pickling and autoclaving as they have on the spare PRTR tubes.

Field radiography utilizing X-ray and gamma-ray equipment was conducted at 1706-KER, 105-KE, PRTR, and 277 West Shops. Radiography of instrument leads, coils, and welder coupons for 100-N area is proceeding routinely. An ultrasonic thickness measurement survey of pressure vessels has been started in 200 East, 200 West, 100-F, and White Bluffs. Completion of the 105-C reactor strain gauge project has been scheduled for the next outage; all gages and instrumentation are in place for making the test. The fluorescent penetrant examination of over-bore nozzles has become rather spasmodic, requiring examination of only 50 to 100 nozzles every time a B, D, or F reactor has an outage.

Fuel element sheath tube testing is proceeding routinely at a rate in excess of 200 tubes per week. Over 1,000 tubes were tested in the past month. Tube shipments remain spasmodic and are creating scheduling problems. Opportunity is being taken, where new tubes are not available, to work off the backlog of tubes to be ultrasonically tested. This test is not required on the order to the vendor, and by agreement is left until last on the work Physical Testing does. About 100 tubes per week are being ultrasonically tested under current conditions.

Considerable assistance has been rendered to the NPR project on a variety of jobs: effect of heat treatment on pipe markings; evaluation of titanium welding; and impact testing.

Arrangements have been made to conduct all 300 Area pressure vessel survey work involving ultrasonic wall thickness measurements.

The infrared heat transfer test system installation has been completed in the 314 Building, and operational tests have proven to be successful. A sizable number of experimental elements will be tested shortly. In-reactor creep transducer evaluation has been re-initiated upon receipt of new transducers.

Ceramic fuel testing activity increased significantly: 304 Zircaloy-4 clad UO_2 fuel rods were processed through radiography and O.D. penetrant tests on a fairly tight schedule; a special request was also completed to radiograph 2,600 feet (10% of total contract) of 0.070-inch-O.D. Zircaloy-4 wire to

determine structural integrity. On the zirconium wire, negotiation for contract completion will be based on the results of the radiographic tests.

Steady progress was maintained on the radiography of the welds for the non-isothermal loop being constructed for HLO.

An evaluation was made of a boiler tube failure for the 300 Area power plant. Analysis disclosed a thermal fatigue failure that can be corrected by replacement of two fittings.

The new Parker fitting probe assembly was completed, and successful detection of prepared discontinuities was demonstrated. The specially-mounted transducers received for this application were tuned using series inductance and shunt resistance to improve performance at lower pulse voltages. The lower voltage is a necessary requirement for the new-type crystal used. The crystal material is lead metaniobate ceramic. Previously these crystals have been operated at the full Immerscope voltage, which is about twice as great as is recommended. The completed assembly has been made available for reactor rear face testing. It is anticipated field trials will be performed at the next reactor outage.

ANALOG COMPUTER FACILITY OPERATION

Studies

The major analog computer problems considered during September include:

1. Reactor Speed-of-Control
2. Reactor VSR Withdrawal Rate
3. NPR Secondary Loop
4. Reactor Control
5. PRTR Critical Facility

Equipment Operation

Computer operations were as follows:

GEDA	EASE	
105	102	Hours of Computer Use
15	32	Hours of Unscheduled Downtime
35	42	Hours of Scheduled Downtime
21	0	Hours Idle
176	176	Total Hours

INSTRUMENT EVALUATION

Gain stability versus temperature variation evaluation tests were made on an RCL Model 20506 linear, transistorized pulse amplifier. The amplifier gain changed -1.3% from 50°F to 110°F; however, it changed -7.0% from 80°F to 130°F. Further tests indicated that acceptable performance could be obtained from only 70°F to about 105°F. For line voltage variations, the gain change was only -0.6% from 115 VAC to 100 VAC.

The evaluation tests on one type of rechargeable Ni-Cd battery for possible HAPO portable instrument use are essentially completed. Tests were run through 43 charge-discharge cycles with satisfactory results. One or more typical portable instruments will be equipped with the units for field tests.

Most evaluation testing was completed on the first model inexpensive ($10) detector which uses a miniature CdS cell plus small organic scintillator for high level dose-rate detection. With appropriate ranging and readout instruments, several hundred feet from the detector, gamma dose rates from less than 5 r/hr to exceeding 10^4 r/hr can easily be determined. All decade ranges within the limits stated are linear. This unit should be especially useful for disaster monitoring. Other minor development and design effort may be necessary for packaging and fabrication.

Tests were made to prove that a reduction of chamber size of the high range (upper range 0-5000 r/hr) TP portable instruments improved, to acceptability, the upper range linearity. The 50 units are now ready for regular field use. Other tests indicated that a dose rate at the chamber of 30,000 r/hr held the meter pointer firmly off scale on all ranges.

Most of the minor changes necessary were completed on the 30 Model II Scintran units fabricated by GE-APED. No major troubles occurred; however, there were five or six minor changes to be made on each unit.

Acceptance Test Procedures Forms were prepared concerning one-hundred 0-600 r self-indicating pencil dosimeters.

Assistance to Biology regarded procuring proper blueprints for the Scintillation Alpha Transistorized Hand and Shoe Counter.

Purchase specifications, test instrument information, and general acceptance data were prepared for Radiological Development and Calibrations, RPO, concerning a planned order for 30 portable transistorized BF_3 neutron monitor instruments.

Paul F. Gast

Manager
PHYSICS AND INSTRUMENT RESEARCH
AND DEVELOPMENT

PF Gast:mcs

CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Reactor Effluent Water Studies

Repeated laboratory tests of removal of tracer arsenate from water by high aluminum flocculation treatment show that 95 percent is removed. Subsequent flocculations on the same water sample show removals of 77, 21, and 4 percent, respectively. These data contrast sharply with reactor process water treatment findings where the high alum process results in little or no removal of arsenic-76-producing parent material. The laboratory tests would indicate that good removals are possible and beneficial results should be achieved from repeated additions of the flocculating agent. Studies are continuing to determine why process water treatment does not result in the removals expected from laboratory findings.

A possible means of reducing the formation of radioisotopes in the reactor tubes is the "poisoning" of the tube and slug surfaces to reduce parent material adsorption. Small scale laboratory tests of twenty salt solutions have shown that some reduction in adsorption capacity (as much as a factor of four) is obtainable. The two most effective salts tested were sodium iodide and sodium chloride. These salts and others which are found to be effective will be tested for their duration of effectiveness and later in reactor tubes.

Three parts-per-million of the complexing agent, EDTA, were added continuously to the cooling water of a chemically decontaminated reactor tube to test its effect on reducing the adsorbability of the radioisotope parent materials. No practical beneficial effect was observed with this agent. A second test with monobasic ammonium phosphate as the agent has been started.

Reduction of Reactor Effluent Contamination

The removal of neptunium from solution by local soils was studied by means of laboratory equilibrium and soil column experiments. The adsorption capacity of soil for neptunium at trace concentrations (10^{-5} M) was increased from 0.025 millimoles/100 g of soil to 0.045 millimoles/100 g of soil when the temperature was increased from 69 to 90 C. This corresponds to soil column capacities at 50 percent breakthrough of 40 and 75 column volumes, respectively.

In studies of the chemical form of neptunium in aqueous wastes it was found that neptunium is strongly adsorbed by sodium-base cation exchange resin and not adsorbed by nitrate-base anion exchange resin within the pH range from 3.6 to 9.6. These results indicate that neptunium is associated with a positive charge, probably as a cation. Dialysis experiments tended to confirm the ionic form of neptunium within the above pH range.

The assembled automatic As-76 monitor was placed in continuous operation on a sampling line from the inlet of the 107-F retention basin. Background tests and counter

efficiency measurements gave satisfactory results. Although the As-76 channel background was higher than anticipated, the background-subtract circuitry held the net background to a low-level relative to anticipated net As-76 counting rates. Some indicated improvements were incorporated as a result of this preliminary on-line experience.

Uranium Oxidation and Fission Product Volatilization Studies

Two fission product release experiments were made using uranium irradiated to about 1300 MWD/T. In both tests, 92 percent of the 11.7 g specimens was oxidized in 24 minutes at 1200 C in air. This is 13 percent greater oxidation than that measured for trace level irradiated (2×10^{14} nvt) uranium. Some of this increase can be attributed to surface roughening during irradiation, but it seems unlikely that this would be significant above the melting point of uranium. These two test results continued the upward slope of the curve of oxidation versus irradiation level obtained from previous work at intermediate irradiation levels.

The rate of release of xenon was measured by gamma scanning the refrigerated charcoal trap during the heating period. The temperature was brought to 1200 C rapidly (600 C per minute). At 1000 C xenon was first detected in the charcoal trap and two minutes later the maximum counting rate was attained. Allowing for some lag time for sweeping the xenon into the trap, it appears that xenon was released as a burst when the uranium melted. This contrasts with trace level tests where xenon continued to be released throughout the test.

The rate of release of cesium was measured by gamma scanning the Millipore filter. Cesium was first detected at a temperature of 680 C, with the maximum counting rate attained 8.5 minutes later. The release was approximately linear during this time.

Recovery of Uranium from Milling Solution

The current process for chemical milling of uranium in NPR fuel element fabrication produces a solution approximating 6 M H_2SO_4 - 0.35 M $CuSO_4$ - 0.2 to 0.4 M HNO_3 - < 0.35 M $UO_2(NO_3)_2$. At higher uranium concentration, the milling rate is too low. Either part or all of the uranium must be removed or the solution discarded. A means of removing the uranium without making the solution unfit for further milling use was sought. Survey experiments showed that uranium can be extracted from the solution with either TBP - Shell Spray Base or D2EHPA-TBP-Shell Spray Base extractants; higher distribution coefficients (E_a^o) were obtained with the latter. The highest uranium distribution ratio obtained in experiments exploring the effects of D2EHPA concentration and solvent loading was 8.2. This was obtained with a solvent composition 1.1 M D2EHPA - 0.2 M TSP - SSB and an organic/aqueous volume ratio of one. Under these conditions, 88 percent of the uranium present in an aqueous initially 0.35 M in uranium was removed in a single batch contact. Some nitric acid but very little, if any, copper or sulfate is extracted along with the uranium.

Neither water nor dilute (0.1 M) nitric acid was effective in stripping uranium from the D2EHPA - TBP - SSB solvent. Sodium carbonate solution is an effective stripping agent. Uranium distribution ratios (E_a^o) of 0.104, 0.0504, and 0.0116 were obtained for one, two, and three molar sodium carbonate, respectively.

The data indicate a successful batch contact flowsheet could be devised. It would involve one extraction contact, one or two stripping contacts, and one contact to recondition the solvent for a succeeding cycle. Recovery of uranium from the sodium carbonate strip solutions would be by precipitation of sodium diuranate.

SEPARATIONS PROCESSES

Disposal to the Ground

Temperature profiles were obtained in monitoring wells near ground disposal sites to assist with predictions of the flow path of thermally warm wastes. Several wells were logged in the process of testing an improved thermistor probe. In a well near the 216-A-6 crib a temperature at the water table as high as 60 C was measured.

Diluent Evaluation - Soltrol 170

Samples from four tank car loads of Soltrol 170 now in use in a Purex Plant test of Soltrol 170 as diluent were evaluated by the "use test" previously described. They were compared to a previously tested sample of Soltrol 170 as well as to a sample of Shell E-2342 from a lot recently used in the Purex plant. The tests indicate that the four car loads of Soltrol 170 are of uniform quality as measured by the "use test" and that, after chemical degradation, the behavior of this Soltrol 170 toward fission product extraction and retention is the same as Soltrol 170 previously tested.

Resin Column Forces

A strain gage weighing system has been developed for use in a fundamental study of resin stresses and the transmission of forces in resin beds under varying static and dynamic countercurrent flow conditions. The weighing system consists of a strain gage pressure transducer modified for use as a load cell. The laboratory mockup of the system makes use of a rigid counterbalanced beam pivoted at the center with a weight pan at one end of the beam. Multiplication or attenuation of the applied force can be accomplished by varying the relative positions of the load cell and the applied force along the beam (variation of mechanical advantage). Repeatability of the system is about ± 1 percent, and it has linear response.

WASTE TREATMENT

Batch Calcination

Investigations were initiated to define and possibly improve heat transfer into the calcine pot during the boildown step in batch calcination to increase the boil-off rates and thereby shorten the overall time cycle.

A 2-ft. high, 4-1/4 in. diameter draft tube was placed in a 6-inch diameter by 3-ft. high pot. The diameter of the draft tube was such that the cross sectional areas inside and outside of the draft tube were equal. The boiling action induces circulation of the liquid through the submerged draft tube. When boiling water, the heat flux was increased by the presence of the draft tube, and the improvement varied directly with the furnace temperature.

Sludge Sampling by Core Drilling

A rotary core drill proposed for sampling sludge in the 241-A-103 underground storage tank is currently being cold tested on such materials as plaster of Paris, calcined synthetic wastes, and dried sodium nitrate. The plaster of Paris was successfully cored with a soft steel bit using minimum bit loading (50-75 lb.), low speeds (40 rev/min.) and air or water bit flushing fluid. However, coring of

the calcined waste was unsuccessful under similar conditions. Drill tests will continue in an effort to develop a "universal" technique, since the sludge waste tank properties may vary widely.

Instrumentation for Waste Storage Tank Bottom Detection

Two methods for determining the proximity to, or actual contact with, the bottom of a waste storage tank are being investigated. The first method makes use of an air core inductance coil which changes inductance as it approaches a metal due to the generation of eddy currents in the metal. A coil wound for this purpose is sensitive to mild steel at distances of 0 to 16 inches in air and 0 to 8 inches in water. Tests in simulated waste solutions and at temperatures to about 170 C indicate that the coil should respond reasonably well in detecting the approach of the mild steel tank bottom.

The second method being investigated will signal contact with the tank bottom by ohmmeter detection of the increased electrical conductivity between the sediment core drill and the tank bottom. Electrical connection to the rotating drill will be made through a slip ring and the other connection will be made to the metallic tank liner.

Waste Solidification by Submerged Combustion

Operation of the submerged combustion equipment continued intermittently during the month concentrating sodium carbonate solution. Difficulties encountered in the burner ignition system prevented fully satisfactory operation. An initially 4 M sodium carbonate solution was concentrated to approximately 8 M at which point the tank contents on cooling partially solidified to a "rigid slush." Further concentration is planned. In other aspects, operation of the system was uneventful with combustion product gases maintained at 675 to 700 C to control entrainment.

Corrosion During Submerged Combustion

The test simulating submerged combustion of Purex organic wash waste was continued with a total aqueous carbonate concentration of three molar. No significant change in liquid or vapor phase corrosion of mild steel was observed as a result of the increased carbonate concentration (earlier part of test was at two molar carbonate). The test has been discontinued. Physical properties of concrete test blocks also exposed during the test are being determined.

Mineral Reactions

Adsorption methods for decontamination of low-level wastes received further experimental study. The adsorption of trace concentration of strontium and cesium from dilute nitric acid systems (0.005 to 0.11 M) was determined in equilibrium experiments with clinoptilolite and IR-120 resin. The results indicate that the resin is capable of adsorbing strontium from nearly 300 times as much waste as is clinoptilolite. On the other hand, clinoptilolite is capable of adsorbing cesium from 60 to 70 times as much waste as is the resin. Thus, decontamination of dilute nitric acid wastes can probably be best accomplished by beds of the two materials in series. In these experiments it was determined that the measured equilibrium distribution coefficients are in reasonable agreement with those predicted from the law of mass action, indicating the possibility of extrapolating the results to wastes with different concentrations of accompanying ion providing the solutions remain dilute.

[redacted]

Considerable difficulty with equilibrium experiments with clinoptilolite was experienced because of a fine suspension that forms during the mixing step of the experiment. The effect is only significant at low salt concentrations. Mass action calculations indicate that previous measurements of cesium K_d for clinoptilolite in dilute ammonia systems were lower than would be predicted, probably as a result of a colloidal suspension.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Hot Semiworks Strontium-90 Recovery

The fourth and final run of the current HLO strontium-90 recovery program is in progress at month's end. In addition to the primary objective of recovering strontium, the secondary objective of the run was to explore the technology required to recover a pure cerium and a cerium-free promethium (rare earth) product by using solvent extraction. Four steps or cycles were involved to ascertain the feasibility of recoveries.

Conditions for the first cycle were selected to isolate the desired fission products from the inerts in the feed stock and to partition these fission products into strontium-rich and rare-earth-rich product streams. Strontium, cerium and rare earths were extracted into 0.47 M D2EHPA - 0.2 M TBP solvent from a citric acid buffered and complexed system containing only enough EDTA to complex iron. The strontium was stripped into 1 M citric acid for a later feed to a second cycle solvent extraction and the rare earths in the solvent were batch stripped into dilute nitric acid.

The second cycle was designed to further purify the strontium. The strontium-rich stream was butted with DTPA (diethylene triamine penta-acetic acid) for cerium complexing, then extracted, and subsequently stripped with dilute nitric acid.

The objective of the third cycle was to segregate cerium and a promethium-rich rare earth fraction. The rare earth by-product from the first cycle was oxidized with 0.1 M $KMnO_4$ and the cerium(IV) batch extracted into 0.4 M D2EHPA solvent. The MnO_2 and excess $KMnO_4$ were "killed" with citric acid, and the phases were immediately separated. The solvent phase was then batch contacted with 0.3 M H_2O_2 and 0.7 M HNO_3 to reduce and strip cerium.

The remaining aqueous from the cerium oxidation step was prepared for a fourth cycle rare earth purification by buffering with citric acid and adjusting to a pH of 2.8. The promethium (rare earths), calcium, and manganese were extracted with solvent followed by a partition of the rare earths from the divalent ions by stripping with a buffered DTPA solution at a pH of 4 to 5.

Analytical information adequate for determining material balances, product quantities and qualities is not yet available.

Strontium Carbonate Filtration

Laboratory bench scale studies were made to determine whether the filtration characteristics of a strontium carbonate slurry would be affected adversely if the compound were precipitated from a solution containing up to 4 M ammonium ion concentration. No adverse effects were noted in solutions of 0.25 M strontium nitrate and one to four molar in ammonium salts.

Other Fission Product Development Studies

Preparation of Cerium-Free Rare Earth Fraction by Solvent Extraction - Further testing of various modifications to the flowsheet proposed for Hot Semiworks preparation of a cerium-free rare earth fraction was done. These generally involved determination of pertinent distribution ratios under proposed operating conditions in preparation for and during the run. All indications were that the proposed procedure should result in satisfactory recovery of strontium and separation of cerium from other rare earths.

Performance of the cerium oxidation and extraction procedure with unused solvent was compared to that with nitric-acid-washed HSW solvent. No significant differences were noted. Performance of the process was impaired when the initial aqueous phase contained an appreciable amount of citrate (which would occur in the event of entrainment of aqueous in organic phase in the 1B Column). Permanganate added to oxidize cerium was reduced more rapidly than in the absence of citrate, and the subsequent extraction of cerium was markedly reduced.

Further study of the possibility of D2EHPA solvent extraction separation of cerium and promethium without oxidation of cerium indicates little promise for the procedure. Calculations based on batch contact data indicate that, if both elements are initially in an organic phase, a cerium decontamination factor of only four could be expected by stripping promethium with DTPA as the complexing agent. Similarly, if both elements are initially in an aqueous phase, cerium could be extracted away from promethium, but promethium losses would be high.

Technetium Recovery - Purex Waste Supernate Studies - The recovery of technetium-99 from alkaline Purex waste supernate was successfully demonstrated on a large scale in the A-Cell ion-exchange equipment, confirming and extending the results of earlier small-scale work as reported in HW-66738. One of the two-inch diameter columns was filled to a depth of eight feet with Amberlite IRA-401 anion resin and 103-A tank supernate was pumped through the column at the as-received pH of 9.9 without addition of reagents or any pre-treatment other than removal of solids (by centrifugation at Purex). Loading was at ambient cell temperature (30-35 C) and at a flow rate of 6.1 ml/min. cm^2. Fifty percent breakthrough was not reached until 448 liters of feed (almost 100 column volumes) had been processed. The column was then water washed and the technetium eluted with 8 M HNO_3 at a flow rate of 1.4 ml/min. cm^2. Elution was very sharp (much more so than in the small-scale experiments) with essentially all of the technetium eluting in only two column volumes of acid.

Four grams of technetium were recovered, for an overall recovery of 80 percent. Concentration factor (feed to product) was 30. Decontamination from cesium (the principal activity in the supernate) was complete, and the decontamination factors from ruthenium and zirconium-niobium were 57 and 67, respectively. Although these correspond to only 0.056 curies of ruthenium and 0.23 curies of zirconium-niobium per gram of technetium (the specific activity of technetium is 0.017 curies/gram), additional decontamination will be required before the technetium can be handled in unshielded equipment. Additional concentration would also be desirable. Both can probably be achieved by a second cycle of ion-exchange.

A second run was in progress at month end to determine whether a lower feed flow rate (about half that used in the first run) will increase capacity and whether a dilute acid wash, prior to elution, will improve zirconium-niobium decontamination.

Supporting laboratory studies showed that IRA-401 is slightly superior to Dowex 1 X 7-1/2 and much superior to Permutit SK (from the standpoint of high technetium distribution coefficients). Equilibrium is achieved quite rapidly with all three resins, 95 percent of equilibrium being achieved in only five minutes with either IRA-401 or Dowex 1. Permutit SK was somewhat slower. From these experiments, IRA-401 is definitely to be preferred. The effect of pH on technetium absorption was also measured. The distribution coefficient onto IRA-401 (from synthetic supernate) was not a very sensitive function of pH, but did tend to increase with pH - from a value of about 190 at pH 6 to 320 at pH 10 and to a value of 510 with 3 M excess NaOH.

Precipitation from Purex 1WW - The experiments reported last month on the recovery of cesium from highly acid solutions were extended to synthetic 1WW. Excellent removal of cesium was achieved, the fraction precipitated ranging from 90 to > 99 percent. Best recovery was with highly acid solutions; partial neutralization with caustic reduced the cesium recovery obtainable. The effects of sodium and potassium ions were also investigated. Mole ratios of four for ammonium and 80 for potassium had little effect, but higher mole ratios reduced cesium carrying significantly.

Technetium in Redox and Purex Product - A series of samples of Redox and Purex uranium product collected during the month of June have now been analyzed for technetium content. Technetium in the Redox uranium varied from 0.7 to 2 percent (average 1.1) of the technetium in the plant feed; the Purex product contained 6-1/2 to 22 percent (average 9.4) of the original feed content. Samples of supernate from the Redox waste storage tanks were found to contain most of the Redox technetium, equivalent to about 12 Kg per tank. A program is continuing to assay additional samples, not only of product but also of in-plant streams.

Solvent Extraction Studies - Ten candidate extractants for cesium were screened during the month; however, only one (dipicrylamine) showed appreciable cesium extraction. Promising extraction coefficients (E_a^o) of 4.1 and 2.2 for 0.025 M and 0.015 M dipicrylamine (in nitrobenzene) were obtained from 103-A supernate. From solutions of lower salt content, extraction coefficients were as high as 527. Extraction is favored by high pH and stripping by low pH. Further experiments will be made with dipicrylamine and related compounds.

Another finding was that tetraphenyl boron is soluble in the Semiworks solvent (0.4 M D2EHPA, 0.2 M TBP, Shell Spray Base) and that this solution will extract cesium.

Promethium Recovery

Two additional B-Cell runs (Nos. 18 and 19) aimed at further testing the recommended peroxyacetate flowsheet and relating precipitate decomposition to radiation intensity were completed. Using standard precipitation conditions (16 volumes of 3 M H_2O_2 per 100 volumes of feed) the time for radiolysis of the precipitate appeared to vary inversely with the radiation level. Thus, the precipitate in run No. 18 (0.3 watts/liter) required about 24 hours for complete dissolution while only eight hours were required in run No. 19 (0.9 watts/liter). A third run (No. 20) was slanted toward recovery of pure cerium, rather than pure promethium. No analytical data are available from this run.

Bulk Fission Product Packaging - In pursuit of multi-product bulk packaging capability in the proposed packaging system, calculations were made on canister modifications and capacities for potential products. With minor modifications, the nominal 4.5-inch diameter by 18-inch long canister can accommodate 22,000, 18,000, 395,000 or 15,000 curies of strontium-90, cerium-144, promethium-147, or cesium-137, respectively, with an arbitrarily selected canister surface temperature of 200 F in ambient air at 100 F.

Fabrication of developmental canisters was completed and design of the loading station is 95 percent complete. A water-cooled, split-block connector was designed and tested for positioning the induction heating work coil. The unit permits side loading of the work piece into split, induction heating work coils.

Shipping Cask Design Verification - Both the HAPO I and II cask designs employ Wood's metal expansion absorption tubes fabricated from partially flattened stainless steel tubes. These tubes are intended to absorb the Wood's metal's growth on aging after solidification and thus limit the stress placed upon the cask internals. Tubes prepared from flattened 3/4-inch, 1-inch and 1-1/4 inch OD tubes were isostatically compressed to determine conditions for permanent set and volumetric absorption versus pressure prior to yield. These data have been transmitted to interested parties. In general, the performance exceeds design requirements.

Shipping Cask Closures - Continued testing of "bell-ring" stainless steel gaskets indicates that the gaskets fail (leakage rates > 1 x 10^{-5} cc He/sec) during cooling from test conditions of 500 psig and 500 C. Modifications to the gaskets are being sought in an effort to obtain resistance to thermal cycling.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Technetium Analytical Method

The radiochemical determination of technetium-99 in the presence of other fission products is rendered difficult by the low specific activity of technetium (2 x 10^5 year half-life) and the fact that it is a very soft beta emitter. The problem is further complicated by the chemical similarity of technetium and ruthenium, both of which form anionic complexes. A quantitative method was developed (in support of the above hot-cell runs) which should be applicable to all Hanford separations plant samples.

The basis of the method is oxidation (and precipitation) of ruthenium in basic solution with solid argentic oxide (AgO), followed by passage through a Dowex 50 column to remove zirconium and other cations. The technetium is finally absorbed on a column of Dowex 1, washed, and eluted with 8 M HNO_3 for mounting and beta counting. The procedure can be repeated if additional decontamination is required. Details are given in a methods report, HW-71152.

Scintillating Glasses

Experimental studies on the use of glass scintillators as alpha detectors have been concluded with a study of the effects of scintillator thickness employing cerium-activated Vycor, which absorbs its own scintillations. Reduction of thickness yielded the expected increase in relative alpha to beta sensitivity, but the variation of alpha sensitivity with thickness was not as expected. Reduction of thickness from 80 to 50 to 20 mils resulted in smaller than expected increases in sensitivity

and further reduction to 10 mils resulted in a sensitivity decrease. Since 10 mils exceeds the alpha range, this sensitivity decrease is attributed to non-optimum cerium concentration near the scintillator-backing plate interface.

EQUIPMENT AND MATERIALS

Hydraulic Equipment

The submerged Hastelloy-C Chempump which is a candidate for canyon service was inspected. Maximum wear of the inboard journal was from 0.5 to 4 mils (lightly bell-shaped end). Other critical parts were worn less than 0.5 mil although some scored lines of the bearings approached 2 mils in depth. The pump had been run for 2000 hours with 50 C water. Life testing has been resumed.

A Gould canned rotor pump has operated for 3700 hours with no significant increase in bearing diameters. The pump is handling 50 C water and life test continues.

A special submerged Chempump, which has been proposed for recovery of cesium from tank farm supernates, has operated smoothly for 150 hours pumping 8 M sodium nitrate. Bearings are lubricated by fresh tap water. Lubrication water has been varied from 1.2 gpm to as low as 0.5 gpm with no noticeable effects. (This may be contradicted after physical inspection.) The test run has been plagued by leaks of the lucite hydroclone and currently the 3-inch clone is being replaced by three parallel smaller units originally designed for model CF Chempumps. During test runs with the 3-inch clone, separation of particulate matter (sand) was adequate only for particles larger than 40 to 60 microns.

Corrosion Studies

Role of Chromium in Nitric Acid Corrosion of Stainless Steel - The study of chromium oxidation state under conditions pertinent to Purex process concentrators was continued. Basic solution concerned was 10 M HNO_3 - 0.01 M chromium. Variables studied were salt content (UNH-$NaNO_3$), temperature, minor constituents (iron, sulfate), condenser efficiency and addition of NO_2 and urea as reductants. From these and previous studies, two methods for maintaining chromium in the (III) state during boiling of nitric acid solutions appear promising. These are (1) reduce any Cr(VI) to Cr(III) with hydroxylamine prior to entry of the solution into the concentrator and bleed NO_2 into the concentrator condenser, or (2) as in (1) except add urea, rather than NO_2.

Purex Demineralized Water Tank - Corrosive attack on the interior walls of the Purex plant aluminum (type unknown) demineralized water tank is characterized by tuberculations or "barnacles" on the interior tank walls. Pits, a few as deep as 1/8 to 3/16 inch, are present beneath these barnacles. The attack appears to be associated with scratches and grinding marks. The last time the tank walls were cleaned. a metallic scraper was used. Galvanic corrosion due to breaking the oxide film or inclusion of dissimilar metal particles from the scraping operation is suggested as the source of the localized attack observed. The tank will be scraped with a non-metallic material and returned to service.

Effect of Cold Working on Corrosion of 304-L in 65 Percent HNO_3 - Exposure of cold worked 304-L stainless steel coupons to boiling 65 percent HNO_3, as described in the August monthly report, was continued to a total of 485 hours (10 test periods). There was still no significant effect of cold working (up to 60 percent after annealing) on the corrosion rates.

Huey Tests on Tubes from Failed 100 Percent UNH Concentrator - Huey tests have been performed on samples from 30 tubes taken from the failed 100 percent UNH concentrator. Corrosion rates observed were 2 - 5 mils/mo on six samples, 5 - 10 on 20, 10 - 15 on one, 15 - 20 on two, and over 20 on one. All tube samples which showed high rates also showed preferential attack on the inside surface. By comparison, standard sensitized 304-L corroded at a rate of 1.4 mils/mo.

Corrosion of Titanium in Fluoride-Containing Purex 1WW - Short-term tests to define the effect of the various constituents in fluoride-containing Purex 1WW were continued. These tests continue to show that both iron and phosphate contribute to reducing the corrosion of titanium in these solutions. Tests aimed at determining the role of chromium are difficult to interpret because of changes in the oxidation state of chromium.

Non-Metallic Materials

Samples of TSX Reactor grade graphite (N-reactor), a product of Union Carbide Corporation, were evaluated for chemical compatibility in bearing service as a replacement for CSGBF graphite which is no longer available. No significant change in the TSX graphite was noted after 10 days in boiling 60 percent nitric acid. The material appears satisfactory for process lubricated bearing service.

PROCESS CONTROL DEVELOPMENT

Recuplex Solvent Extraction Control System

Preliminary tests of the basic concepts of the proposed Recuplex solvent extraction efficiency and capacity control systems have indicated that these concepts are feasible. Capacity control is achieved through column density control and column efficiency through the control of concentration at a given point in the column. It is anticipated that column efficiency control will require additional measurements and computing devices to compensate for changes in pulse frequency, pulse amplitude and feed concentration changes.

A series of runs are being made at constant column density at a number of pulse frequencies with and without concentration control to determine the effects on efficiency as measured by column waste losses.

C-Column Test Facility Instrumentation

The statistical analysis of the data taken during calibration of the 1CF-flowmeter has been completed. A model of the following form was found to fit the data within the experimental accuracy:

$$F = (a + bU)\,[c + \log\,(V - V_o + d)]$$

where

F is the flowrate of the 1CF organic uranium feed
U is the concentration of uranium in the feed
V is the voltage measured by the Data Logger from the pneumatic to voltage transducer
V_o is the voltage at zero flowrate
a, b, c, d are the parameters evaluated by the statistical analysis

the standard deviation of the data about the model is 28 ml/min for flowrates from 600 to 4,000 ml/min.

Two turbine-type flow meters were installed in the C-column test facility, one in the aqueous 1CX stream and the other in the organic 1CF stream. The two meters will be calibrated and compared with the presently installed pneumatic transmitting rotameters over extended period. If these meters prove to be reliable, they will be incorporated in an all-electronic flow control system for the test facility.

The single beam 1CF photometer was removed from service during the month and will be remodeled into a split beam instrument. The modified instrument will utilize a single light path through the sample cell, a beam splitter, two fixed optical filters, two miniature phototubes, and two micro-micro ammeters. The sensing unit will be water cooled to minimize sample cell temperature effects and phototube dark current drift. The concentration indication will automatically be calculated from the two output currents. The remodeled instrument will be installed on the 1CU stream, and it will be evaluated for reliability by a comparison with the 1CU concentration as indicated by the mid-column photometer.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Studies of $PbCl_2$-KCl Systems - Analysis of time-lapse photographs of UO_2 crystals growing through one millimeter diameter holes in a quartz shroud surrounding the cathode has been performed. The analysis confirmed conclusions which had been reached from visual observations. Some of these are:

1. All of the identifiable crystal faces (110, 100 and 111) grow at approximately the same rate, at least in the latter stages of growth.

2. As would be expected, the crystal angles do not change measurably during growth.

3. The crystals reaching the shroud were sufficiently small that several progressed through each hole in the shroud.

4. Many crystals branched quite rapidly immediately after growing through the holes.

5. Once this initial branching ceased, no branching occurred during the remainder of the run (perhaps as much as 95 percent of the run). In fact, there is some evidence of fusion (the elimination of crystal boundaries) in the latter stages of the run.

Additional evidence for the elimination of crystal boundaries as UO_2 growth progresses was obtained by metallographic examination of a section of a UO_2 deposit. When the specimen was examined prior to etching or after a light etch, a definite polycrystallinity was observed near the cathode but, as the distance from the cathode increased, evidence of grain boundaries rapidly disappeared. Severe etching, however, did bring out lines which resemble grain boundaries. Because of the severe nature of the etch necessary to show these lines, it is felt, however, that they cannot represent discontinuities as marked as grain boundaries.

Chronopotentiometric Studies - Chronopotentiometry continues to be a useful tool in studying the species present in molten salt solutions. It has been used to demonstrate the presence of "moisture" in melts and to determine the effectiveness of various methods of removing the "moisture" from the melts.

The conversion of uranyl chloride to uranium(IV) chloride during an HCl sparge of molten salt solutions was shown by chronopotentiometric means. These experiments were performed at 710 C in NaCl-KCl containing about 0.1 weight percent total uranium.

Solubilities of Cl_2 and HCl in Molten Salts - The solubilities of these gases were measured by saturating the molten salt with the test gas, removing the gas present in the lines and vapor space with a brief helium purge, flushing the dissolved gas into an absorbing solution, and then titrating the absorbing solution to determine the amount of gas dissolved. The results are summarized in the following table:

Salt System (Mole Ratios)	Approx. Melting Point	Temp. (°C)	Solubility (ppm) Cl_2	Solubility (ppm) HCl
KCl-NaCl (1:1)	667	800	63	50
		700	53	79
KCl-$MgCl_2$ (3:2)	450	600	35	101
		500	28	135
KCl-$PbCl_2$ (2.5:1)	585	700	20	--
		600	14	--

Of special interest are the observations that Cl_2 solubility increased with increasing temperature in each of the melts studied and that Cl_2 solubility was lower in 2.5 KCl-$PbCl_2$ than in KCl-NaCl or 3KCl-2$MgCl_2$. It was also observed that the period of time required to completely remove the dissolved Cl_2 or HCl by helium sparging was considerably greater in 3KCl-2$MgCl_2$ than in the other melts. Some degree of bonding between both Cl_2 and HCl with $MgCl_2$ is thus implied.

Uranium(IV) Behavior in Low-Temperature Melts - Solutions of uranium(IV) were prepared in various low-melting melt systems by dissolving UO_2 with HCl. The UO_2 dissolved more rapidly in LiCl-KCl melts than in $MgCl_2$-KCl melts at 600 C. The visual appearances of the melts after dissolution of the UO_2 were not the same even though the uranium(IV) concentrations were equivalent, suggesting that the predominant uranium(IV) species is not the same in these two melts.

Upon completion of UO_2 dissolution, the melts were sparged with air and rates of uranium(IV) oxidation were determined. At 600 C the rate was first order with respect to uranium(IV) concentration but at 700 C the rate was zero order in uranium(IV) concentration. The rate of oxidation at 700 C was about twice as great in $MgCl_2$-1.5 KCl as in LiCl-1.5 KCl, again suggesting a difference in the predominant uranium(IV) species existing in these melts.

X-Ray Diffraction Studies: UO_2 Lattice Parameters - Considerable interest in determining the lattice dimensions of various UO_2 crystals has been expressed by Ceramic Fuel Development Operation personnel. Lattice parameters may be affected by the Dynapak Process for the compaction of UO_2 and by irradiation of UO_2, especially at high temperatures.

A technique has been developed for the relatively rapid determination of UO_2 lattice parameters. In this technique, an X-ray spectrometer is employed instead of the commonly used precision back-reflection camera. An internal standard (ThO_2 was found to be best) is employed to eliminate errors due to absorption effects or sample misalignment. Use of this technique allows determination of UO_2 lattice parameters in only about 45 minutes total operator time, about 1/4 the time required by the precision camera method. Lattice constants have been determined to a precision at least as good as ± 0.002 Å, which is sufficient for many purposes although poorer than the ± 0.0001 Å precision attainable with the precision camera. Refinements in the spectrometer technique may allow attainment of precision nearly as good as that attainable with the precision camera.

In the O/U ratio range studied thus far (2.00 to 2.17), a good correlation was found to exist between lattice constant and O/U ratio in arc-fused and in electrodeposited UO_2, but not in micronized UO_2, which produced diffraction peaks distorted in shape. A sample of Dynapacked UO_2 was so largely amorphous that the diffraction peaks were too weak to discern their centers. The precision of ± 0.002 Å in determining the lattice constant yields a precision in O/U ratio of ± 0.013.

Engineering Development - Three large batches of $\overline{UO_2}$ (258 lb. total) produced in the nominal 80 liter $PbCl_2$-2.5 KCl salt melt have had high O/U ratios (2.04 - 2.14), presumably due to electrolysis with an air atmosphere and/or incomplete drying of the melt before electrolysis. The product has been mace-shaped crystals, associated in laboratory studies with high O/U ratios and wet melts. To lower the O/U ratio, a run was made in which most of the air was excluded from the vapor space above the melt. The atmosphere was then essentially chlorine evolved from the electrolysis reaction. Approximately 100 lb. of $\overline{UO_2}$ was produced with the closely packed rectangular crystal structure typical of low O/U ratios. The product O/U ratio was approximately 2.01 as determined by the streak test. Verifying analyses have not yet been obtained.

Processing PRTR Fuel Elements

In support of the program to process PRTR fuels in the Redox Plant, dissolution rates for several aluminum alloys in NaOH-$NaNO_3$ solutions were determined. Instantaneous dissolution rates for 2S aluminum, 6061T aluminum alloy and PRTR spike element alloy were 33, 33 and 22 mg/cm^2-min., respectively, in boiling 20 percent $NaNO_3$ - 10 percent NaOH solution. The dissolution rate of the 6061T alloy (to be used for PRTR shipping canisters) was 14.5 mg/cm^2-min. under initial proposed flowsheet conditions (1.58 M $NaNO_3$ - 1.61 M NaOH) for canister dissolution and averaged 11 mg/cm^2-min. over the entire dissolution cycle.

Dissolution rates for the PRTR spike element alloy (Al-Pu-Ni) were determined for dilute (0.5 - 3M) nitric acid solutions with and without 1.25 M uranyl nitrate and in the absence of mercuric salts. Instantaneous dissolution rates increased from 0.3 to 0.45 mg/cm^2-min. as nitric acid concentration was increased from 0.5 to 3.0 M. The presence of 1.25 M UNH had little or no effect on the dissolution rates.

RADIOACTIVE RESIDUE FIXATION

Mineral Reactions

An experiment with high-level Purex waste supernatant solution was conducted in a 325 Building hot cell. The experiment measured the cesium adsorption capacity of a 7-foot column of Duolite C-3 resin. The column received waste solution at a pH of about 9.9. The cesium decontamination factor for the first seven column volumes of effluent was greater than 500 and 50 percent breakthrough was reached after passage of about 13 column volumes of waste. Previous laboratory experiments indicated an improved cesium capacity of C-3 resin when excess caustic was added to the waste. Bench-scale laboratory column experiments with synthetic Purex waste were performed to evaluate the improvement that might be obtained. In laboratory tests with synthetic waste at pH 9.9, the 50 percent cesium breakthrough point was reached after passage of six column volumes. Upon repeating the experiment with a solution in which the OH^- concentration was increased to 3.1 M, the 50 percent cesium breakthrough point was not reached until passage of 190 column volumes of waste. In eluting cesium from C-3 resin it was found that only about 1/3 as much eluate is required to recover 98 percent of the cesium when 1.0 N sulfuric acid containing 1.0 N ammonium sulfate is used as the eluating agent as when 2.0 N sulfuric acid is used.

Laboratory research was completed in a study of resin particle size and column residence time relationships. The adsorption of cesium by Duolite C-3 resin was examined. From a consideration of breakthrough curves it appears that a column containing a minimum of 20 theoretical plates should be used for optimum performance. To meet this requirement with a column residence time of three minutes would require a resin grain size of less than 0.25 mm, for a residence time of six minutes would require a grain size of less than 0.5 mm, and for a residence time of 12 minutes would require a grain size of less than 0.75 mm.

Condensate Streams

Micro Pilot Plant Run 18, evaluating the decontamination ability of clinoptilolite in the hydrogen form, was completed after treating 5000 liters (20,000 column volumes) of radioactive condensate waste. The Cs-137 concentration in the effluent exceeded its MPC_w after treatment of 15,000 column volumes. The Sr-90 concentration in the effluent exceeded its MPC_w after treatment of 5400 column volumes. Amberlite IR-120 used in Run 17 treated 8800 column volumes before Cs-137 exceeded its MPC_w and the Sr-90 in the effluent never exceeded its MPC_w during the run, indicating a capacity in excess of 14,800 column volumes.

Ruthenium Tetroxide Studies

Study of the effect of temperature on decomposition of ruthenium tetroxide continued. In the temperature range 155 to 195 C, decomposition was very nearly complete; an autocatalysis on RuO_2 already deposited on the walls of the reaction chamber appeared to be the most important variable. Efforts to clean the equipment between runs revealed that the "high-temperature RuO_2" is far more resistant to dissolution than that formed at lower temperatures, an observation which has unpleasant implications for the clean-up of a "hot" calciner.

The absorption of RuO_4 on silica gel was measured from room temperature to 80 C. The measured decontamination factor was about 10^4 over the entire range, and the exit activity was so low that more reliable values could not be assigned.

In-Cell Spray Calciner

Additional components of the in-cell calciner have been received, and it will soon be possible to assemble the calciner ex-cell for cold testing. Insulation cans are currently being built and fitted to the column. The jacks, for elevating the column, have been received but will require modification since the associated gear boxes proved too large to fit into the cell. The powder valve for the bottom of the column has been completed and will be installed on the 8-inch demonstration unit for testing.

Several runs were made in the demonstration unit to determine the efficiency of the membrane filters which it is planned to use for sampling purposes in the hot-cell unit. Electron microscopy, a thermal precipitator (a dust sampling device reputed to be 100 percent effective in the sub-micron range), and a Gardner and Associates Type CN Small Particle Detector (a cloud chamber instrument) were employed for comparison purposes. Although the particles leaving the scrubber are extremely small (of the order of 0.1 micron) it was concluded that the membrane filter will work well as a sampler and that a CWS filter will be adequate for final clean-up.

BIOLOGY AND MEDICINE - 06 PROGRAM

Geology and Hydrology

A method for deducing the permeability distribution of heterogeneous soils from the observed ground water potential pattern was tested. Potential data from a region in which essentially lateral flow is assured were used for simplicity in testing. A permeability distribution pattern was developed from the isopotential contour pattern and permeabilities measured along one isopotential contour, using a linearized approximation technique. The permeability pattern was applied to the "steady flow in soils" computer program to evaluate the areal potential distribution. These computed potentials compared well with those measured in the field.

An analytical solution of the Laplace equation for saturated flow was developed for the well packer situation. With the equation it will be possible to obtain values of permeability for selected strata from in-well packer measurements.

In the "steady flow in soils" computer program, initially selected values of potential at node points in a network are successively improved by an iterative technique. Convergence is slow and long computation time is required when the initial values are poorly chosen. A program was developed to permit the use of a coarse network with few node points for rapid computation, to provide better initial values for later computation of the larger network. The program will interpolate initial values for each point in the large network required for accurate computation. The use of this technique was found to permit more rapid iterative network calculations in the cases tested.

Eight of the 16 wells on Project CAH-921 are complete; two are being drilled. About 60 percent of the estimated total footage is drilled in about 75 percent of the time allotted for project completion. Total footage drilled is about two percent over estimates to terminating formations. However, one well was 103 percent deeper than predicted, three others were 10-14 percent shallower than predicted. These four wells, adjacent to 200 East Area, showed that the knowledge of the geological structure there was not adequate for accurate predictions.

Technical assistance was provided in selection of a burial ground site for 300 Area solid waste. The site lies about 3.5 miles north and one mile west of the current site, but east of Route 4S. The land surface there is slightly higher than at the current site and the depth to ground water about the same, but the distance to the Columbia River is 3.5 miles versus 2.5 miles at a point more remote from potential exploitation of the Columbia River. Gravels at the disposal site, rather than sand as at the old site, also will simplify excavation and burial.

Soil Chemistry and Geochemistry

The effect of competing sodium and calcium on the strontium adsorption capacities of Decalso, Linde 4A zeolite, and clinoptilolite was studied. Adsorption in the presence of significant concentrations of competing ion is a measure of the adsorbent's specificity for strontium. At neutral to alkaline pH, Linde 4A zeolite was the most strontium selective of the materials studied. Acidic conditions caused the physical degradation of Linde 4A and Decalso. Of the three, clinoptilolite showed the best acid-resistance, and hence had the greatest strontium adsorption capacity at low pH. Some organic cation exchange resins, such as IR-120, are superior to clinoptilolite, however, for strontium adsorption in the acid region.

Field Apparatus Development

The thermistor temperature probe was adapted for use with the Widco well logger after considerable difficulty with undesirable voltage signals and water leakage in a connector. The troubles were corrected, and continuous temperature logging with the improved equipment is now possible.

An improved pulse detector system for in-well gamma scintillation monitoring was checked for stability over the anticipated temperature range and found to be stable. A pre-amplifier and voltage dividing network were fabricated for the scintillation probe to permit its use with the detector system and the logger.

A redesigned power unit permitted satisfactory operation of the vertical flow meter using the wire line and reel of the Widco logger. A somewhat greater zero shift with this cable system than that experienced with the breadboard model was attributed to small stray voltages introduced when the armored shield of the wire line contacted the well wall. In proving tests, vertical well currents were measured in two wells and compared with earlier measurements. Vertical currents up to 200 cc/min - 140 cc/min were found in two other wells, not measured previously. The estimated sensitivity of this device is about ± 30 cc/min in the 8-inch well, a value somewhat higher than earlier achieved using the breadboard model.

Scandium-46 Procedure

A procedure was developed for the determination of Sc-46 in reactor effluent and river waters which is simple, rapid and which does not require a lengthy decay period to remove interferences. The Sc-46 is removed from the water sample made 0.5 N in nitric acid by adsorption on a column packed with glass beads coated with tri-n-octylphosphine oxide (TOPO). The Sc-46 is eluted from the column with alcohol and counted by gamma spectrometry. Small percentages of Cr-51, Cu-64 and Np-239 are also removed but do not interfere when the measurement is made on the 2.0 mev gamma addition peak in a well crystal counter. The yield is greater than 90 percent.

Promethium-147 Bioassay Procedure

A bioassay procedure for Pm-147 for individuals exposed to the long-lived rare earths has been developed. The procedure is a modification of our present RE-TTA extraction method and provides a detection limit of about 5 d/m/sample (99 percent confidence level) for a 30 minute count on a low background beta counter. The procedure involves the use of Pr as a carrier which causes a 50 percent reduction in the final counting rate due to self absorbing of the weak (0-23 mev max) beta in the carrier. The use of Ce and Sc as carrier (which can be removed in the extraction step) are being tried. If successful, they would improve the sensitivity by 50 percent. The procedure as developed is rapid--2 - 3 hours total.

W. H. Reas

Manager
Chemical Research and Development

WH Reas:cf

BIOLOGY LABORATORY

A. ORGANIZATION AND PERSONNEL

Four summer employees returned to school during the month: P. L. Hackett, B. J. McClanahan, G. S. Rhyneer and K. R. Price.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 02 PROGRAM

Effect of Reactor Effluent on Aquatic Organisms

The study of the effect of fish population density on the incidence of columnaris infection continued to show that this disease is considerably density dependent.

No incidence of columnaris was detected on Hanford slough fish even though water temperature was still well within the range where the disease is normally seen. Temperature effects on virulence of C. columnaris have been initiated. First results indicate that when the organisms are cultured at 30 C, virulence is higher than when culturing is done at 20 C. Mortality of fish exposed to 30 C organisms was 70 per cent compared to 50 per cent when 20 C cells were used.

Waterfowl

A cooperative study with the Environmental Studies and Evaluation Operation and State Game Department was developed to study the dispersion of waterfowl from Hanford and their harvest by sportsmen. The study will involve radioisotope analyses of heads from birds killed by hunters.

BIOLOGY AND MEDICINE - 06 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Strontium

To study the distribution of Sr^{90}-Y^{90} in various "compartments" after a single oral administration, a total of 24 yearling trout were each force-fed 15 µc Sr^{90}-Y^{90} in September. At post-treatment three fish were sacrificed at eight different time intervals. Various tissues and organs are being processed.

Inert calcium appears to have no effect on Sr^{85} uptake through the gills of rainbow trout as measured by the gill perfusion technique.

Studies of the comparative effects of different alkaline earths upon the absorption of Sr^{85} and Ca^{45} from the perfused small intestine of the rat were continued with results being obtained on magnesium and barium. With increasing levels of alkaline earths in the perfusion fluid, the ratio of Sr^{85} to Ca^{45} absorbed is increased when the alkaline earth is calcium, it remains approximately constant when the alkaline earth is strontium, and it decreases when the alkaline earth is magnesium or barium.

Two swine on a daily feeding regimen of 625 μc of Sr^{90} attained body burdens by 40 days of approximately 2700 μc or about 10 per cent of the total administered dose. Assuming an even distribution of the Sr^{90} in the skeleton, the average skeletal dose rate would be 50 rads/day. Since there is not a uniform deposition, dose rates up to 500 rads/day probably occur.

Three animals fed 125 μc/day for approximately a year have estimated body burdens of 1400 μc of Sr^{90}. Assuming even distribution of Sr^{90} in the skeletons of the 125 μc/day animals, the average skeletal dose rate would be about 15 rads/day. All of these animals still appear grossly normal, show no bone changes radiographically and exhibit normal blood values.

Six animals fed 5 μc of Sr^{90} daily for two and one-half years (since they were nine months old) were removed from Sr^{90} feeding. This action was necessitated by housing limitations in our high level facility and the realization that the daily feeding of animals exposed to Sr^{90} since conception should be more rewarding. These animals will be retained for lifetime observation.

The final experiment of this phase of the study on strontium and calcium binding in blood compared serum from an animal injected intravenously with Ca^{45} and Sr^{85} with pre-injection serum from the same animal to which Ca^{45} and Sr^{85} were added in vitro. Included in this phase of the study was a test of the effects of serum pH and $CaCl_2$ additions on the relative ultrafiltrabilities of calcium and inorganic phosphate. The results of this experiment should be obtained and analyzed by the end of October.

All of the IBM programs for the Sr^{90} toxicity experiment were completed. A major effort will be made to have all data from the experiments transformed to the programs by the first of December. Data Processing is now making adjustments and appropriate extensions to the existing Biology programs to provide a general form for computation of counting data for single radionuclides and nuclide pairs.

Comparative Toxicity of Strontium, Radium and Plutonium

One animal from the control group and each of the groups injected with Sr^{90}, Ra^{226}, and Pu^{239} at six weeks, six months and one year of age were sacrificed 18 months after the start of the experiment. These specimens will provide information on the early changes following intravenous administration of these bone-seeking radionuclides.

A total of 21 additional animals (females) were injected intravenously with these nuclides as follows:

Age	Sr^{90} (~64 μc/kg)	Ra^{226} (~6.4 μc/kg)	Pu^{239} (~1.3 μc/Kg)
1 yr.	5	5	5
3 - 4 yrs.	3	3	0

Inclusion of the aged animals provides us with a group which approximates the skeletal development of the dogs in the Utah study at the time of injection and should be extremely useful for interspecies comparisons.

Three of the one-year-old females injected with Ra^{226} were placed in metabolism cages in order to provide early excretion data.

Radiographs were taken of all comparative toxicity animals. No changes of consequence from lesions previously noted were observed.

Iodine

Uptake of I^{131} by bean plants was increased by the addition of carrier iodine as the potassium salt. Toxic levels of iodine had no affect on potassium uptake.

The eyes of representative animals from the Sr^{90}, comparative toxicity and I^{131} studies were examined by Dr. Wm. Magrane, Consultant in Veterinary Opthalmology to AEC. No significant changes were detected which could be attributed to the radionuclides under study.

Plutonium

Tests were made of a new chelating agent, triethylenetetramine hexaacetic acid (TTHA). This compound is structurally similar to DTPA. Preliminary results suggest that TTHA is at least as effective as DTPA and possibly more effective. There is also an indication that it may be more toxic than DTPA; although this may be due to the form in which it was administered.

Transfer of Radionuclides to Milk

The maximum milk concentrations relative to plasma concentrations occurring within two days following intravenous injection of the following nuclides were:

Ce^{144}	500-600 per cent
Np^{237}	2 per cent
Pu^{239}	2-3 per cent
Am^{241}	150-300 per cent

Bone Marrow Protection Studies

CF-1 mice were injected with rat bone marrow intravenously at the age of one day and at subsequent weekly intervals in an effort to establish a "tolerance" to the heterologous marrow. This pre-treatment with bone marrow did not improve the protective effect of the heterologous marrow administered subsequent to the 900 r X-irradiation.

Radioactive Particles

Radiographs and EKG's of dogs two years after inhalation of $Pu^{239}O_2$ indicate possible involvement of the heart. Further tests are planned to confirm this in these and other dogs. In other experiments dogs inhaling $Pu^{239}O_2$ aerosols with a mass median diameter of 0.65 μ deposited four per cent of the total amount inhaled. Other dogs deposited 30 per cent when exposed to 3.3 μ particles (MMD) and 60 per cent when exposed to 4.3 μ particles (MMD).

Radiation Effects on Insects

A three-month study of the X-ray tolerance of two closely associated species of flour beetles was terminated. Radiation was given at times of significant gonadic and/or somatic developmental changes. Effects were measured by observations of sterility and lethality. Tribolium castaneum was consistently more radioresistant than T. confusum. T. castaneum has one pair more of chromosomes than T. confusum--perhaps this confers the increased radioresistance.

In order to help explain oviposition failure during the early part of adult life, morphological studies were made of the reproductive system of control T. confusum. Fresh dissections showed that a female has two ovaries each of which consists of four ovarioles. The ovarioles, although very long, contained no cells except at the anterior region each of which contained a group of cells--apparently potential germ cells. This would account for late oviposition.

Microbiological Studies

The effects of various levels of D_2O on uptake of phosphate, potassium and glucose by yeast were studied. No significant affects were noted on the uptake of potassium or glucose, however, phosphate uptake is markedly inhibited. Inhibitions of 80 and 98 per cent, respectively, were obtained in 50 and 100 per cent D_2O solutions. The effects on phosphate metabolism in part, at least, account for the previously observed effects on growth rates and respiration.

Project Chariot

Field studies at the Arctic test site were concluded for 1961. All samples and equipment were returned to Hanford. Analyses of samples were in progress.

HA Kornberg

Manager
BIOLOGY LABORATORY

HA Kornberg:es

C. Lectures

a. Papers Presented at Meetings

First Symposium on Radioecology, Fort Collins, Colorado, Sept. 11-15, 1961:

W. C. Hanson, "Iodine in the Environment: Its occurrence, utilization and effect", Sept. 14.
W. C. Hanson, "A New Method for Measuring Waterfowl Dispersion", Sept. 13.
J. J. Davis, "Some Effects of Environmental Factors Upon Accumulation of Worldwide Fallout in Natural Populations," Sept. 11.
J. J. Davis (presented by W. H. Rickard), "Cesium and Its Relationships to Potassium in Ecology," Sept. 15.
W. H. Rickard, "Vegetational Analyses in a Creosote Bush Community and Their Radioecologic Implications," Sept. 13, 1961.
R. E. Nakatani, "Effect of Chronic Feeding of Sr^{90}-Y^{90} on Rainbow Trout," Sept. 13.

M. P. Fujihara, "Chondrococcus columnaris: Laboratory and Field Studies," American Society for Microbiology, Seattle, Washington, Sept. 16, 1961.

b. Seminars (Off-Site and Local)

None

c. Seminars (Biology)

None

d. Miscellaneous Lectures

L. K. Bustad, "Experimental Animal Farm Research" - Safety Meeting, 271-B Bldg., September 25, 1961.
W. C. Hanson, "Project Chariot," Central United Protestant Boy Scout Troop, Richland, September 25.

D. Publications

a. HW Documents

None

b. Open Literature

R. T. O'Brien, "Radiation sensitivity studies on related fermenting and respiring yeasts," Radiation Botany 1, (1), 61-68 (1961).

H. A. Kornberg, "The use of element-pairs in radiation hazard assessment," Health Physics 6, 46-62 (August 1961).

J. E. Ballou and R. C. Thompson, "Metabolism of zinc-65 in the rat. Consideration of permissible exposure limits," Health Physics 6, 6-18 (August 1961).

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - SEPTEMBER, 1961

ORGANIZATION AND PERSONNEL

F. W. Plotke was placed on leave of absence on September 6, 1961, to start work on the degree of master of business administration at the University of Washington.

R. D. Anderson, a temporary summer employee, terminated on September 22, 1961, to return to school at the University of Idaho.

D. E. Hudson was placed on the rolls as a Junior Scientist effective September 11, 1961.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Model

Presentations of the present status of the model were made to several groups. Comments during the various meetings indicate interest in the following factors:

1. Comparisons of predictions from model data with PIP forecasts.
2. Any further clarification of the effect of research and development upon the improvement patterns of the model.
3. Simplification of the analytical techniques used to derive information from the model.
4. Application of model forecasts to a series of plant environments, e.g., constant production, increased production, etc.

The comparison of model predictions with PIP forecasts was attempted during the month using rather rough estimations. Further calculations indicate that the comparisons will have to be refined. For example, factors to convert Kg Pu expressed in the PIP report to MWD are affected by future changes to such an extent that present factors are not suitable. Another problem lies in the design efficiency used to determine the number of equivalent reactors which may come from future dollars of investment.

The last two factors to be considered represent progress in the application of the system rather than any progress in understanding it. Some work has been done in applying the results to other environments, but clearly defined cases need to be determined and studied systematically.

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STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Fuel Element Performance

In view of the potentially greater differences between ingots than previously realized which may exist, the ingot-dingot, rolled-extruded production test was redesigned slightly in order to better evaluate this effect. In addition, alternate designs were suggested in the event core geometry during heat treatment is included as a variable.

A production test to evaluate the effects of certain heat treatment variables on dimensional distortion during irradiation was designed. This test and the above test will be discussed with feed site personnel in a meeting in Cincinnati on October 3 - 4, 1961.

A final design was formulated in connection with the test to evaluate N-quality uranium.

Dimensional distortion and hot spot data plotted as functions of HAPO canning date were brought up to date to include all available Quality Certification Data. A means was developed whereby this can easily be done on a routine basis. The relationship between warp and hot spot frequency was further confirmed.

Considerable attention is being given UT-2 data with respect to determining causes of variation in the UT-2 readings. UT-2 measures grain size distribution within a core. A look at preliminary data has indicated the need for a designed experiment aimed at determining measurement variations. This will be run in the near future. Also in this connection, a tentative acceptance sampling plan has been formulated for use at the feed sites in the sampling of ingots prior to shipment.

A paper on the use of statistics in fuel performance studies was presented at the fifth Technical Conference of the Chemical Division of the American Society for Quality Control at Charleston, West Virginia, on September 28 - 30, 1961.

General

Analysis of the data from the Pilot Plant experiment run to determine optimum canning cycles for the eight-inch I and E fuel element is continuing.

Further work is being done in fitting calibration curves to data which relate exposure density of film to fuel element clad thickness.

Assistance is being given in the interpretation of an offsite document which defines a different way of calculating the growth index from X-ray

diffraction data. This differs from the existing method primarily in the way in which the data points are weighted.

Written comments were given as requested relative to the significance of conclusions drawn from a number of rupture and reject curves.

A means of auditing the frequency of misclassified pinhole rejects was suggested.

At the request of Manufacturing Operation, Fuels Preparation Department, a study was initiated to investigate the possibility of applying the methods of linear programming to the complex problem of fabrication scheduling.

Irradiation Processing Department

Process Tube Replacement

Further consulting assistance has been given in connection with the process tube leak problem. Means of analyzing probolog data to determine a decision rule telling which tubes to probolog have been suggested, and an experiment has been designed for D-Reactor in which a sample of tubes will be probologged after every metal cycle.

Reliability Studies

Work continued on the provision of a reliability analysis of various instances of trip logic of the kind generally known as "majority gate" logic. In this connection, a reliability algebra for four-state devices has been constructed. Using this algebra, it is now possible, for the first time, to provide, for safety systems employing a "k out of n" type trip logic, an accurate reliability model which will yield simultaneously the probability of a catastrophic type failure and the probability of a spurious scram. Since any two-state device can be interpreted as a degenerate four-state device, the algebra can be shown to include classical Boolean algebra as a special case. Further properties of the algebra are being investigated.

General

Work continued on the problem of constructing a stochastic model of within-pile neutron flux in the presence of neutron sinks.

Chemical Processing Department

Z-Plant Information Study

Continued machine failure prevented effective debugging during the month. On-line operation was scheduled for September 26, but was prevented by a failure in the typewriter circuitry. At the present time, the status of

the program is such that on-line operation can be started at the convenience of operating personnel with final debugging being performed on the graveyard shift.

General

Further studies were made investigating the correlations between measured impurity contents and metallurgical characteristics of the fabricated parts. Some surprising results were found. A similar study for buttons is proceeding.

Further investigation was made of the previously studied relationship between powder processing rate and button density.

A comparison was made of neutron count data with mass spectographic isotopic analyses for a limited sample of buttons. Good agreement was found.

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

Contract and Accounting

Inventory Studies

Some assistance has been given in determining the expected error of book-physical difference estimates using different sample sizes in the 1961 General Supplies inventory.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Pulse Column Test Facility

A revised calibration function for the rotometer was estimated from experimental data. This function differs from the original one in that flow rate is expressed in terms of uranium concentration instead of solution density. The entire function was re-estimated since density and uranium concentration values for the test solutions were determined from independent chemical analyses. The revised function is being programmed into the master data reduction system and will be used to estimate the organic feed stream flow rate during pulse column test facility experimental runs. Calibration experiments are currently underway on a similar rotometer which will be used to monitor the distilled water inlet stream. The calibration function for this case will be estimated in a similar manner.

Analysis of variance calculations have been completed on the absorptiometer calibration experimental data to determine the magnitude of the reference cell voltage drift. A formula for correcting sample cell voltages to a

[redacted]

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nominal level with contemporaneous reference cell data was derived from this analysis. The mid-column photometer calibration data were corrected for minor temperature differences using the temperature correction function, which takes into account not only the photometer temperature during the time of the sample reading but also the photometer temperature when standard water readings are being made. The corrected data are currently being analyzed to determine the function which best expresses the relationship between read-standard voltage ratio and uranium concentration.

Reactor Effluent Studies

A discussion was held with personnel of Radiological Chemistry concerning the contribution that mathematical and statistical techniques and philosophy might make in the reactor effluent studies. Current efforts are directed toward digesting past RC experimental work and bringing ORSO personnel abreast of the current activities in the program.

General

A mathematical model is being developed to aid in studying diffusion in a zirconium-clad uranium core fuel element which initially contains thin layers of hydrogen source material.

The IBM-7090 Program which evaluates the service longevity of a proposed neutron flux monitor in terms of its isotopic constituents has been completed and put into service as an aid in design studies.

A solution has been obtained to a multiregional potential problem suggested by Geochemical and Geophysical Research.

3000 Program

Machining Development

Work continued in connection with the development of tape controlled guide mechanisms for the Gorton lathe.

4000 Program

Swelling Studies

The analysis of variance calculations on void fraction and void density data were completed and the results were discussed with Physical Metallurgy personnel. The analysis shows up the relative effects of burn-up, axial position, annealing temperature, and annealing time on void fraction and void density figures for each of the fission gas pore size distributions. Further analysis is in progress to more precisely determine the functional form of these effects.

Corrosion Studies

Experimental data are being collected from the X-8001 alloy autoclave experiment designed to investigate the functional relationship between time and aluminum corrosion penetration. The first three groups of samples have been removed from the autoclave, and preliminary analysis is underway. Exposure times on these samples were 80 hours, 175 hours, and 300 hours. Each time the autoclave is opened six samples are removed permanently from the experiment and stripped to obtain an experimental penetration value. All samples currently in the experiment, are weighed during the time that the autoclave is shut down. Following the completion of the experiment analysis of the data should indicate the relationship between penetration and weight gain, in addition to allowing for very precise evaluation of whether or not the parabolic-linear penetration relationship with time is, in fact, the case.

A preliminary analysis has been made of data from a test previously designed to evaluate the effects of using slight amounts of chromic acid in an autoclave as a corrosion inhibitor.

5000 Program

Radiochemical Analyses

Work continued on the correction of program data in the IRA master file. The computer program for the quantitative reduction of a set of time dependent multichannel energy spectra is being debugged.

6000 Program

Biology

A draft of an article on the relation of cesium^{137} to rainfall was sent to the concerned party in the Biology Operation for revision.

Analysis of data in connection with Project Chariot was continued.

Other

Atmospheric Diffusion Studies

All the Operation Greenglow sample data have been obtained from Atmospheric Physics Operation on IBM cards. Several diffusion experiments have been selected for preliminary analysis, and a number of tentative models have been considered for the explanation of the experimental data. Appropriate IBM programs are being readied to determine the agreement of these experimental data with the models.

Radiation Protection Studies

Further work was done with the film badge pencil data from a sample of HAPO people. The initial screening experiments and correlation studies have been finished and the evaluation of the accompanying summary statistics is in progress.

A discussion was held to familiarize certain RPO personnel with the statistical philosophy behind the setting of "detectable" and "detection" limits from analysis of appropriate blank and spike samples.

Instrumentation

An IBM program is being written to do the routine analysis of data from reference system calibration studies conducted by the Instrument Research and Development Operation. The method of analysis is an outgrowth of a recent detailed statistical evaluation of a number of sets of calibration data which reported the sensing of the distance traversed by a linear variable differential transducer by number of test and standard instruments. It is hoped that the IBM program will completely automate the calculations necessary to evaluate the precision of test data and to estimate final calibration functions.

METHODS DEVELOPMENT

Statistical

A bibliography on composite distributions has been completed which summarizes the pertinent material available in the Technical Information Operation Library. It also includes abstracts of pertinent articles not available on-site. The material is organized for ready reference to specific decomposition of compound distributions problems which arise in connection with solving certain Hanford problems.

Numerical

The IBM-7090 Program for obtaining numerical solutions to transient-state nonlinear diffusion problems has been tested on a problem whose analytical solution is known. The results have shown the program performs satisfactorily. As soon as the necessary modifications are made to handle time and space-dependent source functions, the program will be ready to put into service.

Further debugging was done on NELLY, the nonlinear least squares routine discussed in Los Alamos Document LA-2367. A flowchart was constructed of the P-subroutine, which does iterative least squares portion of the analysis, for inclusion in an HW document to explain the use of the routine HLO personnel.

Work continues on revising the BIMD statistical routines for use on the IBM-7090. To date, one screening routine and two analysis of variance routines are operational. Current efforts are directed toward adapting an analysis of covariance routine and a general linear hypothesis routine.

Carl A. Bennett

Manager
Operations Research and Synthesis

CA Bennett:dgl

PROGRAMMING OPERATION
SEPTEMBER, 1961

I. REACTOR DEVELOPMENT - 04 PROGRAM

A. PLUTONIUM RECYCLE PROGRAM

In order to obtain average cross sections from different sources to check the validity of Westcott cross sections used in MELEAGER, it is necessary to average the point cross sections over the entire neutron energy range up to about 10^7 ev. To use the Spectrum Code of General Atomics, which was designed for the thermal portion of the flux (up to around one ev), a complete energy spectrum averaging must be accomplished. One possibility is that of enlarging the energy range of Spectrum Code. The other alternative is that of performing the slowing-down calculations (above ten ev) by another method, and dovetailing the results together. Both alternatives necessitate the extension of the present range of energies used in Spectrum Code.

This has been done by planned rearrangement of the 75 energy points available in Spectrum to include the higher energies. The first objective was to determine the minimum number of points required to accurately define neutron flux energy spectrum in the region from zero to one ev. To date, a completely satisfactory arrangement of 43 energy points has been found. This leaves 32 points to define the energy spectrum in the regions above one ev. This has been done with considerable success up to ten ev for fluxes obtained with U-235 and Pu-239 fueling. An extension to 10^7 ev with the 75 points presently available appears to introduce considerable inaccuracy.

An exact derivation of the ideal plutonium value equation was made to eliminate possible objections as to the selection of simplified relationships for illustrations. The final results are unchanged, however. Some additional work must be completed before a final document is started.

1. Computer Code Development

The fuel cost MINIMIZER code has been rewritten to increase reliability with the minimum number of calculated points. This was accomplished by increasing the accuracy of the polynomial fits and applying a knowledgeable bias to those fits which were in error due to a lack of information. Extensive checks on the MINIMIZER'S accuracy

are being made at the present time. The accuracy of minimization is most important when applied to comparative studies, such as combined cycles and plutonium value determination. Often differences in minimized fuel cost are very small, yet may be used to guide further work.

During September the jacketing cost portion of the rigorous economics code was used to do some preliminary calculation of jacketing cost for a model plutonium fabrication plant study. After the code has been shown to describe the plant accurately, then production yields, losses, and other operating parameters will be varied to ascertain the sensitivity of these factors upon fabrication charges.

The following modifications were made to PUVE (PUVE determines plutonium values from comparative fuel cost data):

1. Plutonium values for a sequence of recycle steps are calculated on both a $/gram fissile and a $/gram total basis.

2. The extrapolation calculation was changed so that an iterative calculation is made until the relation:

$$\frac{X_{n-2}}{X_{n-1}} = \frac{X_{n-1}}{X_n}$$

is satisfied. While this change will make little difference in recycle series of many steps (i.e., approximately ten) there will be an improvement in the results calculated for shorter series (i.e., five).

3. The extrapolation result is printed along with the results of changing the final batch value in the extrapolation calculation by $\pm$ \$0.10, $\pm$ \$0.25, $\pm$ \$0.50, and $\pm$ \$1.00 per gram fissile and per gram total.

Curve fits of plutonium value as a function of Pu-242 content in the batch were made by an existing computer code. The fits were best for a second order equation but these were rejected as they contained a maximum in the region of interest. First order fits were found to be adequate most of the time but when they were not an equation of the form, $y = k - ax^n$, was hand calculated. This could be coded easily if such a function were needed in the future.

2. Salt Cycle Reprocessing Economics

Work progressed on the computer program to evaluate the economic merits of Salt Cycle reprocessing of Plutonium Recycle fuels. Preliminary runs obtained from the computer were being checked. These runs are the means for evaluating the effect of the major cost variables on the relative economics of Salt Cycle reprocessing compared with conventional Solvent Extraction reprocessing.

B. SPECIFIC FUEL CYCLE ANALYSIS

Almost all activity has been directed to "checking" and "cleaning up" the data obtained during the accelerated computation effort last summer. So far, the cleanup has significantly altered only the plutonium values of highly recycled plutonium that contains considerable Pu-242. This alteration resulted from examining the statistical methods employed to solve for the values of successive plutonium batches in a recycle sequence. The method now adopted is based on statistical methods to estimate the value of the last batch and then, by perturbating this last batch value, the most probable set of plutonium values for the recycle sequence is estimated and checked by automatic plotting. This method has been incorporated in the most recent version of the PUVE routine which solves for the plutonium value.

The cleanup campaign also has involved considerable effort in the direction of variable spatial concentrations of U-238 when plutonium is used. It appears that as Pu-240 is added to the system the reduction in U-238 spatial concentrations to properly adjust the total fertile absorption cross section can be overdone causing a reduction, rather than an increase, in plutonium values. In fact, as the U-238 spatial concentration is reduced, the plutonium value often increases to a peak and sharply declines. Efforts have been made to demonstrate this with the present MELEAGER CHAIN code by somewhat arbitrarily altering the spatial concentration. The guesses, to date, of appropriate concentrations have been poor. Efforts are now under way to gain insight into this problem by varying the spatial concentrations and examining the reactor for a short exposure period (few hundred seconds of reactor operating time only) and then correlating the resulting initial conversion ratio, thermal utilization, etc., to the appropriate spatial concentrations. With these improved "estimates", the MELEAGER CHAIN code will then be used to ascertain the plutonium value. By this technique, it is hoped that, for a given reactor, it will be economically feasible to compute the plutonium value as a function of the amount of plutonium available for enrichment (from none to an unlimited amount) for all feasible U-238 spatial concentrations.

A revision of the study of alternative cladding materials showing their effects on fuel costs was substantially completed during September. (This revision was interrupted by the high priority combined cycle work during June, July and August.)

The combined cycle work during September consisted of examining the results of the previous computer runs for consistency and reasonableness, and in setting up a storage system for printed output data and for the more than 300 reels of magnetic tape involved.

In many of the combined cycle cases, six enrichments are insufficient to give accurate minimization of fuel costs. Considerable effort is going into an analysis of the most efficient way to expand the existing physics library so that accurate minimization can be obtained. This problem is being attacked in two ways:

1. A new PROTEUS tape incorporating additional enrichment cases will be obtained by merging data from new MELEAGER runs with the information on the old PROTEUS tapes.

2. QUICK code itself is being modified so that it can specify the order of fit used in minimization so that the best statistical extrapolation of existing data is obtained. Considerable data are being examined to determine the optimum approach.

Another modification is being made to QUICK to facilitate reporting of combined cycle results. A condensed table of results is being written simultaneously on a summary tape in addition to a more detailed report on the conventional tape with additional diagnostic information and plots for questionable cases.

An EDIT code is being written and will produce a condensed version of the basic MELEAGER tapes. This condensed version will tabulate information which was not formerly preserved on a readily accessible tape. This version will be specifically set up to prepare summary tables of results in any fashion desired or to facilitate plotting of data. Furthermore, this will store the useful data from approximately 100 tapes on 10 tapes.

II. OTHER ACTIVITIES

1. Mercury Isotopes

The study of the economics of mercury-204 isotope separation by the monochromatic photosensitization process was continued. The extremely low power cost estimate was confirmed in communication with the inventor. Contacts were made with others who have been studying this process to discuss bases for estimating production costs.

The report on "Application of Mercury Isotopes" is well under way and as currently scoped is outlined in the following manner:

Section One:

Reasons for the consideration of mercury (in particular mercury-204).

A. Comparison with other coolants.

B. The advantages and disadvantages of mercury.

Section Two:

Description of reactor concepts that could utilize mercury as a coolant.

A. Reactor types for mercury.

1. Fast (Consider each mercury isotope.)
2. Epithermal
3. Thermal

B. Fuel element-coolant concepts.

Section Three:

Analysis of various concepts.

A. Brief analysis of all concepts presented.

B. Detailed analysis of mercury slurry fuels using the computer code IDIOT (transport theory fuels).

C. Detailed analysis of prototypical reject fuel concept with mercury cooling.

D. Detailed analysis of prototypical semirapid mercury slurry fuels cooled with mercury or with another coolant.

Section Four:

Areas are defined where further study must be made, both by laboratory experiments and by computations.

Section Five:

Estimate of mercury-204 separations cost (also other mercury isotopes).

Appendix:

A. Availability of mercury and bismuth.

1. Availability of mercury.
2. Separation of mercury-204.
3. Availability of bismuth.

B. Mercury heat transfer.

2. Chemical Reprocessing

Study was initiated on the investigation of the economics of an alternate Redox type (volatile solvent) separation process.

3. Radioactive Heat Sources

In the course of preparing a final report on the thorium-230 studies, the laboratory analytical work for which was completed last May, compilation of the estimated costs of radioisotopes as recorded in unclassified sources was completed. These costs, expressed as dollars per initial watt of heat generated, gave the following results: (as shown on page F-7).

These results, together with half-life considerations, continue to show the very favorable position of the Th-228 and U-232 isotopes as a source of thermal energy.

Isotope	Watts/Gram	Cost Basis (Projected Future)	$/Initial Watt
Sr-90 (+ Y-90)	0.78	$ 0.30/curie (42.60/gm)	$ 54.60
Cs-137 (+ Ba-137)	0.46	0.30/curie (58.60/gm)	127.50
Ce-144 (+ Pr-144)	21.5	0.01/curie (31.80/gm)	1.48
Pm-147	0.4	0.07/curie (64.20/gm)	160.50
Po-210	141.0	55.00/curie (247,400/gm)	1754.00
Th-228 (+ chain)	161.0	410/gram	2.55
U-232 (+ chain)	4.4	390/gram	88.60
Pu-238	0.54	1600/watt (864/gm)	1600.00
Cm-242	120.	145/watt (17400/gm)	145.00

4. Hazards Analyses

Material from HLO components was assembled for inclusion in a draft of the NPR hazards evaluation report. Some work is still in progress on the calculation of the consequences of release of fission products. Recent information on population density, meteorological and geological characteristics was incorporated in the report.

Study of the potential hazards involved in the shipment of Ce-144 was initiated; present scheduling indicates that shipments of Ce-144 will be made in December, 1961, and May, 1962. The potential hazards involved in the routine shipment of plutonium is the subject of a separate study.

W. K. Woods

Manager,
Programming

WK Woods: jm

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF SEPTEMBER 1961

A. ORGANIZATION AND PERSONNEL

Frances B. Flora retired from the General Electric Company on September 8. Glen D. Brown and Fern K. Bowen resigned from the Company on September 22 and 29, respectively. Wendall A. Briggs was transferred from Fuels Preparation Department to Internal Dosimetry on September 18. Myrtle S. Ghent was reactivated effective September 21. Paul E. Cox was transferred from Irradiation Processing Department to Internal Dosimetry effective September 25. Changes within the Radiation Protection Operation included: Gordon A. Little and Thomas C. Mehas transferring from Radiological Development and Calibrations to Radiation Monitoring on September 1; R. Claude Henle transferring from Radiation Monitoring to Internal Dosimetry on September 15; Dale E. Rickaby transferring from Environmental Studies and Evaluation to Radiation Monitoring on September 18; and Claude D. Hooker transferring from Radiation Monitoring to Environmental Studies and Evaluation. The work force now totals 134.

B. ACTIVITIES

Occupational Exposure Experience

There were no new cases of plutonium deposition confirmed by bioassay analyses during the month. The total number of plutonium deposition cases that have occurred at Hanford is 271, of which 198 are currently employed.

A high-level spread of plutonium contamination in the decontamination laboratory at the 325 Building resulted in general contamination from 20,000 to 40,000 d/m on the floor area with one small spot reading 6×10^6 d/m, and skin contamination of 1000 d/m to one employee. Negative air samples and nasal smears indicated no ingestion or inhalation of the contaminant. Bioassay analyses are in progress.

Additional laboratory analyses of a construction employee who was contaminated with plutonium oxide during the removal of a hood in the 234-5 Building in August indicated inhalation and excretion of significant quantities of the plutonium oxide. Bioassay analyses of urine samples continued to indicate little deposition of soluble plutonium. Feces samples for the ten days following the exposure contained about one permissible body burden (0.04 μc) of plutonium. A total assessment of this exposure will not be possible for several months.

Investigation of a high fission product air sample at the 292-T Building revealed that the air contamination resulted from the movement of equipment from a junior cave. Examination of an HLO Chemist and a Radiation Monitor in the Whole Body Counter showed minor deposition of radioactive ruthenium. Calibrations for ruthenium-106 indicated a deposition of about 1.7×10^{-2} μc or 0.2 percent of the permissible body burden for the Chemist. Lesser trace quantities were detected in the Radiation Monitor.

Dosimetry calculations indicated that an FPD Maintenance employee may have received a dose up to 300 rads to a small area on the palm of his hand while working at the PRTR. The exposure occurred when he picked up a small cotter pin in the discharge pit which was drained to replace a rupture disk. The cotter pin was previously exposed to the flux region of the reactor. Calculations, based on dose rate instrument measurements, indicated that the contact dose rate for a gloved hand was 3500 rads/hour, of which about half was penetrating radiation. The localized dose of 300 rads was considered a maximum estimate because other articles in the hand may have provided shielding for the cotter pin. The average dose to the entire hand was ~5 rads.

Dose evaluation, based on the film badge dosimeter system, showed that a CPD Laboratory Technician exceeded the Hanford operational control for the calendar year with a total gamma dose of 3.1 r. As reported last month, the employee received 2.1 r for a four-week badge period although no explanation for the dose was determined. Evaluation of her film dosimeter for the following four-week badge period showed a dose of 0.83 r. Investigation by CPD again failed to reveal the source of the exposure. These apparent exposures, when added to previous accumulated dose for the calendar year, result in the total of 3.1 r. The work activities of the employee were placed under close scrutiny to prevent additional significant exposure.

Maintenance work associated with a planned outage at PRTR involved dose rates to 320 r/hour while replacing flux monitor changers. Air-borne filtrable contamination from noble gases was only of minor consequence during operational and shutdown periods with concentrations of 7.3×10^{-6} μc/cc. Samples from the heavy water systems showed tritium of 183 μc/l, 140 μc/l and 32.2 μc/l in the moderator, reflector, and primary coolant, respectively. The maximum tritium concentration in air samples collected in the vessel was 5.4×10^{-5} μc/cc. Four bioassay samples out of 146 submitted for tritium analysis showed values greater than 5 μc/l. The maximum samples was 18.8 μc/l corresponding to a whole body dose of 130 mrems in the following 28 days.

Environmental Experience

One routine background aerial survey flight was made to Spokane on September 21 and return. No significant change in previous results was noted.

A radiological survey of beach areas on the Columbia River between Ringold and Richland was conducted as a follow-up to the original survey conducted during July 1961. Complete evaluation of the results to determine the feasibility of allowing recreational activities on the river up to Ringold is not yet complete.

A total of 187 fish comprising fifteen species, predominantly whitefish, suckers, and squawfish were obtained from routine sample locations at Priest Rapids, Hanford, Ringold, and Burbank. Two hundred and sixteen tissue samples from these fish were prepared and submitted for radiochemical analysis The duck sampling program similar to last year's program was initiated at the end of the month in preparation for the 1961 hunting season. Preparations have been completed for receiving and processing duck heads donated by Tri-City area hunters.

Ten routine produce samples consisting of seven milk samples from the Ringold, Riverview and Benton City areas, two pasture grass samples from the Riverview area, and one sample of Willapa Bay oysters were obtained for radiochemical analysis.

An increase by a factor of 10 to 100 over the results of the samples taken during the first eight months of 1961 was noted on all air filters from ten sampling regions in the Pacific Northwest. No increase in the general background radiation level was detectable.

Studies and Improvements

All of the radiators for the K-fluorescent X-ray equipment were mounted on holders to provide improved positioning of the radiator materials. The energy peaks for the radiators were studied and the dose rates from the remounted radiators were measured.

The prototype Hanford dosimeters were exposed to various beta-gamma doses to evaluate their performance capability. Exposures were made to plutonium metal at the 234-5 Building following which exposures to standard uranium-beta spectrum were added to evaluate the dosimeters' capabilities of measuring low energy gamma doses in the presence of beta radiation. The personnel dosimeter development program was continued on schedule throughout the month.

Debugging of the automatic densitometer was continued throughout the month. A number of additional electrical components were added to improve the deficiencies in the electronic circuits. The punch equipment used with the densitometer required major adjustment by the manufacturer. A trial run of several hundred pieces of exposure film was begun to determine the reliability of the densitometer.

Three days of positive ion accelerator time were utilized in further calibration of the Hanford foil neutron dosimeters. The exposures were made to study the energy and angular dependence of the dosimeter. These were the first tests to be performed with the commercially manufactured moderator units.

Calibration of the glass dosimeter fluorods shielded with 0.020 inch of tantalum and mounted in the prototype personnel dosimeter was begun. The Co^{60} gamma calibration of the fluorods contained in the prototype dosimeter for doses from 10 r to 3000 r was completed. The performance observed agreed closely with the calibration data taken about a year ago with fluorods from a different manufacturer's lot.

One day of accelerator time was used to irradiate silicon diode neutron dosimeters. The performance studies of the silicon diode dosimeters has indicated that the 0.075 inch diodes exhibit properties superior to the other diode thicknesses that have been studied. A forward resistance change of 1.5 percent per rad with 30 milliamperes flowing through the diode was observed.

A program leading to characterization of air contaminants at Hanford was begun. An initial study of available literature and air sampling procedure in use at Hanford was completed. Preliminary investigations indicated that air flow calibrations routinely used throughout the Hanford Plant are inadequate and improved equipment to provide this calibration is required. It appears that nominal modifications to the flow rate calibration equipment currently in use can provide the necessary calibration accuracy.

A new 220 KVP X-ray tube of improved design was installed, calibrated, and is in routine use at the Calibrations facility. A 488 gram piece of plutonium metal was received at the Calibrations Building. It will be used during the next several months for special studies involving the calibration of personnel dosimeters for plutonium exposures. Hanford Laboratories Nuclear Safety Specification was completed by Critical Mass Physics and radiation safety procedures for the use of this source were prepared and approved.

Assistance in dose measurement was provided to Special Devices Development, IPD, in a study of TV camera lens clouding caused by excessive gamma radiation. Several fluorod dosimeters were provided and read following exposure with the TV camera. Dose estimates to the exposed fluorods were as high as 500,000 r.

Work continued on the development of the creel survey. To date, 290 fishermen contacted by the State Game Department have given an annual estimate of their catch. The analysis of the data has not been completed.

Work on the environmental consequences following an accident at NPR was initiated during the month. This work will be incorporated into the NPR Hazard Analysis.

At the request of CPD an analysis was made to determine the potential radiological problems which may be associated with an accident in a 241-BY waste tank where the volume of coating waste would be reduced by submerged combustion of propane. This work was documented in HW-71146.

The estimates of isopleth areas as a function of exposure to various air concentrations for three heights of emission at three different wind speeds were completed. Such information is available for four different conditions of atmospheric stability.

The capabilities of the bioassay function were reviewed and the statistical limits for "detection" and "detectable" quantities of plutonium were determined. In the 99 percent confidence interval, the detectable limit was $\sim$0.02 d/m and the detection limit was $\sim$0.04 d/m.

Collimating devices for the I^{131} thyroid examination equipment were received from the vendor and are now available for use in the Whole Body Counter laboratory.

A firm commitment to release the Whole Body Counter laboratory for one full day of research and development work each week (Wednesday) was made to Radiological Physics. This will continue for an indefinite period. The examination of radiation incident cases and contaminated injury cases will continue to take precedence over all other activities of the Whole Body Counter.

Twenty-four boxes, for the storage of emergency monitoring equipment and instrumentation, were completed. Arrangements have been made to store these at field locations such as exclusion area badgehouses, fire stations, etc. The RPO Emergency Call List was revised. Letters and billfold-size cards were prepared and distributed to various offices and field personnel. The list of emergency monitoring instruments available in and near the 700 Area was revised and reissued in the form of billfold-size cards.

An order for 100 self-reading pencil dosimeters with a dose range from 0-600 r was placed and the dosimeters were received. The 50 emergency monitoring CP-TP meters with 0-5000 r/hour range were calibrated and readied for use. Instruments No. 1 and No. 2 were calibrated to read from 0-10,000 r/hour. Tags identifying the ranges of each instrument were attached to the detection probes to assure clear designation of emergency monitoring instruments.

A practice session was held on September 26 for members of the ERC and HLO Plotting Room. The emergency problem used was realistic and was well handled by the ten members attending. Several beneficial suggestions were received by the Plotting Room members present, which, when integrated into the system, will materially improve the program.

C. VISITORS

The following visitors met with various members of the Radiation Protection Staff during the month:

C. G. Amato - American Machine and Foundry Atomics, New York City, New York
E. L. Fountain - Mercury Test Site, Las Vegas, Nevada
K. Larson - UCLA Nuclear and Physics Laboratory, Los Angeles, California
Sixteen students of the Newport, Washington, Civil Defense Class

D. EMPLOYEE RELATIONS

There were no suggestions submitted by the personnel of the Radiation Protection Operation during the month; thus the total remains at thirty-four. Five suggestions were rejected. Five suggestions submitted by RPO personnel are pending evaluation.

There was one medical treatment injury during the month for a frequency of 0.45. No security violations occurred during the month of September.

Job Hazard Breakdowns for the Radiological Development and Calibrations Operation and the Internal Dosimetry Operation were reviewed and new ones prepared as appropriate.

A training session on the use of emergency radiation monitoring instruments was held for members of the 300 Area Emergency Rescue Squad. Instruction included the use of the new high-range TP capable of measuring dose rates up to 5000 r/hour.

E. SIGNIFICANT REPORTS

HW-69203 - "An Adiabatic Calorimeter for Stopping Power Measurements in Thin Foils" by H. V. Larson, I. T. Myers, R. I. Elder, and W. J. Dittrich.

HW-70411 - "Evaluation of Radiological Conditions in the Vicinity of Hanford, January-March, 1961" by Environmental Studies and Evaluation Staff.

HW-70552 - "Evaluation of Radiological Conditions in the Vicinity of Hanford, April-June, 1961" by Environmental Studies and Evaluation Staff.

HW-70830 - "Environmental Consequences of a Serious Accident in the Fuel Recycle Pilot Plant" by G. E. Backman.

HW-71146 - "Potential Contamination Spread Evaluation - Submerged Combustion of Coating Waste" by G. E. Backman and W. A. Haney.

HW-71220 - "Monthly Report - September 1961, Radiation Monitoring Operation" by A. J. Stevens.

HW-71041 - "Analysis of Radiological Data for the Month of August, 1961" by R. F. Foster.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-August 1961 - Mid-September 1961)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.3	% MPC_w-GI*
Separation Areas	Gross Beta	2.0×10^{-7}	µc/cc
Pasco	Isotopic	4.4	% MPC_w-GI**
Kennewick	Isotopic	< 1.0	% MPC_w-GI**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	6.0×10^{-8}	µc/cc
Hanford	Isotopic	1.3	% MPC_w-GI*
Pasco	Isotopic	7.8	% MPC_w-GI**
McNary Dam	Gross Beta	No Sample	
Vancouver, Washington	Isotopic	0.4	% MPC_w-GI**
Atmosphere			
I^{131} Separations Areas	I^{131}	2.0×10^{-13}	µc/cc
I^{131} Separations Stacks	I^{131}	0.8	Combined curies/day
Active Particles - Project	--	9.0	ptle/100 m^3
Active Particles - Environs	--	3.6	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	4.4×10^{-6}	µc/g
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/g

* The % MPC_w is the percent of the maximum permissible limit for occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

** The % MPC_w-GI is the percent of the maximum permissible concentrations for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

PERSONNEL DOSIMETRY AND RADIOLOGICAL RECORDS

External Exposures Above Permissible Limits

	Sept	1961 to Date
Whole Body Penetrating	0	0
Whole Body Skin	0	1
Extremity	0	0

Hanford Pocket Dosimeters

Dosimeters Processed	2,892	36,750
Paired Results - 100-280 mr	12	392
Paired Results - Over 280 mr	4	20
Lost Results	0	0

Hanford Beta-Gamma Film Badge Dosimeters

Film Processed	10,530	92,099
Results - 100-300 mrads	1,053	8,507
Results - 300-500 mrads	215	1,154
Results - Over 500 mrads	32	214
Lost Results	35	281
Average Dose Per Film Packet - mrad (ow)	7.52	8.33
- mr (s)	29.80	22.73

Hanford Neutron Film Badge Dosimeters

Slow Neutron

Film Processed	804	12,366
Results - 50-100 mrem	0	0
Results - 100-300 mrem	0	0
Results - Over 300 mrem	0	0
Lost Results	5	63

Fast Neutron

Film Processed	262	3,007
Results - 50-100 mrem	1	368
Results - 100-300 mrem	12	118
Results - Over 300 mrem	0	0
Lost Results	5	63

Hand Checks

Checks Taken - Alpha	30,481	300,730
- Beta-gamma	43,162	458,252

Skin Contamination

Plutonium	31	274
Fission Products	38	426
Uranium	0	46
Tritium	20	20

Whole Body Counter	Male	Female	Sept.	1961 to Date
GE Employees				
Routine	41	0	41	509
Special	8	1	9	57
Terminal	55	8	63	82
Non-employees	5	0	5	68
Pre-employment	13	3	16	38
	122	12	134	754

Bioassay

	Sept.	1961 to Date
Confirmed Plutonium Deposition Cases	0	8*
Plutonium - Samples Assayed	552	4,777
- Results Above 2.2×10^{-8} µcPu/Sample	14	123
Fission Produce - Samples Assayed	564	5,401
- Results Above 3.1×10^{-5} µc FP/Sample	1	14
Uranium - Samples Assayed	188	2,265
Biological - Samples Assayed	0	196

Uranium Analyses

	Following Exposure Units of 10^{-9} µc U/cc			Following Period of No. Exposure Units of 10^{-9} µc U/cc		
Sample Description	Maximum	Average	Number Samples	Maximum	Average	Number Samples
Fuels Preparation	16.8	3.4	60	8.8	2.6	56
Fuels Preparation**	0	0	0	0	0	0
Hanford Laboratories	16.7	3.1	33	8.1	2.5	31
Hanford Laboratories**	0	0	0	0	0	0
Chemical Processing	6.0	3.0	2	0	0	0
Chemical Processing**	0	0	0	3.9	3.9	1
Special Incidents	3.0	2.6	2	0	0	0
Random	1.7	1.3	3	0	0	0

Tritium Samples	Maximum	Average	Count	Sept. Total
Urine Samples				
Routine	17.6 µc/l	2.4 µc/l	112	
Samples Above 5.0 uc/l	18.2 µc/l	14.5 µc/l	6	
				118
D_2O Samples				
Moderator	192.0 µc/ml	182.0 µc/ml	6	
Primary	36.8 µc/ml	33.5 µc/ml	6	
Reflector	145.0 µc/ml	131.0 µc/ml	6	
				18
Water Samples	0.87 µc/ml	0.0129 µc/ml	48	48

* The total number of plutonium deposition cases which have occurred at Hanford is now 271, of which 198 are currently employed.

** Samples taken prior to and after a specific job during work week.

Calibrations

	Number of Units Calibrated Sept	1961 to Date
Portable Instruments		
CP Meter	899	8,233
Juno	251	2,222
GM	504	4,745
Other	139	1,488
Audits	103	934
	1896	17,622
Personnel Meters		
Badge Film	324	12,189
Pencils	0	7,174
Other	251	3,121
	575	22,484
Miscellaneous Special Services	698	7,470
Total Number of Calibrations	3,169	47,576

A R Keene
Manager
RADIATION PROTECTION

AR Keene:ljw

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - SEPTEMBER, 1961

GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 2.87 for the month and 2.89 for the year-to-date.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 19,912 hours. This includes 12,839 hours performed in the Technical Shops, 5,007 hours assigned to Minor Construction, 95 hours assigned to other project shops and 1,971 hours assigned to off-site vendors. Total shop backlog is 20,135 hours, of which 60 per cent is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 3.7 per cent (649 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	6,636	33.3%
Irradiation Processing Department	1,487	7.5%
Chemical Processing Department	548	2.8%
Hanford Laboratories Operation	11,219	56.3%
Construction Engineering & Utilities	22	.1%

Requests for emergency service decreased to a level requiring a 3.7 per cent overtime ratio compared to a 5.3 per cent ratio for the previous period.

At the close of the reporting period, there were two open requisitions for Machinists and one for a Stock and Tool Attendant. Qualified candidates have been interviewed and are in process.

There were eleven medical treatment injuries, which is on the high side of the level forecasted for this Operation.

CONSTRUCTION OPERATION

There were 64 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $193,564. One hundred and three new orders, five supplements and adjustments for underruns amounted to $73,568. Expenditures during the month on HLO work were $114,903. Total J. A. Jones backlog at month's end was $152,230.

Summary

	HL		CE&UO	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	63	$ 182,944	1	$ 10,620
Issued during the month (Inc.Sup. & Adj.)	108	73,568	-	--
J. A. Jones Expenditures during month (Inc. C.O. Costs)		107,016		6,886
Balance at month's end	61	149,496		2,734
Orders closed during month	95	66,715		

Current Maintenance Work Orders - 7 Face Value $8,800.

Project CGH-834 - 189-D Building - High Temperature High Pressure System - Pneumatic lines from the vessel cells to the pressure gauges on Panel # 1 are complete. With the exception of 4 ft. of heavy wall tubing the 5000 Psi discharge line to the air vessels is installed. All wiring is installed except thermocouple leads to the instrument on "J" panel. Both new compressors are lubricated and ready for testing. Insulators are complete in the compressor shed and only have a little work left in the main building. Lead sheet impressions were made of the Heat Exchanger Head to tube sheet fit and sent to the vendor. No response has been received from them yet.

FACILITIES ENGINEERING OPERATION

Project Activity

At month's end there were 15 active projects having total authorized funds in the amount of $2,703,000. The total estimated cost of these projects is $7,684,000. Expenditures on these projects through August 31, 1961 were $496,000.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end	15
Number of new projects authorized in September	0
Projects completed in September CGH-923 Spectroscopy Laboratory CGH-935 Metals Storage Building - 300 Area	2
New Project Proposals submitted to AEC in September	0
New projects awaiting AEC approval: CGH-918 Second Whole Body Counter Facility CAH-917 Field Service Center CGH-922 Burst Test Facility for Irradiated Zr Tubes	3

Project Proposals complete or nearing completion are as follows:

Modifications to the H-1 Loop - 105-H Building
Critical Mass Lab. - Stage II

Engineering Services

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, other P.A.C. and equipment Projects. The proposed manual of procedures for the acquisition and use of pressure systems is being prepared for final issue.
"Split-Half" Machine for Critical Mass Studies	Design essentially complete, except for electrical and instrumentation work.
10 KW Tube Dryer - 314 Building	Design complete. Installation 25% complete.
Process Tube Monitor - 309 Building	Design started.
HLO Electrical & Signal Systems	Buildings are routinely metered and records maintained. A lighting level survey is being made in all buildings. Signal systems are being standardized.
Monorail Trolley - 326 Building	New insulated electrical conductors are being installed on trolley as a safety precaution.
Power Transfer Switch - 306 Building	A new switch is being installed for transferring electrical loads during emergency power periods.

Drafting and Design Services

The work load in the 3706 Building drafting room and in the 327 Building is steady with no overtime required. Work loads in 306, 314, 308, and 1707-D Buildings are steady with little or no overtime required.

The equivalent of 152 design drawings were completed this month as compared to 147 last month.

Major design and drafting work in progress includes the following:

1. Process Tube Monitor - Mark III. 15 drawings required - Work completed.
2. Gas Loop Test Section - PRTR - 4 drawings required - Work completed.
3. Ultrasonic Development Tank - 13 drawings required - 90% complete.
4. Fission Product Packaging Equipment - 22 drawings issued for comment - about 50 required.
5. Calandria Mock-Up for Test Work - Work essentially complete.
6. Shim Rod Drive Mechanism - PRTR - 10 drawings required.
7. Optical Measurement Device - In-Reactor - 5 drawings required.
8. Graphite Creep Capsule - 4 drawings required.
9. Control Rod Drive Modification - 5 drawings required.
10. Tensile Test Holder and Capsule - 4 drawings required - 30% complete.

Plant Maintenance Operation

Total costs for August were $119,187 which is 90% of forecasted expenditure.

Analysis of Costs

Although maintenance expenditures were less than anticipated, the costs of utilities were higher. The total expenditures continue at about 90% of predicted. This underrun at the beginning of the year provides a comfortable margin of $25,000 for unusual winter expenditures. This margin is reduced, however, by the apparent $4,000 increase in utility costs.

Improvement Maintenance

Item	
Relocation and Alterations	$7,239
Repainting	3,290
Heat and Vent Modifications	74
Crane	944
Total	$11,547

Special Activities

1. Painting

   a) The exterior of 328 is being painted by a lump sum contractor because of the excessive plant forces backlog and because the job is out of schedule. The job was essentially complete at month end.
   b) The painting in 329, which could be scheduled at this time, was completed.
   c) The scheduled painting of the interior of 3745 Building was started at month's end. Construction forces had lined some of the walls and painted them the previous month.

2. Tiling

   a) The corridor in 3707-C Building was tiled.
   b) An order was issued to Construction forces to tile 3746 Building.

3. Significant Space Modifications:

   a) 326-306. The move of equipment to 306 was complete. The installation of some of the items is being deferred. The renovation of rooms 10A and 13A is progressing beyond 80%.
   b) 234-5 - 231-Z. Work has begun on the move of equipment from 234-5 to 231-Z Building.
   c) Approval was obtained to relocate TC-1 as 3718-C as a PRTR storage building.
   d) Approval was obtained to install new laboratory furniture, hoods and shielding in 222-U, Rm. 6. At the same time, the room is to be repainted, retiled, and the utility and exhaust systems refurnished.

Waste Disposal and Decontaminated Service

Quantities of Waste Removed:

	August	July
Concrete barrels	16	16
Loadluggers-hot waste	4	3
Milk pails	42	40
Gattling gun	0	2
Crib waste	340,000 gal.	305,000 gal.

Discussion

The number of concrete barrels and loadluggers remain relatively constant. Milk pails, however, fluctuate between 24 and 46. Crib waste gallonage increased from 255,000 in April to 340,000 in August. Part of this is attributable to 327-A air conditioning water which has been stopped.

The issuance of the report on crib waste handling has been deferred for a short time while Chemical Effluent Technology makes some short term studies.

Plant Engineering and Miscellaneous

Approximately 26,000 square feet of prints were reproduced during the month.

The total estimated value of the twelve requisitions issued during the month was $26,000. This procurement is primarily for approved HL projects.

The contingency maintenance work of research equipment moves is complete in 326 and 306 Buildings and work is in progress for 234-5 and 231-A buildings.

TC-1 Building will be relocated and installed on a foundation for use as a permanent storage building.

A work order has been issued to Plant Forces for changes to room 123 and 123-A of 328 Building. Field work to start in October.

Floor tile was installed in 3707-C Building and 3745 Building will be tiled next month.

Painting of the exterior of 328 Building is nearly complete.

Work continued on sealing the exposed walls and ceilings in the 3745 Building, and painting has started.

The following is a summary of [illegible] activity [illegible]

TECHNICAL INFORMATION OPERATION

Approval was received from the AEC on a revised section for the Hanford Classification Guide covering chemical processing activities. The significant changes relate to plutonium purification and reduction technology, most of which has been declassified. The changes of immediate interest to HAPO personnel were announced via HW-71000 "Classification: Chemical Processing".

A total of 29 pages were revised for the Hanford Classification Guide, HW-37965, incorporating the new chemical processing section and other changes recently authorized.

A conference was held with Data Processing and Business Systems Development personnel to explore the possibility of utilizing data processing equipment and personnel in the preparation of Key-Work-In-Contect (KWIC) indexes for such bibliographies as the NPR bibliography (HW-67261) and the PRTR title list (HW-66632).

Last month the backlog in Technical Publications was 33 reports. It reached a high of 38 this month even though we have been at full staff. New reports have been arriving on the average of one per working day. The PRTR annual (HW-7000) came to us on a priority basis on August 11 and was issued September 22.

Five-copy reviews are now being prepared at 300 Area Duplicating on their new Xerox 914 Copyflow. This procedure will simplify storage, handling and printing problems at 300 Area Duplicating and also facilitate last-minute typographical changes on duplimat masters.

Further study of the microfilming program continued during the month. The problem is that the original estimate of the number of documents unsuitable for microfilming was much too low. The Business Systems Development Operation, which includes the Records Management function at HAPO, is taking the position that our quality standards are too high and that more poor-copy documents can be satisfactorily microfilmed. A new microfilm reader-printer is being tried out (Recordak) which may give better reproduction than our 3M Machine. Some new guidelines for the selection of documents to be microfilmed will be developed.

Work is going forward in developing additional uses for the IBM 858 Card-a-type unit. A program using it to prepare revision sheets for Plant operating manuals has been completed. A plugboard for a generalized print-out program has also been wired. Principal problem is finding time in which to work in these added jobs. The unit is now busy all day long with document issuance and routing.

Work Volume Statistics

	August	September
Document Distribution and Files		
Documents routed and discharged (copies)	16,195	16,056
Documents issued (copies)	17,908	10,491
Documents sent off-site (copies)	8,116	4,912
Document reserves filled (copies)	423	774
Documents picked up and delivered	17,524	18,327
Document Accountability		
Holders of classified documents whose files were inventoried	279	173
Documents inventoried in Files (copies)	--	--
Documents destroyed or retired (copies)	3,493	5,607
Documents revised (copies)	894	1,113
Documents pulled and documents filed (copies)	15,241	11,127
Documents reclassified	442	173
Documents microfilmed	2,542	1,824
Accountable copies of SECRET and DOCUMENTED	194,444	197,256
Reference and Publication		
Books cataloged (new titles)	104	163
Books added to the collection (volumes)	209	202
Ready reference questions answered by professional staff	140	140
Literature searches by professional staff	71	79
Reports abstracted (titles)	229	268
Formal reports prepared (titles)	18	10
Off-site requests for HAPO reports (copies)	303	161
Reports released to CAP (titles)	36	24

	August	September
Library Acquisitions and Circulation		
Books ordered (volumes)	425	430
Periodicals ordered	97	84
Books circulated (volumes)	1,694	2,195
Periodicals circulated (issues)	3,273	3,737
Inter-Library Loans	83	78
Films borrowed or rented	4	36
Industrial film showings	49	52
Bound periodicals added to the collection	87	153
Bound periodicals discarded	18	14

Library Collection

	Main Library	W-10 Library	108-F Library	Ind.Med.	Total
No. of books	32,226	8,700	1,855	2,080	44,861
No. of bound periodicals	15,056	17	1,933	23	17,029
	47,282	8,717	3,788	2,103	61,890

Classification and Declassification

	August	September
Documents, including drawings and photographs reviewed for downgrading or declassification	67	53
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	38	29
Documents submitted to Declassification Branch, Oak Ridge	3	3

J. L. Boyd
Manager
Laboratory Auxiliaries

JL Boyd:jw

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222 H

DATE 9-30-61

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 9-3-61	$ 1,087,408
			ESTIMATED TOTAL COST	$ 1,120,000

STARTING DATES			EST'D. 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. 5-1-62	

ENGINEER

REDO - DP Schively

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I	100	100	100
GE-TIT. II			
AE-TIT. II			
CONST.	100	100	93
PF			
CPFF	17	100	91
FP	7	100	100
Govt. Eq.	76	100	92

SCOPE, PURPOSE, STATUS & PROGRESS

An internal safeguards review has indicated that the NaK heater will have to be replaced by a more conventional type unit, alternate designs are now under consideration. Removal of the NaK heater is in progress.

PROJ. NO.	TITLE	FUNDING
CAH-842	Critical Reactivity Measuring Facility	58-e-15

AUTHORIZED FUNDS				
$ 360,000	DESIGN $ 45,000 / CONST. $ 315,000	AEC $ 148,000 / GE $ 212,000	COST & COMM. TO 9-3-61	$ 175,830 (GE)
			ESTIMATED TOTAL COST	$ 360,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 11-17-59 / CONST. 10-3-60	DATE AUTHORIZED	DIR. COMP. DATE 8-15-61	DESIGN 2-1-61 / CONST. 11-30-61	

ENGINEER

REDO - WS Kelly

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	100	78
PF			
CPFF	57	100	61
FP	43	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

A revised project proposal requesting an extension of the scheduled completion date is being circulated for approval. A new schedule will be submitted when it is approved.

The instrumentation console has been received.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CGH-857	Physical & Mechanical Properties Testing Cell - 327 Bldg.	0290

AUTHORIZED FUNDS				
$ 460,000	DESIGN $ 57,000 / CONST. $ 403,000	AEC $ / GE $ 460,000	COST & COMM. TO 9-17-61 / ESTIMATED TOTAL COST	$ 74,945 / $ 460,000

STARTING DATES			ESTD. COMPL. DATES	
DESIGN 11-2-59 / CONST. 5-15-62	DATE AUTHORIZED 9-22-61	DIR. COMP. DATE 12-15-62	DESIGN 3-15-61 / CONST 12-15-62	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		540
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT.II	100	100	100
AE-TIT.II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in the 327 Building.

Directive No. HW-498, Mod. 2 dated September 22, 1961, releasing total project funds has been recieved by the General Electric Company.

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 9-17-61 / ESTIMATED TOTAL COST	$ 307,242 / $ 400,000

STARTING DATES			ESTD. COMPL. DATES	
DESIGN 11-1-59 / CONST. 5-15-61	DATE AUTHORIZED 10-1-59	DIR. COMP. DATE 2-28-62	DESIGN 2-15-61 / CONST. 2-28-62	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	3	140
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		35
DESIGN ENGINEERING OPERATION		716
GE FIELD ENGINEERING	.2	6

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT.II	95	100	100
AE-TIT.II			
Vendor	5	100	100
CONST.	100	13	13
PF			
CPFF		13	13
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to prepare specimens from irradiated materials for use in determining their physical and mechanical properties and involves the installation of a cell in 327 Building.

Construction of the next phase is being scheduled to conform to receipt of cell castings. These are expected about 12-1-61.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222 H

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CAH-866	Shielded Analytical Laboratory - 325-B Building	61-a-1

AUTHORIZED FUNDS					
$ 700,000	DESIGN $ 60,000	AEC $ 546,500	COST & COMM. TO 9-17-61	$ 28,110 (GE)
	CONST. $ 640,000	GE $ 153,000	ESTIMATED TOTAL COST	$ 700,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 9-5-59	5-31-60	DESIGN 11-15-60	
	CONST. 6-28-61	DIR. COMP. DATE 6-30-62	CONST. 6-30-62	

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	12	445
COST PLUS FIXED FEE		
PLANT FORCES	0	3
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	10	100	100
AE-TIT. II	90	100	100
CONST.	100	14	12
PF	3	1	1
CPFF	2	0	0
FP	95	10	9

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.

Contractor is preparing to pour slab under cells and is backfilling around outside walls.

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 9-17-61	$ 508,068 (GE)
	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 3-15-61	
	CONST. 11-2-60	DIR. COMP. DATE 6-30-62	CONST. 6-30-62	

ENGINEER

REDO - PC Walkup

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		400
COST PLUS FIXED FEE	14	696
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	26*	24
PF	2	0	0
CPFF	57	25	24
FP (1)	10	100	100
(2)	31	5	2

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Company
(2) Lewis Hopkins Construction Company

*Revised scheduled has been approved.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222 H

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-h-1

AUTHORIZED FUNDS				COST & COMM. TO 8-31-61	$ 359,855
$ 420,000	DESIGN $ 44,000	AEC $ 400,000		ESTIMATED TOTAL COST	$ 420,000
	CONST. $ 376,000	GE $ 20,000			

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	8-8-60	DATE AUTHORIZED 9-2-60	DESIGN	3-31-61
CONST.	7-10-61	DIR. COMP. DATE 3-31-62	CONST.	6-15-62

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	9	485
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	36	20
PF	1	30	30
CPFF			
FP	99	36	20

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides additional space for biological research supporting services, and involves and addition to the 108-F Building.

First floor slab and radiation and control room walls to second floor have been poured. Pipe sleeves, conduit air ducts and outlets were installed. Air conditioning equipment drawings were returned to vendor for resubmittal. Structural steel is being fabricated. Indications are that Allied Engineering are overloaded in their design organization. We have been advised they have not started work on our order.

PROJ. NO.	TITLE	FUNDING

AUTHORIZED FUNDS				COST & COMM. TO	$
$	DESIGN $	AEC $		ESTIMATED TOTAL COST	$
	CONST. $	GE $			

STARTING DATES			EST'D. COMPL. DATES	
DESIGN		DATE AUTHORIZED	DESIGN	
CONST.		DIR. COMP. DATE	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

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CAE-896	Stress Rupture Test Facility	60-1

AUTHORIZED FUNDS					
$ 90,000	DESIGN $ 7,500	AEC $ 78,500	COST & COMM. TO 9-17-61	$ 11,476 (GE)
	CONST. $ 82,500	GE $ 11,500	ESTIMATED TOTAL COST	$ 90,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	7-29-60	3-6-61	DESIGN	12-1-60
CONST.	3-20-61	DIR. COMP. DATE 10-15-61	CONST.	12-15-61

ENGINEER

FEO - H Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	1	375
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	98	81
PF	2	100	100
CPFF			
FP	98	100	85

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

The construction phase of the job is essentially complete; however, overall completion has lagged badly because of lack of receipt and installation of equipment.

The major equipment item holding up completion is the instrument panel assembly which is being done by Coates Electric in Seattle for Minneapolis-Honeywell. This fabricator was contacted by phone and it was established that all material including the Foxboro instruments, is on hand. However, the earliest shipping promise was October 6. The high pressure valves were shipped September 12, but to date have not been received. Two of the six accumulators failed to pass inspection because of inclusions shown by the magnetic particle test. Three passed the hydrostatic pressure test when the vendor's equipment broke down. The contractor is being notified to expedite shipment of the successful units so that as much of the installation as possible can be completed.

Because of these further delays it is becoming more evident that the project completion date will not be met. This has been indicated to the Commission with regard to action that may be taken to extend the project completion date.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CAH-901	Structural Material Irradiation Test Equipment - ETR	0290

AUTHORIZED FUNDS					
$ 125,000	DESIGN $ 12,000	AEC $	COST & COMM. TO 9-17-61	$ 84,868
	CONST. $ 113,000	GE $ 125,000	ESTIMATED TOTAL COST	$ 125,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 9-15-60	9-2-60	DESIGN 3-31-61	
	CONST. 6-26-61	DIR. COMP. DATE 10-15-61	CONST 10-15-61	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		700
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	89	98
PF	100	89	98
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides for the installation of equipment at the ETR for which changes in the physical properties of reactor structural materials subjected to in-reactor conditions can be determined.

Installation is complete except for some lagging of pipe in the sub-pile room and corrections to instrumentation.

PROJ. NO.	TITLE	FUNDING
CGE-902	Uranium Scrap Burning Facility	61-j

AUTHORIZED FUNDS					
$ 36,000	DESIGN $ 5,000	AEC $ 27,500	COST & COMM. TO 9-17-61	$ 5,750 (GE)
	CONST. $ 31,000	GE $ 7,500	ESTIMATED TOTAL COST	$ 36,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 5-15-61	12-15-60*	DESIGN 7-25-61	
	CONST. 9-12-61	DIR. COMP. DATE 12-31-61	CONST 12-31-61	

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	20	20
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a means of making uranium scrap material safer for storage and off-plant shipment by converting this scrap to a stable uranium oxide. The facility will be adjacent to the 333 Building.

*Accepted by the General Electric Company 5-17-61.

Construction was started September 12, 1961.

SEMI – MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. – Hanford Laboratories

HW- 71222 II

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CAH-914	Rattlesnake Springs Radioecology Facility	61-j

AUTHORIZED FUNDS					
$ 90,000	DESIGN $ 3,400*	AEC $ 71,700	COST & COMM. TO 9-17-61	$ 14,444 (GE)
	CONST. $ 86,600	GE $ 18,300	ESTIMATED TOTAL COST	$ 90,000

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 3-1-61		12-22-60		DESIGN 6-15-61
	CONST. 7-12-61	DIR. COMP. DATE	10-31-61		CONST. 12-1-61

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	7	312
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS*	100
TITLE I			
GE-TIT. II			100
AE-TIT. II	100	NS*	100
CONST.	100	77	76.3
PF			
CPFF	7	0	0
FP	93	83.8	82

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow performance of radioecological studies under local environmental conditions. It consists of constructing field facilities for this purpose. Approval signatures for project drawings and specifications were obtained 5-31-61.

*Bovay Engineers. Contractor work started 7-13-61.

Mechanical spillways have been installed in both dams. Pond excavation has been completed.

The well has been drilled and accepted. Work is in progress on the fence installation, sewer piping and power line. Erection of the metal building started 9-6-61.

PROJ. NO.	TITLE	FUNDING
CAH-916	Fuels Recycle Pilot Plant	Funds Avail. to Comm.

AUTHORIZED FUNDS					
$ 100,000	DESIGN $ 100,000	AEC $	COST & COMM. TO 9-17-61	$ 100,000
	CONST. $	GE $ 100,000	ESTIMATED TOTAL COST	$ 5,000,000

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 3-1-61*		2-17-61		DESIGN 3-1-62
	CONST. 5-1-62	DIR. COMP. DATE			CONST. 7-1-64

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	14
TITLE I	11	100	100
GE-TIT. II	89	NS	4
AE-TIT. II			
CONST.	100	NS	
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

The revised project proposal for detail funds has been approved by HOO-AEC and was forwarded to Washington D. C. AEC for approval.

Mechanical design is developing wall plug-in cubicles for equipment in the Hot Pilot Cells.

Ventilation design studies for exhaust filters and fans were reviewed and a system with all fans exterior to the building selected.

Other design work has started on floor elevations and size and type of cranes required.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CAE-917	Field Service Center - Atmospheric Physics	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 154,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN	12-15-61*	DATE AUTHORIZED	DESIGN	3-15-61*		WT'D.	SCHED.	ACTUAL
CONST.	4-15-62*	DIR. COMP. DATE	CONST	9-1-62*	DESIGN	100		
ENGINEER					TITLE I			
FEO - JT Lloyi					GE-TIT. II			
MANPOWER		AVERAGE	ACCUM MANDAYS		AE-TIT. II			
FIXED PRICE								
COST PLUS FIXED FEE					CONST.	100		
PLANT FORCES					PF			
ARCHITECT-ENGINEER					CPFF			
DESIGN ENGINEERING OPERATION					FP			
GE FIELD ENGINEERING								

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities necessary to conduct atmospheric physics research and development programs.

*Based on AEC authorization by 11-1-61.

The AEC has advised General Electric Company that the letter to be sent to Washington is being reviewed by the various local AEC departments.

A meeting was called by the AEC to resolve questions raised by local AEC divisions. Answers to these questions have been presented by General Electric Company.

PROJ. NO.	TITLE	FUNDING
CAH-918	Second Whole Body Counter Cell - 747 Building	62-k

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 110,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN	11-1-61*	DATE AUTHORIZED	DESIGN	3-1-62*		WT'D.	SCHED.	ACTUAL
CONST.	7-1-62*	DIR. COMP. DATE	CONST.	5-1-63*	DESIGN	100		
ENGINEER					TITLE I			
FEO - KA Clark					GE-TIT. II			
MANPOWER		AVERAGE	ACCUM MANDAYS		AE-TIT. II			
FIXED PRICE								
COST PLUS FIXED FEE					CONST.	100		
PLANT FORCES					PF			
ARCHITECT - ENGINEER					CPFF			
DESIGN ENGINEERING OPERATION					FP			
GE FIELD ENGINEERING								

SCOPE, PURPOSE, STATUS & PROGRESS

Project Proposal Revision was submitted to the Commission on July 5, 1961. The Review Board deferred it indefinitely on July 13. It has been indicated that correspondence will be submitted by the Commission suggesting other lines of approach to strengthen the justification for this project.

No correspondence was received by 9-30-61.

*Based on Commission approval by 10-15-61.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222 H

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CAH-919	Air Conditioning - 314 Building	

AUTHORIZED FUNDS				COST & COMM. TO 9-17-61	$ 4,185 (GE)
$ 35,000	DESIGN $ 3,750	AEC $ 28,650		ESTIMATED TOTAL COST	$ 35,000
	CONST. $ 28,650	GE $ 6,350			

STARTING DATES		DATE AUTHORIZED 4-18-61	EST'D. COMPL. DATES	
DESIGN	5-2-61	DIR. COMP. DATE 9-15-61	DESIGN	7-5-61
CONST.	6-15-61		CONST.	11-1-61

ENGINEER

-FEO & OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		290
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	100
TITLE I			
GE-TIT.II		NS	100
AE-TIT.II			
CONST.	100	100	80
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will supplement existing cooling units, thus providing cooling air supply commensurate with heat load and outdoor temperatures.

Directive AEC-188, dated March 8, 1961, authorized the project and assigned management to the AEC. Work authority was issued 4-18-61, to the G.E. Company.

Two units are in operation. #3 unit installation is complete. Relocation of an existing unit and installation of unit #4 remains to be done. The pipefitters walkout has stopped installation progress on this project. Work will not be completed by the directive completion date.

PROJ. NO.	TITLE	FUNDING
CAH-921	Geological & Hydrological Wells - FY-61	61-1

AUTHORIZED FUNDS				COST & COMM. TO 8-31-61	$ 62,218
$ 79,000	DESIGN $ 1,000	AEC $ 69,500		ESTIMATED TOTAL COST	$ 79,000
	CONST. $ 78,000	GE $ 9,500			

STARTING DATES		DATE AUTHORIZED 3-21-61	EST'D. COMPL. DATES	
DESIGN	4-15-61	DIR. COMP. DATE 12-31-61	DESIGN	5-15-61
CONST.	5-22-61		CONST.	12-31-61

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	6	620
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			
AE-TIT.II		75	75
CONST.	100	57	61
PF	0		
CPFF	3	87	75
FP	97	56	61

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

Contractor is operating 2 rigs, each on a two nine-hour shift basis. Approximately 2900 ft. of hole has been completed.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222 H

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CGH-922	Burst Test Facility for Irradiated Zirconium Tubes	62-k

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO $
$	CONST. $	GE $	ESTIMATED TOTAL COST $ 228,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 11-15-61*		DESIGN 5-15-62*	
	CONST.	DIR. COMP. DATE	CONST. 12-1-62*	

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 was forwarded by HOO-AEC to AEC, Washington, with recommendation for authorization.

*Based on AEC authorization 11-1-61.

PROJ. NO.	TITLE	FUNDING
CAH-924	200 KW Induction Heating System - 306 Building	0290

AUTHORIZED FUNDS	DESIGN $ 3,200	AEC $ 24,650	COST & COMM. TO 9-17-61 $ 5,730 (GE)
$ 31,000	CONST. $ 27,800	GE $ 6,350	ESTIMATED TOTAL COST $ 31,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 5-1-61	3-27-61	DESIGN 7-1-61	
	CONST. 10-1-61	DIR. COMP. DATE 2-28-62	CONST. 1-1-62	

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	NS	90
TITLE I			
GE-TIT. II		NS	90
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.

J. A. Jones Purchasing placed an order 9-12-61 with Ajax for the induction heating work stations. Delivery is expected by 10-31-61.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222 ±

DATE 9-30-61

PROJ. NO.	TITLE	FUNDING
CAH-927	Additions to the 271-CR Building Waste Treatment Demonstration Facility	61-j

AUTHORIZED FUNDS					
$ 80,000	DESIGN $ 4,000	AEC $ 17,500	COST & COMM. TO 9-17-61	$ 11,378 (GE)
	CONST. $ 76,000	GE $ 62,500	ESTIMATED TOTAL COST	$ 80,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 6-15-61		DESIGN 10-16-61	
	CONST. 10-15-61	DIR. COMP. DATE 3-31-62	CONST. 3-31-62	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER	4	73
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	87	80
TITLE I			
GE-TIT. II			
AE-TIT. II	100	87	80
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.

Cost comparison between design at comment stage and the project proposal has resulted in reduction of design requirements to the minimum consistent with functional consideration.

PROJ. NO.	TITLE	FUNDING
CAH-932	300 Area Retention Waste System Expansion	62-k

AUTHORIZED FUNDS				
$	DESIGN $	AEC $	COST & COMM. TO	$
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 70,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 10-15-61*		DESIGN 1-1-62*	
	CONST. 2-1-62*	DIR. COMP. DATE	CONST. 6-1-62*	

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will increase the basin capacity commensurate with the increased volumes handled. This will permit transfer to crib waste of contaminated waste if required, and still permit adequate sampling time for the normal flow.

The project proposal was submitted to HOO-AEC for authorization on 5-5-61.

The proposal was returned unapproved on September 12, 1961, with a letter suggesting alternate solutions. These were reviewed for feasability and practicability. A letter is to be forwarded to the Commission following the review.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222 R

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CGH-935	Metals Storage Building	61-j

AUTHORIZED FUNDS					
$ 22,300	DESIGN $ 500	AEC $	COST & COMM. TO 9-17-61	$ 22,300
	CONST. $ 21,800	GE $ 22,300	ESTIMATED TOTAL COST	$ 22,300

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 1-2-61	6-16-61	DESIGN 2-10-61	
	CONST. 6-22-61	DIR. COMP. DATE 10-31-61	CONST. 9-29-61	

ENGINEER

FEO - DS Jackson

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	1	125
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	100
TITLE I			
GE-TIT. II	100	NS	100
AE-TIT. II			
CONST.	100		100
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a building adjacent to the 328 Building in which fabrication materials and components can be stored for use by the Technical Shops.

The project was completed September 29, 1961. A Physical Completion Notice is being prepared. This project will no longer be reported.

PROJ. NO.	TITLE	FUNDING
CAH-936	Coolant Systems Development Laboratory	62-k

AUTHORIZED FUNDS				
$ 12,000	DESIGN $ 12,000	AEC $	COST & COMM. TO 9-17-61	$ 12,000
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 93,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 9-8-61	8-9-61	DESIGN 1-1-62	
	CONST. 4-10-62	DIR. COMP. DATE	CONST. 10-10-62	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER - Bovay Engineers	.5	4
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	0
TITLE I			
GE-TIT. II			
AE-TIT. II	100	NS	0
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides facilities for the conduct of corrosion and decontamination studies for nuclear reactor coolant systems, by the addition of a 2700 sq. ft. laboratory facility on the west side of the 1706 KE Building.

A design schedule is in preparation.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71222

DATE 9-30-61

PROJ.NO.	TITLE	FUNDING
CGE-937	Safety Improvements to 231-Z Building	61-j

AUTHORIZED FUNDS				
$ 45,000	DESIGN $ 5,500 / CONST. $ 39,500	AEC $ / GE $ 45,000	COST & COMM. TO 9-17-61	$ 40,646
			ESTIMATED TOTAL COST	$ 45,000

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 7-12-61		6-29-61		DESIGN 9-29-61
	CONST. 7-10-61	DIR. COMP. DATE	5-15-62		CONST. 2-1-62

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	
TITLE I			
GE-TIT. II		NS	100
AE-TIT. II			
CONST.	100	12	10
PF			
CPFF	100	12	10
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides supplemental ventilation and installation of a fire detection system in the 231-A Building.

The work release to J. A. Jones has been issued for the entire amount of work. Procurement of materials has been started and bids for the exhaust fans and motors have been requested.

Bids for the exhaust fans have been received and all take off has been completed. Orders for material are being placed. Construction period has tentative been shortened to a completion date of February 1, 1962.

PROJ. NO.	TITLE	FUNDING

AUTHORIZED FUNDS				
$	DESIGN $ / CONST. $	AEC $ / GE $	COST & COMM. TO	$
			ESTIMATED TOTAL COST	$

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN				DESIGN
	CONST.	DIR. COMP. DATE			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

EMPLOYMENT (Professional)

Advanced Degree - Six Ph.D. applicants visited HAPO for professional employment interviews. Two offers were extended; three acceptances and three rejections were received. Current open offers total two.

Technical Graduate Program - Two Technical Graduates were placed on permanent assignments. Six new members were added to program rolls and five terminated. Current program members total eighty-eight.

EMPLOYMENT (Non-Professional)

Twelve requisitions were filled during the month with seventeen active requisitions remaining to be filled.

HEALTH, SAFETY AND SECURITY

Preparation of the new Health and Safety Manuals has been completed. Distribution now awaits receipt of posts for the binders.

PERSONNEL DEVELOPMENT

One hundred sixty Laboratories employees are currently enrolled in seven courses offered by the Laboratories. Four of the seven courses are technically oriented and account for ninety-eight enrollments. In addition, ninety-two Laboratories employees have submitted tuition refund applications for fall courses, thus making a total of two hundred fifty-two employees engaged in educational pursuits.

for O. E. Boston, Manager
Professional Placement
and Relations Practices

OEB:lmh

TABLE II PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1961 to date

	Visits to Richland			Offers			
	Cases Considered	Invited	Visited	Offered	Accepted	Open	On the Roll
PhD	95	2	7	2	3	2	2
Exp. BS/MS	18	1	1	1			
Prog. BS/MS	No Action						

B. Technical Recruiting Activity - HL - September 1, 1961 to date

	Visits to Richland			Offers			
	Cases Considered	Invited	Visited	Offered	Accepted	Open	On the Roll
PhD	95	2	7	2	3	2	2

In addition to the above activities, 1 exempt employee has transferred into HL from other HAPO departments and 1 technical graduate has accepted off-program placement in HL to date.

C - Technical Graduate Program
Month ending September 30, 1961

Number Personnel on Assignment	88
(HAPO Tech Grad Program 73	
(Engineering & Science Program 15	

Distribution of Assignments by Departments

IPD	33
HLO	36
CPD	11
FPD	6
C&AO	1
CE&UO	1

Distribution of Assignments by Function

Research & Development or Engineering	63
Other	25

FINANCIAL OPERATION MONTHLY REPORT
SEPTEMBER 1961

Personnel

There were no personnel changes in Financial Operation during the month.

Activities

GENERAL ACCOUNTING OPERATION

Following is the status of approval letters seeking Commission concurrence in proposed actions:

Number	Title	Status
AT-52	Expanded Use of Whole Body Counter	In hands of Commission since 6/29/61. AEC feels further study is required.
AT-104	Fission Products Dispersal Handbook	Addendum No. 1 to include Dr. Gamertsfelder in process.
AT-105	Symposium on the Biology of Trans-uranic Elements	Washington AEC still consider-ing.
AT-182	Technical Advisory Board on Radiation Control	Approved 10/2/61.
AT-187	Proposal for University of Washington Library School Student Practice Work in Technical Information Operation.	Approved 9/25/61.
AT-188	National Committee on Radiation Pro-tection and Measurements.	Approved 9/27/61.
AT-194	Participation in Standardizing Activities	In process - not yet submitted to AEC.

The following actions under Agreement AT-6 were agreed to by the Company and the AEC:

Irradiation Samples for Phillips Petroleum Company	9/26/61
Participation in IAEA Panel	9/21/61
Cooperative Research Project - Reed College	9/11/61
Joint U.S. Euratom Research and Development Program	9/7/61
Appointment of Dr. B. R. Leonard to Advisory Group	9/29/61

Travel during the first quarter of the current fiscal year has been at a much lower level than in FY 1960 and FY 1961 as shown below:

	FY 1962	FY 1961	FY 1960
July	78	81	83
August	89	103	109
September	91	130	94
Total	258	314	286

The following new or revised OPG's were issued in September:

New	Revised	Number	Title
X		33.5.1	Use of Project Work as Research for University Thesis
	X	22.1.10	Technical Administration Operation Organization
	X	9.2	Procurement of Equipment, Materials, Services and Supplies
	X	3.4.5	Attendance Recognition Plan
	X	3.4.6	Employee Service Recognition Plan

A draft of HAPO OPG 5.2 - Acquisition of Plant and Equipment was reviewed and comments submitted to Contract and Accounting Operation for incorporation in the OPG.

The fifty Relations OPG's were reviewed with the Manager, Technical Administration for changes required due to the recent reorganization.

Twenty-five revisions were received to the AEC Manual. The details to these revisions are covered in a separate report to Section Managers.

Six requests for the establishment of new forms were received and processed.

Action as indicated occurred on the following projects during the month:

New Money Authorized HLO

CGH-857 Physical and Mechanical Properties Testing Cells, 327 Building $385,000

Physical Completion Notices Issued

AEC-167 Plutonium Recycle Test Reactor (AEM Services Only)

A physical inventory of HLO 300 Area fixed property was started during the month of September. When finished in October, this will complete HLO's fixed property inventory. The inventory count is being taken by C&AO personnel assisted by HLO Financial and custodial personnel.

Preparations are being made to transfer custodianship of the Hot Semi-Works from Hanford Laboratories to Chemical Processing Department, effective October 1, 1961.

Plans have been made for two members of the HLO Property Accounting to visit the ETR and MTR Plant Site at Arco, October 9 through October 12. Units of property acquired on Projects CA-681 and CAH-901 will be the subject of the visitation. The combined dollar impact on HLO Plant records for these two projects is in excess of $1.1 million.

Preparations were completed for the physical inventory of movable cataloged property in custody of Biology to start October 16, 1961, and continue through November 6, 1961.

Reports were issued on results of the physical inventory of movable equipment in custody of Reactor and Fuels R&D, Laboratory Auxiliaries and Calibrations Operation. Inventory results in connection with the inventory of Laboratory Equipment Pool movable property were forwarded to C&AO for completion of reconciliation. These inventories disclosed the following shortages:

Reactor and Fuels	Nine items	$1 408
Laboratory Auxiliaries	One item	2 038
Calibrations	--	--
Laboratory Equipment Pool	--	--
	Ten Items	$3 446

The annual physical inventory of precious metals and special materials in custody of 97 HLO holders was taken on September 27, 28, and 29, 1961. In accordance with established practice this inventory was witnessed by Financial personnel. Reconciliation of the inventory findings is in progress and upon completion a report of results will be issued. Total HLO investment at August 31, 1961, for this type of material was $1,349,310 which represents 89.4% of total HAPO investment ($1,509,178).

We have received from Nuclear Materials, notification that forthcoming Survey 19, Part I will consist of a verification of HAPO inventories of normal uranium, tritium, deuterium, and enriched lithium, as of the end of October 1961. A team consisting of HOO-AEC personnel and a member of the Nuclear Materials Operation will witness physical inventories.

A listing itemizing equipment stored in the Laboratory Equipment Pool as of August 31, 1961, was published and distributed within HLO and to interested personnel in other components.

Sixty-eight items valued at $219,389 were received at the Laboratory Equipment and Material Pool during the month. The bulk of this material which has a value of $205,638, is being held for the convenience of others and includes 54 drums of normal uranium valued at $169,872. Twenty items valued at $9,298 were loaned or transferred in lieu of placement of requisitions and five items valued at $4,075 were withdrawn by custodians. There are currently 863 items valued at $535,938 physically located in the Pool of which 142 items valued at $20,003 are uncataloged type items and 103 items valued at $250,332 are being held for the convenience of others.

Heavy Water losses chargeable to operating cost for the month of September amounted to $49,093, representing $3,919 scrap material and $45,174 (BPID) loss. This includes an adjustment to the reported August loss which was understated 2230 lbs., valued at $31,131.

COST ACCOUNTING OPERATION

Work on the preparation of the FY 1962 Mid-Year Budget Review will be held to a minimum during October due to (1) the present funding problem related to the Plutonium Recycle Program, and (2) the current uncertain status of the supplemental programs submitted in the FY 1962 Revised Budget. The FY 1962 Revised Budget will be relied upon to the extent practicable until receipt of a firm financial plan and the current problem of funding PRTR Operations is resolved.

At the request of the Atomic Energy Commission, the 06 Program supplemental research and development proposals submitted in the Budget for FY 1963 and Revision of Budget for FY 1962 were revised and resubmitted to reflect comments of Washington-AEC personnel on the level and direction of the proposed research.

One special request code was established during the month as follows:

Accounting Code	Activity
.4L	Fabrication of irradiated samples for Phillips Petroleum Company. Authorized amount - $54,000.

Work identification code .99 was assigned to accumulate costs of salary, continuity of service, and travel of J. C. Tverberg while participating in Euratom. Mr. Tverberg will be associated with this joint U. S. - Euratom Research and Development Program for one year. Funds will be made available to Hanford Laboratories in the next financial plan under Budget Activity 04-03-01-000, Euratom.

A special report concerning estimated costs of solid waste disposal by Hanford Laboratories in the 300 Area for FY 1961 was prepared and submitted to Contract Accounting as requested. Labor, maintenance and other related operating expenses were estimated at $30,000 for the fiscal year and depreciation on related capital equipment was estimated to be $1,300.

Considerable effort was devoted to detailed analysis of PRTR operating costs for FY 1961 and FY 1962 costs-to-date to facilitate the planning and forecasting of FY 1962 PRTR operating costs.

GENERAL

Interviews of staff personnel were completed for collection of data in our Study of Technical Reporting Practices. Study results have been assembled into a draft that is now being typed in final form.

Definitions were resolved on policies concerning performance of systems and procedures studies, and of areas to be studied by Business Systems Development Operation representatives.

A study report of Blue Cover Document publication procedures was issued by BSDO. The report contained generally worthwhile recommendations for shortening document publication time. Depending on managements' acceptance, it is planned to introduce the changes during October.

Assistance was given to a representative of the Records Center in arranging a plan to set up improved records retention and disposal schedules for Hanford Laboratories Research and Development components.

Eight separate investigations of Hanford Laboratories practices were carried out at the request of the GE Traveling Auditors.

W. Sale
Manager - Finance

W Sale:bk
October 12, 1961

INVENTIONS OR DISCOVERIES

No inventions or discoveries reported for September.

END

DATE FILMED

4/9/93