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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT

OCTOBER, 1961

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NOVEMBER 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
OCTOBER, 1961

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November 15, 1961

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TABLE I. HLO FORCE REPORT

DATE: October 31, 1961

	At beginning of month		At close of month		Total
	Exempt	Salaried	Exempt	Salaried	
Chemical R & D	124	116	125	118	243
Reactor & Fuels R & D	200	186	198	189	387
Physics & Instrument R & D	92	59	94	60	154
Biology	33	48	34	47	81
Operations Res. & Syn.	18	4	18	4	22
Radiation Protection	38	96	38	93	131
Laboratory Auxiliaries	47	186	34	134	168
Financial	19	15	19	16	35
Technical Administration	100	10	104	59	163
Programming	18	4	18	4	22
General	4	3	4	3	7
TOTAL	693	727	686	727	1413

BUDGETS AND COSTS

October operating costs totaled $2,310,000; fiscal year-to-date costs are $9,246,000 or 35% of the $26,556,000 control budget. Hanford Laboratories' research and development costs for October, 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 Programs	$ 53	$ 45	$ 171	$ 605	28%
04 Programs	974	1 015	3 880	10 150	38
05 Programs	69	76	265	993	27
06 Programs	206	232	829	2 720	30
	1 302	1 368	5 145	14 468	36
FPD Sponsored	130	121	482	1 400	34
IPD Sponsored	112	123	447	1 325	34
CPD Sponsored	164	130	533	1 570	34
Total	$1 708	$ 1 742	$6 607	$18 763	35%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

NPR fuel development continued with the irradiation of the first full-sized NPR tube-tube element in the ETR loop. The irradiation is continuing without incident.

Although the swelling observed in five NPR inner tubes irradiated to 2100 MWD/T was slightly higher than expected, no observable warp or other ill effects were noted.

It has been demonstrated by in-reactor rupture tests that the rapid in-reactor corrosion rate of NPR fuels is a consequence of fuel cracking rather than an inherently more rapid corrosion rate of irradiated uranium metal.

A preliminary evaluation of the single tube segregated-enrichment fuel element concept is to be obtained by an irradiation of an experimental element in the 6x6 M3 loop of the ETR. The fabrication of the element and associated hardware for this test has been started. This concept is an alternate to the NPR tube-tube design.

Tests with irradiated NPR-type fuel tubes which were defected and ruptured ex-reactor continue to show the desirability of cooling the water to 200 C as soon as possible. Two recent ex-reactor tests compare favorably in rupture rate and apparent mechanism with the last two ETR in-reactor rupture tests.

Additional boiling burnout data were obtained for the inner surface of the inner tube of the NPR fuel element. Under certain conditions burnout occurred unexpectedly at a point upstream of the outlet end. However, this does not change the boiling burnout safety factor for the NPR fuel element.

NPR shielding studies indicated that radiation leakage through the front shield would be greater than design tolerances. A recommendation that the front face biological shield be changed to 245 lb/ft^3 density iron-serpentine concrete was adopted.

Service failures of 420 stainless steel and 1075 carbon steel "Truarc" retaining rings employed on the old reactor front nozzles have been duplicated in the laboratory and appear to be due to hydriding lowering the static fatigue limit. From laboratory tests to date, Ph 15-7 Mo steel rings are the most promising replacement ring material.

The presence of hydrogen in excess of the solubility limit in Zircaloy increases the post-breakaway corrosion rate in 400 C steam by a factor of 2 to 3. Repetitive thermal cycling also increases the long-term corrosion rate of Zircaloy, but to a substantially smaller degree.

No significant hydriding was found in the Zircaloy-2 process tube recently removed from KER Loop 3. Examination was at the maximum flux location.

Continued improvements were shown in most phases of PRTR operation during October. A continuous 10-day run at full power was concluded on October 31. Heavy water losses during this run averaged about 50 pounds per day based on stack gas samples. Over-all operating efficiency during October was a highly satisfactory 56.5%.

Monitoring of eight PRTR Zircaloy process tubes in-reactor during the late September outage revealed continued satisfactory observations. Further examination of tube #1154, removed in July, revealed no hydriding or white corrosion product at the base of the deepest (5 mils) wear-corrosion groove.

Four 19-rod cold swaged UO_2 fuel elements, inspected during a recent PRTR outage, showed no evidence of loosening of the wire wraps, crud buildup, or serious surface damage.

UO_2 fuel elements of the nested tubular design and 19-rod elements fabricated by hot swaging, cold swaging, and vibrational compaction are ready for charging in the PRTR at the next outage.

Zircaloy-clad, UO_2 fuel elements containing one-eighth inch diameter particles of fully enriched UO_2 (PuO_2 stand-in) have operated successfully for an extended period in the MTR. The local heat flux is estimated to be nearly ten times that found in the PRTR.

Swaged UO_2 capsules clad in Zircaloy have been discharged from the MTR after being irradiated to 53,000 MWD/T.

A single crystal of arc-fused UO_2 was discharged from the ETR after irradiation to an exposure of 8900 MWD/T.

An adaptation of the conventional vibrational compaction technique to permit the fuel to be vibrated from a beam suspending the specimen is being developed as a means of eliminating potential contamination hazards which may be present in the refabrication of partially decontaminated UO_2.

The first irradiation cycle for the 6.25 w/o Pu-240 Phoenix capsule (GEH-21-1) has been successfully completed in the MTR, and after a ten-day cooling period, reactivity measurements were made in the ARMF.

Examination of the aluminum-plutonium intentional rupture element by Radiometallurgy indicated that none of the wires had loosened and the element was generally unaffected as a result of irradiation. Only a small amount of corrosion was noted at the point of rupture.

A set of PuO_2 pellets pressed from powder derived by a 550 C air calcination of the oxalate was heated to various temperatues in high vacuum ($\sim 3 - 5 \times 10^{-5}$ mm Hg) in order to study the thermal compositional stability in very low oxygen pressures, simulating fuel core environment. Reduction occurred slowly at temperatures up to 1740 C while at 1900 C reduction was considerably greater.

The effective depth of oxidation of large graphite pieces has been shown to be only half that previously believed. This has a favorable effect on interpretation of any potential EGCR burning hazard.

An in-reactor creep test was conducted at 600 C on 20 percent cold worked Zircaloy-2. Comparison of the in-reactor rate to that measured in an identical ex-reactor test indicated that there was no

effect of neutron irradiation at this temperature. A third generation creep capsule was modified by the insertion of water cooling coils around the specimen. Bench tests indicate that excess gamma heat will be dissipated by these coils.

Seventy percent cold worked Zircaloy-2 was found to suffer less reduction in uniform elongation than annealed Zircaloy-2 after an exposure to 10^{19} nvt. It is also observed that the transverse and longitudinal properties of the irradiated alloy differ less for the cold worked condition than for the annealed condition.

2. Chemical Research and Development

A second hot cell test of the recovery of technetium-99 from Purex 103-A waste supernate by strong base ion exchange resulted in the recovery of five grams of product at a concentration of 0.42 g Tc/l. Decontamination factors of 190, 21,000 and 280 were realized for cerium, cesium and zirconium-niobium, respectively.

Strontium-90 recovery activities in the Hot Semiworks were concluded on October 14, 1961, with the transfer of the facility to the Chemical Processing Department. Preliminary material balances for the program indicate a recovery of over 800,000 curies of strontium-90, of which over 700,000 curies met product specifications.

The final run in the strontium recovery campaign resulted in successful demonstration of the technical feasibility for the simultaneous recovery of strontium-90, cerium-144, and a cerium-free rare earth concentrate. Although the recovery efficiencies for fission products other than strontium-90 were less than desired, these were caused by force-fitting the recovery process and operation to existing Hot Semiworks equipment.

Laboratory studies have confirmed that the presence of colloidal iron in influent river water can affect the efficiency of arsenate removal by the high alum, reactor water treatment process. In a laboratory simulation of this treatment, greater than 94 percent removal of arsenate was achieved even in the presence of colloidal iron at pH 7. At pH 6.75, however, arsenate removal was only 77 percent in the presence of colloidal iron vice 96 percent in its absence.

Promising results were obtained on the use of film "poisoning" agents to reduce absorption of parents of radioisotopes onto reactor tube surfaces. Of many such reagents tested to date, octadecylamine acetate shows the greatest promise, reducing arsenate adsorption by a factor of about ten one-day after its addition.

The detection limit for I-131 in milk has been improved in keeping with new requirements of the Federal Radiation Council. Concentration by anion exchange of the I-131 in a 20-liter milk sample allows analysis at the 1 μμc/liter level. Direct gamma counting of a 3-liter sample between two 9-in. x 4-in. sodium iodide detectors allows analysis at the 3 μμc/liter level.

Refined chronopotentiometric measurements have disclosed that cathodic reduction of uranyl ion to UO_2 in molten chloride systems proceeds stepwise through a soluble uranium(V) state.

Exploratory studies aimed at effecting cleaner separation of plutonium from uranium and rare earths via precipitation of PuO_2 out of lower melting molten chloride systems where plutonium(IV) can be stabilized are being made. Addition of MgO to a LiCl-KCl melt during a chlorine sparge at 550 C resulted in the precipitation of about 80 percent of the plutonium and, unexpectedly, about five percent of the uranium also, for a separation factor of about 15.

Electron microscope studies have shown particulates in the off-gas from the Radiant Heat Spray Calciner to be in the range 0.01-0.1 microns. Conventional wet scrubbers give poor removal of particles in the size range as evidenced by the fact that a Peabody scrubber gave essentially no removal. A new approach termed the electrostatic bubble scrubber gave decontamination factors of 10 to 15, however, and an effluent dust loading of about 20 $\mu g/ft^3$.

A Micro Pilot Plant Run is being made to determine the effectiveness of the combined use of Amberlite IR-120 and clinoptilolite for the extraction of long lived fission products from Purex condensate waste. To date, strontium-90 and cesium-137 concentrations in the effluent have not exceeded their respective MPC_w's after the treatment of about 20,000 column volumes of waste.

The results of previously conducted soil column tests showed that existing Redox plant cribs, with two exceptions, have estimated remaining lives for radioisotope removal in excess of ten years. The exceptions are the 216-SL-1 and 2 (Redox laboratory and 300 Area wastes) cribs which have an estimated useful life of 3 to 6 years.

Decontamination of plutonium from ruthenium by anion exchange was tested using Redox II BP. Results were encouraging, the test yielding a ruthenium decontamination factor of 450 and a product of acceptable chemical purity.

3. Physics and Instrument Research and Development

Additional relaxation of critical mass limitations in the 234-5 Building will result from further in-hood experiments of the type reported last month. During the current month these techniques were applied to three storage hoods with the result that current limits for these hoods can now be substantially increased.

In the Critical Mass Laboratory, experimental work continued to gather data on plutonium nitrate solutions. To date a total of twenty-three criticality determinations has been made. In addition to current determinations, equipment improvements under development include: liquid level measurement, semi-conductor neutron detectors for buckling measurements, a new type period meter, and a control rod drive assembly.

Establishment of shipping rules for 3% enriched, dry UO_3 will be substantially aided by results obtained from the calculational side of the critical mass program. These Monte Carlo type calculations gave results in good agreement with existing experimental data for mixtures with higher hydrogen content and may thus be extrapolated to the dry condition (atomic ratio of hydrogen to uranium less than unity) with some confidence. According to the calculations 3% enriched UO_3 in this dry condition will not be critical in any amount.

Extensive nondestructive tests were made on NPR primary loop piping at the request of IPD. Radiographic, ultrasonic, and fluorescent penetrant tests, including special adaptations, were made on weld beads in thick-walled pipe sections at the Pasco HUICO shop, and on samples in the 306 Laboratory. Radiography did not resolve fine discontinuities in the weld. Although analysis of the ultrasonic tests is not yet completed, difficulties have been encountered from interfering signals from minor laminations in base metal near the weld. Small intergranular cracks in the weld have been detected by sectioning and macro-etching.

Process tube distortions at C, D, and F reactors were measured with the Mark I optical traversing devices. Test results indicated a need for better sensitivity and readability. Appropriate improvements have been devised for the Mark II model now being fabricated.

In order to obtain some insight on the need in the Plutonium Recycle Program for irradiation experiments in neutron spectra other than that available in PRTR, plutonium burnups in a variety of neutron spectra were calculated. The analyses indicated that such experiments, properly controlled, could provide useful data for checking burnup analyses.

Continuing effort was applied to several physics computer codes during the month. MELEAGER was revised to include provisions for maintaining a stepwise constant reactivity by varying the SDPV, slowing down power. The RBU basic library updating was completed and analyses of plutonium and uranium solutions for code checking purposes continued. A program for updating the G-2 nuclear data tape using the RBU basic library data was completed. Program HET to calculate the eigenvalue and fluxes for a heterogeneous reactor is being revamped in an attempt to get more accurate answers to PRTR Pu loadings. An informal report on HFN is being processed for reproduction.

Experimental information on the neutron energy spectrum in a plutonium fueled reactor was obtained from a plutonium nitrate experiment in the PCTR. The observed substantial increase of "neutron temperature" over moderator temperature will aid in obtaining insight into the adequacy of calculational methods when applied to plutonium.

The theory of the multiple-parameter eddy current nondestructive test method for detecting and identifying small individual test parameter changes has been experimentally confirmed in a four-variable test simulation.

Expensive machining costs for large, scintillation-detector light pipes can be reduced by a new plastic casting technique. For example, $800 to $1000 per instrument can be saved in fabricating the new six-probe alpha-beta-gamma monitor.

Two consecutive months of satisfactory operation for the coincident-count alpha air monitor show that the system will reliably alarm in about one hour for a continuous Pu-239 air concentration of 2×10^{-11} $\mu c/cc$ (10 MPC), even with abnormally high radon-thoron background concentrations.

An invention report was filed on a Pulse Triggered Semi-Conductor Tone Generator, an improved aural alarm for radiation protection instruments.

In Air Force-supported programs, data summaries for the first series of atmospheric diffusion experiments conducted at Vandenberg Air Force Base, California, were forwarded to the Air Force for further analysis. A total of 52 field trials were included, embracing a wide range of atmospheric stabilities and wind speeds over rough coastal terrain. Several experiments conducted during periods of fog were also included.

4. Biology

Evidence continues to accumulate that the incidence of the fish disease columnaris increases with crowding of fish. Further, there are some good indications that columnaris does not infect salmon since gill lesions on these fish would not yield any of the organisms, whereas scrap fish did yield columnaris. In addition, a strain of columnaris organisms with intermediate virulence did not change virulence when irradiated by tritium.

The 1961 salmon survey of spawning in the vicinity of Hanford was initiated during November. The survey was started one or two months late due to the delay in obtaining a charter airplane from which to make the survey. Difficulties were encountered in spotting salmon nests due to the lateness of the season.

Because of the absence of any manifestation of toxicity among swine fed up to 125 μc Sr^{90}/day, a new feeding level of 3.1 mc Sr^{90}/day was initiated in three swine. It is hoped this very high level will show responses that can be found in lower level groups.

Triethylenetetraminehexaacetic acid (TTHA) orally administered to rats previously injected with plutonium removed all but 8 percent of the plutonium. DTPA administered under the same conditions left 13 percent. Preliminary evidence indicates that the new drug will probably be effective at non-toxic doses when orally administered.

In obtaining background data need for experiments designed to clarify effects of radiation on reproduction in a population, another enigma of nature was uncovered. The male insect (Tribolium confusum) are fecund the first day of adult life, but the females are not until the sixth day.

5. Programming

As a result of renewed AEC interest, computations are being made of the reactivity limited lifetime of plutonium fuels in an HLO reactor concept having different amounts of moderator in various zones to allow absorption of excess neutrons in fertile fuel rather than in control systems. The computational program includes comparison of this concept to a similar system, the Edlund Spectral Shift Reactor, and more particularly, to reactors employing the continuous, i.e., "graded," discharge fuel cycle wherein the excess neutrons from the fresh fuel are absorbed in the highest irradiated fuel to prolong fuel exposure.

In a final report on thorium-230 it is indicated that the resulting uranium-232 (and thorium-228) from power reactor irradiation of thorium-230 will be available in quantities and at costs such as to be highly favorable materials for application as radioisotopic power producers to logically compete with strontium-90, plutonium-238, cesium-137, promethium-147, and curium-242.

TECHNICAL AND OTHER SERVICES

Statistical designs for three production tests were presented to personnel from feed sites for approval and action. The concept of including feed site variables in the design in order to remove the corresponding effects from the comparisons of interest represents a major change in the planning and execution of production tests on fuels.

A proposal to simulate reactor operations using a computer was submitted to IPD for comments and approval.

A tentative program for intensifying statistical studies concerned with all phases of the reactor tube leak problem has been agreed upon with IPD personnel.

Full-time system consultation in connection with the computer installation in 234-5 Building was completed early in October. The pertinence of the computer concept and the relative ease of system modification to accommodate process changes was successfully demonstrated.

In connection with plutonium purification and fabrication, the completion of a generalized linear regression program provided an opportunity to make a more comprehensive analysis of data obtained in process studies directed toward greater dimensional stability. The program is also being used to analyze data on the purity of the plutonium at the button stage.

A mathematical model for the diffusion of hydrogen in a zirconium-clad uranium core fuel element was constructed and a formal solution obtained. A solution was also obtained to a mathematical model for the study of steady state fluid flow from a multicompartment test well.

Further work was done on the algebra of four-state devices. Graphs were plotted showing time dependent probabilities of different states under several different conditions of input and output logic.

An interruptive package has been programmed so that all BIMD statistical routines can be used directly on the IBM 7090.

On September 26 the Federal Radiation Council published its second official memorandum for the radiation protection guidance of Federal agencies. The principal interaction with Hanford will be with the radionuclide iodine-131. Plans were made for the improvement on measurement techniques for iodine-131, and for reducing the local control limit for release of iodine-131 to the atmosphere.

A review of the number of unplanned whole body radiation exposures in excess of the local control limit of 1 r in 4 weeks shows that there have been six such cases in 1961. This frequency is abnormally high as compared to previous years and may indicate the need for more stringent control.

Sharp increases in the iodine-131 concentrations in milk and pasture grass were detected during the month. Commercial milk samples purchased locally indicated iodine-131 concentrations as high as 840 μμc/l. Iodine-131 concentrations in milk produced by locally pastured cows reached 550 μμc/l. These increases are apparently attributable to weapons debris from atmospheric testing, and are similar to measurements found in other areas receiving fallout.

One new case of plutonium deposition was confirmed by bioassay analysis during the month. The total number of plutonium deposition cases that have occurred at Hanford is 272, of which 197 are currently employed.

There are 18 currently active projects having combined authorized funds in the amount of $5,558,000. The total estimated cost of these projects is $10,807,000. Total expenditures on them through September 30, 1961 were $2,589,000. In addition, project proposals have been submitted requesting authorization of $334,000 total project funds on 3 new projects.

Project CAH-901, Structural Materials Irradiation Test Equipment, was completed during the month. Estimated final cost is $122,500 compared to authorized funds of $125,000. Completion was October 15, 1961.

SUPPORTING FUNCTIONS

Heavy water losses charged to operating cost for the month of October amounted to $36,000. This includes an adjustment to the reported September loss which was understated 1400 lbs. ($19,544).

Travel activity continues at a level approximately 20% below that of the last two years. To date in FY 1962, 309 trips have been started compared with 463 at the end of October 1960.

Equipment procured by HAPO to support University of California Lawrence Radiation Laboratory research and development programs valued at approximately $700,000 (first cost) was officially transferred to Hanford Laboratories during the month.

Advanced Degree - Three Ph.D. applicants visited HAPO for employment interviews. Five offers were extended; two acceptances and two rejections were received. Current open offers total three.

Technical Graduate Program - Five Technical Graduates were placed on permanent assignment. Current program members total 83.

W. H. Rees
for Manager
Hanford Laboratories

HM Parker:WHR:st

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

TRUARC Ring Failures. TRUARC retaining rings of both 1075 carbon steel and 420 stainless steel have been employed on the front nozzles at the K Reactors. Failures of these rings in service have prompted an investigation of the reasons and possible solutions.

The high hydrogen concentrations in the carbon steel rings which failed in service indicate a possible lowering of the static fatigue limit and embrittlement by absorption of corrosion product hydrogen. To determine the relative vulnerability of the various ring materials to hydrogen, stressed sample rings were immersed in a 1 v/o bath of H_2SO_4, and made cathodic to a Pt wire anode. A current density of 10 amps/dm^2 was maintained. The temperature of the bath was kept below 25 C by water cooling. The time-to-failure was taken as a qualitative measure of the resistance of the ring to corrosion product hydrogen.

The test showed the 1075 carbon steel, the Cd-plated carbon steel and the 420 stainless steel to be extremely vulnerable to electrolytic hydrogen, failing in 3 to 17 minutes when the maximum tensile fiber stresses of the rings were maintained at 100,000 psi. Armco PH-15-7 Mo is much more resistant: one ring lasting 11 hours and another showing no breakage after 22 hours. The time-to-failure increases greatly, with decreasing imposed tensile stresses, for all ring materials.

A test has been initiated in which rings of carbon steel, 420 stainless steel, and PH-17-5 Mo are exposed to treated reactor process water while stressed to 130,000 psi maximum tensile fiber stress and galvanically coupled to mild steel. The only ring to fail thus far was of 420 stainless steel, after a period of 1.7 hours.

To date the most promising candidate for ring material is Armco PH-17-5 Mo stainless steel.

Erosion-Corrosion of Aluminum Alloys. As reported last month, erosion-corrosion was indicated on X-8001 and 1245 aluminum alloys (in 300 Area tap water at 102 C), since applying a 100-psi back-pressure on the flow system reduced the corrosion rate on both alloys two-fold at the highest flow velocity of 76 ft/sec. Further tests in October, applying the back-pressure at the lower flow velocities (43 and 59 ft/sec) showed no significant reduction in the corrosion rates below those observed with no back-pressure.

Effect of the Hydrogen Content of Zircaloy-2 on the Corrosion Rate. About 250 ppm hydrogen was added to a group of 30-mil Zircaloy-2 coupons to almost reach the 280 ppm solid solubility limit for hydrogen at 400 C. The pre-transition corrosion rate in 400 C, 1500 psi steam for the hydrided samples was the same as the group of controls which had 25 ppm hydrogen. The time to transition was normal for both groups. However, after transition at 40 days, the hydrided samples corroded faster than the controls by a factor of two to three, indicating that the presence of hydrogen in excess of the solid solubility limit increases the corrosion rate in 400 C steam.

Corrosion Product Hydrogen Pickup. Previously reported work has shown that the amount of corrosion product hydrogen pickup for Zircaloy-2 exposed to 400 C steam could be reduced by maintaining an oxygen concentration of 3 to 4 ppm in the feed water to the autoclave, with no measurable effect on the corrosion rate of Zircaloy-2 as compared with degassed (oxygen-free) systems.

The effect of higher oxygen concentrations in the vicinity of 50 ppm is currently being investigated. Initial data for Zircaloy-2 show no further reduction in hydrogen pickup below that reported for water containing the 3 to 4 ppm oxygen concentration. On the other hand, the corrosion rates of the Zircaloys in 400 C steam appear to have been increased slightly by the higher oxygen concentration. The weight gains at 28 days in 400 C steam containing 50 ppm oxygen are 44.0 mg/dm^2 (Zr-2), 56.4 mg/dm^2 (Zr-4), and 61.8 mg/dm^2 (low Ni Zr-2) as compared with 35.9 mg/dm^2 (Zr-2), 36 mg/dm^2 (Zr-4), and 46 mg/dm^2 (low Ni Zr-2) obtained in systems operating with 3 to 4 ppm oxygen.

Zircaloy Components for Coextrusion

Properties of the Zircaloy-2 components for the coextrusion process may contribute to interface roughness and dimensional variations in the cladding of the N fuel. The grain structure and room temperature hardness of the components from three of the four vendors have been characterized in the as-received condition and after simulated coextrusion preheat cycles. The grain structure of the as-received components reveals metal that is heavily cold worked, partially recrystallized, recrystallized to a fairly uniform grain size, and recrystallized with severe grain growth near the outer surface. Two components also had grains oriented in a layered pattern apparently as a result of a large number of stringers. Grain diameters range from 8 microns in some components to 26 microns in others with grains as large as 130 microns near the surface of one component. The hardness of the heavily cold worked metal is about 99 Rockwell B; of the partially recrystallized, 93 R_B; and of the completely recrystallized 88-92 R_B. The severe grain growth near the outer surface of one component resulted in a hardness range of 75 to 84 R_B; the inner surface was 88 R_B.

After the simulated coextrusion preheat cycles all components were in the annealed condition with hardnesses ranging from 87 to 92 R_B except for the component with severe grain growth. The hardness of the outer surface remained at 75 to 84 R_B.

The heavily cold worked metal annealed to grains 8 to 14 microns in diameter. There was little if any increase in grain size of any components caused by the preheat cycles except for limited grain growth near the surface of three components where grain diameters increased from 10 to 14 microns.

There are several possible effects these properties could have on the quality of the coextruded fuel. The smaller grain sizes should promote a more uniform deformation at the uranium-zircaloy junction and result in a smoother interface. Layered grains and stringers could contribute to a fibrous Zircaloy surface and uranium-zircaloy interface. The interface roughness of samples from coextrusions will be measured. With varying amounts of grain growth present in a component, the extrudability could be significantly influenced, thus causing variations in clad thicknesses over general areas along or around the fuel. Clad dimensions of coextrusions using this component are being measured.

Radiometallurgy Laboratory Studies

NPR-type fuel elements from the sixth and seventh ETR rupture tests were examined and the corrosion weight losses of uranium were determined. There was no evidence of deterioration of the Zircaloy baskets adjacent to the reaction areas (RM Nos. 581 and 585).

Five NIN elements which were irradiated to 2000 MWD/T at simulated NPR conditions in the KER facility were in excellent condition after testing. Maximum warp observed was 56 mils double throw and the average increase in the diameter was about 10 mils (RM-587).

Metallurgical examination of the second KER size tube-in-tube element, GEH-10-41 and 42, which was irradiated at high temperatures in the 6x9 loop of the ETR, was completed this month. The Fe-Be-Zr alloy braze at the end caps of the inner tube was partially cracked at the hot end and completely cracked adjacent to the uranium at the cooler end. The braze at the hot end of the outer element was in good condition, but at the cooler end had not bonded to the uranium, and growth at the end of the uranium had occurred which was similar to that previously observed in elements with unbonded end caps (RM-709). Metallographic examination of the inner bore of the element from KER single tubes irradiated to 3500 MWD/T revealed some cracking of the uranium but no serious defects in the closures on the cladding (RM 584).

Preliminary examination of a NaK capsule for production test 402-A, irradiated for five days in DR Reactor, indicated that a rupture had apparently been caused by overheating due to restricted coolant flow.

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

Basic Metallurgy Studies

Zirconium Alloys of Variable Tin and Oxygen Content. The purpose of this program is to determine the effect of tin content, oxygen content, and extrusion temperature on the extrusion constant of Zircaloy-2. Double vacuum arc melting is being used to furnish the extrusion billets. Melting of this material is 62 percent complete, with five primary ingots to be melted and 13 secondary ingots to be melted. Estimated date for completion of melting is November 15, 1961. Three of these billets are currently being prepared for primary extrusion.

Metallic Fuel Development

Fuel Irradiations. Cross sections of a KSE-3 single tube fuel element irradiated to 3600 MWD/T have been examined in Radiometallurgy. The uranium fuel conforms completely with the highly distorted inner clad. The bond between the clad and fuel in the distorted areas is intact without indications of cracking or separating. The deformed inner clad is free of cracks or tears. Some fuel cracking was observed in these cross-sections, but these may have been produced during sample preparation rather than during in-reactor operation. There are no observable inadequacies in the braze-bonded closures or in the heat-affected ends of the elements.

Fuel swelling of five NPR inner tubes (NIN's) irradiated to 2100 MWD/T averages 2.8 percent. The average volume mean fuel temperature of the five elements was approximately 400 C. The fuel swelling is somewhat greater than predicted on the basis of the swelling data obtained from KSE elements.. No serious warp was observed in these irradiated NIN elements.

Irradiation of a full-sized NPR tube-in-tube fuel element in the new 6x6 M3 loop at the ETR has continued. The loop outlet water temperature is 271 C, and the test loop is performing satisfactorily. Current plans call for measuring the element during the outage now scheduled to begin about November 13. The accumulated exposure is 104 MWD/T.

The Radiometallurgy examination of the sixth and seventh ETR in-reactor rupture tests has been completed. The data on the seventh test were reported last month. In the sixth test, which had been irradiated to 400 MWD/T, the cladding blistered and cracked locally around the defect saddle, and corrosion was progressing on a plane front through the uranium. This type of corrosion attack appears to be intermediate between that typical of unirradiated material and that typical of material irradiated to the 1000 to 2000 MWD/T range. The weight of the uranium converted to oxide in the 26 minutes following the end of the incubation period was estimated to be 40 grams.

The following conclusion has been reached on the basis of this series of seven tests:

Under comparable conditions, irradiated material has a shorter incubation period and a faster rate of corrosion following the incubation period than unirradiated material. Both of these effects can be attributed to the irradiation induced cracking which occurs both in the uranium and on the uranium side of the bond layer. There is no evidence that the uranium corrosion rate itself is appreciably changed by irradiation.

Capsule Irradiations. 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. A circumferential failure of the cladding occurred near the end cap of one of the rods with 0.020-inch thick cladding. A longitudinal cross section through the end cap showed that the cladding failure was very similar to the clad-shear failures observed in irradiated tubular fuel elements having unbonded end caps. In a companion fuel rod with 0.030-inch thick cladding, the uranium-Zircaloy-2 bond failed, but no failure of the cladding occurred.

Eighteen capsules with three test samples in each capsule and three instrumented capsules with thermocouples in the uranium were charged in DR Reactor on October 2. On October 6, the upstream capsule in one of the three process tubes failed as the result of severe overheating of the Zircaloy-2 capsule. All eighteen capsules were discharged with less than 100 MWD/T exposure as a consequence of this failure. As the failure was the result of blocked coolant flow rather than a capsule deficiency, seven additional capsules are being readied for charging at the next reactor shutdown.

Single Tube Fuel. A dual enrichment, Zircaloy-2 clad single tube has been successfully coextruded to provide material for preliminary irradiation testing of the concept in the ETR. Determination of the quality of the bonding has not yet been accomplished, but in all other respects the tube appears satisfactory. The coextrusion billet consisted of an outside Zr-2 can, a ring of 1.6 percent enriched uranium, a ring of natural uranium, and an inside Zr-2 sleeve, all canned in copper. The external dimensions of the canned billet were: 7.5 inches OD x 1.25 inches ID x 18 inches long. It was extruded on the 333 Building press. The 1.6 percent uranium component was made from two KSE-3 billets upset from 5.5 to 7.5-inch diameter. The KSE-3 billets had previously been alpha extruded from 11-inch diameter beta heat treated ingots. The natural uranium component was an NIN billet which had been alpha extruded from an 11-inch diameter, beta heat treated ingot. The extrusion was made at a 14:1 extrusion ratio.

Fluted Fuel. An irradiation request document has been prepared for the irradiation of six 18-inch long, fluted fuel tubes in the KE-3565 facility. All six test elements being fabricated meet zirconium wall thickness, straightness, and bond quality requirements. However, three of the six may have to be reprocessed to a shorter length because of porosity in the end cap braze. The test facility is scheduled to be available by the first of the year.

Thermocouple Fuel. A second attempt to coextrude a rod clad in Zr-2 and containing a solid Zr-2 rod at the center of the uranium thermocouple fuel elements was apparently successful. Complete evaluation has not yet been made. The out-of-roundness of the Zr-2 core was corrected by use of extruded rod for the coextrusion billet core. The severe dog boning of the Zr-2 core experienced in the first attempt was alleviated considerably by tapering the leading end of the billet core to approximate the shape of the core as it flows through the die.

Metallic Fuel Measurement. Methods of numerically analyzing measurements of radial displacements and thicknesses of tubular fuel elements have been developed. A computer program is written which determines the Fourier components describing the circumferential data. These components are used to determine mean radii, mean thickness, ovality, radial displacement of the axes, and variations of the mean circumferential curvature. Ten equally spaced circumferential records are used to analyze the radial displacements of the axes of the inner and outer tubular surfaces. Fourier components of these displacements are used to establish axial radii of curvature. A least square fit determines the angle and twist of the axial displacements. Data output is printed for each circumferential station and a summary review for all axial stations. Cards are punched containing the reduced data so that pre- and post-irradiation conditions can be compared.

Heat Treatment. Sections of Zircaloy-2 clad, I&E fuel with 0.94 enriched, Fe-Si additive uranium cores are being heated at a series of alpha phase 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. The study thus far has shown:

1. There is slight, if any, beta treated grain refinement as a result of 2 - 16-hour soaks at 950 F (510 C) to 1050 F (565 C).

2. Growth of the U(Fe-Si) compounds occurs during these alpha treatments.

3. Higher temperature 1150-1200 F (620-650 C) annealing results in continued growth of precipitate and apparent precipitation along preferred crystallographic planes.

4. These higher alpha temperature anneals produce a larger beta treated grain size.

5. Alpha grain growth occurs during the anneals and micro hardness is decreased, presumably due to stress relief and growth of the precipitate.

Twelve 23-inch long Zircaloy-2 clad NPR inner tubes have been beta heat treated a third time in order to compare the change in warp with that

which occurred on the first and second beta treatments. In addition, the warp of the elements was measured at 300 C to obtain data in the range of the fuel element operating temperatures. Eleven 23-inch long bare uranium NPR inner tubes were beta heat treated for the second time and the warp was also measured at 300 C. The average warp at 300 C for the Zr-clad elements was 39 mils and for the bare uranium elements was 30 mils. Room temperature warp measurements have not yet been completed.

Fuel Straightening. A straightening program is being carried out using FPD production material that is "out of spec" due to excessive warp. Approximately seventy inner fuel elements are available in the beta heat treated condition. It is proposed to make three production tests from this material to study effects of reactor operation on fuel straightened by three different methods.

PT #1 Approximately 20 elements, straightened by reverse bending and re-beta heat treatment.

PT #2 Approximately 20 elements, straightened by rolling in high alpha (600 C) phase.

PT #3 Approximately 20 elements, straightened by alpha rolling and re-beta heat treatment.

Closure and Joining. Original weld tests on the 600 KVA resistance welder were to establish basic operating limits for "Projection Welded-Brazed Closures". Maximum and minimum current values have been set; however, optimum values for heating time, pressure, and other variables have not been established. Two out of 13 test welds had good Zircaloy to Zircaloy welds and nearly complete Zircaloy to uranium bonding.

Experimental NPR fuel elements with closures prepared by cathodically etching the uranium end face, assembling and electron-beam welding the Zircaloy end cap in the same chamber without exposure to air, followed by hot pressing, have given evidence of sound bonding at the uranium/Zircaloy interface. However, under these fabrication conditions, the bond at the interfaces between the Zircaloy cap and the Zircaloy cladding is generally poor, thus indicating the need for a bonding medium in these zones. Previous experience has shown copper to have desirable properties for such an application. Techniques and equipment have been developed for plating narrow bands of copper on the ID and OD sidewalls of the cap, of such width that the uranium-contacting faces and the weld-bead zones are kept copper free. Components for making 12 such closures have been prepared.

Production Support Welding. Installation of the equipment for welding supports on NPR outer fuel elements in the 333 Building has been completed. It has been demonstrated that the equipment can be adjusted to produce a support circle within the 2.660 - 2.665 diameter tolerance. The remaining responsibility of HLO is to continue efforts to improve the process insofar as weld machine settings are concerned. A device which converts the aforementioned equipment for the attachment of NPR inner supports is being fabricated in Tech Shops.

Drop Test Fuel. A request has been made for twelve NPR fuel elements having a cracked internal structure. These elements are to be used in the "drop test". The artificially induced cracking is intended to simulate in some degree the conditions existing in an element after long exposure. Cracking of the uranium, without injuring the jacket, is accomplished by making a slight swage reduction of the fuel element while it is in the beta phase. Both the inner and outer tubes of the element are subjected to an approximate 50-mil reduction in OD at about 690 to 700 C. At this temperature, the jacket material, Zr-2, is quite plastic and therefore is not injured by the swaging. Ultrasonic tests have verified the cracking of the uranium.

2. REACTOR PROGRAM

Corrosion and Coolant Systems Development

Diffusion of Water Vapor in NPR Core Graphite. Last month it was reported that carbon monoxide stopped the diffusion of water vapor through NPR core graphite, probably by the reaction $CO + H_2O \rightleftarrows CO_2 + H_2$. Diffusion experiments have been continued using 650 C NPR core graphite and various CO-CO_2-H_2O mixtures in helium. It was found that CO_2 additions partially offset the water removal effect of CO, but none of the $CO + CO_2$-H_2O mixtures in helium resulted in as high a water transport rate through the graphite as He-H_2O mixtures alone. With the inlet water partial pressure at 0.5 mm and the graphite at 650 C, the maximum water transport occurred at about 3 to 4 percent CO_2 and 0% CO. Addition of CO to the CO_2-H_2O-He gas reduced the water transport rate but even with 3 percent CO, sufficient water diffused through the graphite to maintain the ZrO_2 film on a Zircaloy process tube. Thus, it appears that the adverse effect of CO reducing the water transport rate may be counteracted by the addition of 1 to 3 percent CO_2 to the gas mixture.

Effluent Activity and Corrosion Testing. Initial chemical addition tests have been completed in SP-7 and SP-8 (4963 KE, 5063 KE). Chemicals added were EDTA, phosphate ion, and citrate ion. Before each chemical was added, the tubes were decontaminated with Turco 4306 B. Corrosion samples have been exposed throughout these tests and will remain in-reactor to the end of the present fuel element exposure for an evaluation of the effects of these decontaminations and chemical additions on the corrosion of aluminum, carbon steel, and Zircaloy-2.

Evaluation of Inhibitors. Laboratory tests indicate that the acid inhibitors Rodine 12W and Rodine 92A, are not as effective as either phenylthiourea or West Chemical 5268-1, for inhibiting attack of 0.3M sulfuric - 0.1M oxalic acids on carbon steel, aluminum, or stainless steel. Both Rodine materials are effective for carbon and stainless steel at 45 C, but are only one-half to one-fourth as effective as 5268-1 on carbon steel at 90 C. Rodine 12W appears to slightly inhibit corrosion of aluminum at 90 C, but permits pitting of stainless steel at 90 C. Rodine 92A inhibits stainless steel corrosion in the acid mixture at 90 C, but apparently catalyzes galvanic pitting of aluminum in this mixture at the same temperature.

Cyclic Testing of Oakite Bisulfate Compound. The fifth cycle of eight scheduled cycles has been completed in TF-1 loop employing alkaline permanganate (18% NaOH - 3% $KMnO_4$) followed by Oakite OEM-232-A-24 (a sodium bisulfate based cleaner). At the end of the fourth cycle, the carbon steel samples and welded carbon steel-stainless steel samples were corroding at the average rate of 0.2 mil per cycle. Zircaloy-2 and 304 stainless steel were corroding at less than 0.01 mil per cycle. Type 420 stainless steel was corroding at 0.12 mil per cycle, and the Haynes alloys were attacked in the characteristic manner by the alkaline permanganate.

Rupture Testing Irradiated Zircaloy-Clad Fuel. The two 1200 MWD/T tubes irradiated in KER-4 at 242 C and rupture tested with programmed cooling rates in the IPR (as reported last month) have been weighed and photographed by Radiometallurgy. The tube that was subjected to a scram cool-down rate after a five-minute hold period at 300 C lost 22 grams of uranium. The rupture consisted of a single blister about 5/8 inch in diameter with the corrosion proceeding into the uranium.

The other tube that was subjected to a slow cooldown following the five-minute hold period at 300 C lost 35 grams of uranium. In this tube the rupture consisted of a single one-inch diameter blister. The blister appeared to have started as a smaller blister, and then to have formed seven to eight additional blisters around its base. The cladding was torn at several of the smaller blisters in addition to a larger opening at the initial blister.

A new rupture test was conducted in the IRP using a rod which had been exposed to 2250 MWD/T in KER at 265 C. The object of the test was to determine whether reducing the temperature to 200 C would essentially stop the rupture even with extended exposure at 200 C. Following an incubation time of 22 minutes at 300 C, the water temperature was held for 15 minutes at 300 C and then lowered to 200 C, the test being continued for an additional 315 minutes. During this time at 200 C the activity level in the filter built up very slowly and linearly. Since the apparent weight loss of uranium was low, the entire test was repeated. This time the rod was run at 300 C for 90 minutes and then at 200 C for 150 minutes. The activity increase at 300 C was linear and still comparatively slow (from 200 mr/hr to 2100 mr/hr in 90 minutes). The rate of activity buildup at 300 C was 100 times as fast as the rate at 200 C. The fuel element will be transferred to Radiometallurgy for weighing and photographing.

Derusting of NPR Carbon Steel Piping. A number of candidate chemical treatments and proprietary rust removers are being tested on a laboratory-beaker scale for their effectiveness in removing rust from carbon steel piping, with a minimum of corrosion of the base metal. The most promising process will be further demonstrated in an ex-reactor loop system (TF-14).

Structural Materials Development

Post-irradiation evaluation of Zircaloy Pressure Tubes. The Zircaloy process tube discharged from KER Loop 3 has been cut into 2 to 4 feet lengths, and sections representative of maximum, intermediate, and minimum exposure to fast flux have been moved to the Radiometallurgy Laboratory.

A two-inch long sample was cut from the maximum exposure section. The crushing action of the guillotine fractured the sample longitudinally. Metallographic samples have been cut adjacent to the fracture and 180° around the tube. Transverse sections have been observed on the metallograph and show a normal cold worked structure. Comparison with a similar section taken from the same tube before irradiation shows a considerable increase in second phase material concentrated at the grain boundaries of the irradiated sample. Neither the pre- nor post-irradiation samples show an appreciable amount of hydride in their structures.

Elevated temperature burst tests have been performed on three sections of unirradiated tubing from the same lot as the KER Loop 3 tube. The maximum stress in the tube wall was 60,500 psi to 62,200 psi at about 275 C. These results are slightly lower than expected, being more nearly typical of 30 percent cold work than the 50 percent actually present in the tube.

Nonmetallic Materials Development

Effect of Flux on Graphite Contraction. Fabrication has started on the GEH-13-8 graphite irradiation capsule. This capsule, to be irradiated in the N-5 position of the ETR, is designed as a high temperature, flux-intensity effect test. All sample positions will be operated at the same temperature, approximately 700 C. Over the length of the capsule there will be a difference in fast neutron flux, $E > 0.18$ Mev, of a factor of six. This range of neutron flux should show differences in distortion rates if radiation damage is dependent on flux intensity. Graphites being tested are CSF, TSX, and TSGBF. Three samples previously irradiated in the GEH-13-5 capsule, a similar flux intensity test, will be included in this test.

Preliminary results from the GEH-13-5 capsule are given in the following table:

Preliminary Exposure nvt x 10^{-21} (E > 0.18 Mev)	Temp. °C	% Change in Length*			
		CSF	CSF	AGOT-LS	AGOT-LS
0.19	670 ± 20	+0.05	+0.03	+0.03	+0.04
0.65	700 ± 10	+0.05	-0.004	+0.04	+0.003
1.30	725 ± 10	-0.03	-0.10	-0.02	-0.10
1.20	725 ± 10	-0.07	-0.11	+0.02	-0.11

*Negative values denote length decreases.

These results show slight differences in distortion rate when normalized to an exposure of 1 x 10^{21} nvt. However, until additional testing is completed it cannot be ascertained whether this is a flux or an exposure effect.

Irradiation-Induced Oxidation of Polyethylene. Theories of flow characteristics in polymers that have recently been presented by Dr. A. S. Michaels, et al, of MIT, have permitted calculations to be made of the diffusion coefficient for oxygen in gamma irradiated polyethylene. The value obtained was 2.8 x 10^{-7} cm^2/sec which may be compared with the previously determined experimentally based value 1.7 x 10^{-7} cm^2/sec, (see HW-SA-2254). The agreement is good considering the assumptions involved in both calculations.

Thermal Hydraulic Studies

Thermal Hydraulic Characteristics of the Overbore Fuel Elements for C Reactor. Laboratory experiments were conducted to investigate heat transfer conditions and fuel temperatures which would result from coolant flow loss following a failure of a hydraulic fitting at the inlet of an overbore process tube at C Reactor. The purpose of the experiments was to define the operating conditions at which the flow of coolant from the rear header would not be sufficient to prevent melting of the fuel elements following such an event.

In the experiments, electrical resistance heating of a metal test section was used to simulate nuclear heating of a 32-piece charge of C-VI-N I&E fuel elements in a smooth bore zirconium process tube. The test assembly consisted of a 1.991-inch OD by 0.339-inch ID tube centered in a 2.147-inch ID process tube with ceramic "self-support" rails. With this test section generating heat under steady state conditions, the water supply line was opened suddenly to atmosphere at the inlet and the rear header fluid was maintained at a constant pressure. After three seconds the heat generation rate in the test section was decreased at a rate simulating a 1400 ih reactor scram. Temperatures, pressures, and flows in the test section were monitored on high speed recorders.

Data from the experiments were analyzed to indicate those reactor operating conditions under which melting of fuel jackets could be expected following an inlet piping rupture. It was concluded, for example, that for a rear header pressure of 60 psig, melting of fuel elements jackets could be expected for any tube above 1400 KW but not for tubes below 1200 KW. For 40 psig rear headers, the limitations would be 1300 KW and 1000 KW. A complete description of the experiments and a more thorough discussion of the results were prepared for presentation in HW-71075.

Heat Transfer Conditions for Eccentric Annuli. Experiments were continued to determine the heat transfer conditions when fuel elements are not situated in a coaxial position within the process tube. Limited data applicable to I&E fuel elements in a BDF process tube were obtained for the case of 75% eccentricity. (Percent eccentricity is the fraction of the normal

annulus thickness that the fuel element is displaced from a coaxial position toward the wall of the process tube.)

The test section used was a 30-inch long electrically heated rod, 1.445 inches in diameter, placed within a 1.604-inch tube. All of the heat generated within the rod was transferred to water flowing through the annulus. Two boiling burnout points were obtained at a constant flow rate of 23 gpm and a pressure of 121 psig. (These conditions correspond to those in the flow annulus for I&E fuel elements in the fringe tubes at a BDF reactor.) During the approach to burnout, the heat generation rate was gradually increased while temperature measurements were made of the heated surface and cooling water at points around the annulus of the test section. The conditions at boiling burnout were as follows:

Run No.	Flow Rate (lb/hr-sq ft)	Bulk Water Temperature (°F Below Boiling Point)	Heat Flux (B/hr-sq ft)
6	4,400,000	205	808,000
7	4,400,000	184	711,000

During the last run a hole was melted in the heated rod near the inlet end and the tests were terminated to repair the test section.

Data obtained previously with a test section for K Reactor were correlated with the following equation:

$$\phi_{BO} = 800\ (1-\epsilon)^{0.8}\ G_{avg}^{0.5}$$

where

ϕ_{BO} = burnout heat flux, Btu/hr-sq ft

ϵ = eccentricity fraction

G_{avg} = average mass velocity over annulus, lb/hr-sq ft.

This equation was based on data obtained over a range of flow rates of 3.01 to 5.24 x 10^6 lb/hr-sq ft, pressures of 53 and 107 psig, and bulk water temperatures of 5 to 225 F below saturation temperatures. The use of this equation for reactor application would indicate that film boiling conditions could be expected for any fuel elements in K Reactor that are situated 75% or more eccentric in the process tubes. High surface temperatures would be encountered on such fuel elements.

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

and boiling burnout conditions were detected by noting the temperature excursions as measured by thermocouples attached to the outside wall of the test section.

In all of these runs boiling burnout was detected unexpectedly upstream of the outlet end. These data were all obtained at 1500 psig and are as follows:

Mass Velocity ($lb/hr-ft^2$)	BO Heat Flux ($Btu/hr-ft^2$)	BO Location(1)	Enthalpy at BO Point (Btu/lb)	Enthalpy At Outlet (Btu/lb)
4.8×10^6	0.816×10^6	8.6	666	823
4.8×10^6	0.747	6.6	695	804
5.8×10^6	0.984×10^6	8.6	666	824
5.8×10^6	0.983	5.6	694	796
6.7×10^6	1.124×10^6	6.6	704	823
6.7×10^6	1.201×10^6	6.6	680	807
6.7×10^6	0.878×10^6	3.6	672	722

(1) Feet upstream of outlet end of 12-ft long rod.

It was concluded tentatively that the flow patterns associated with these particular conditions influenced the heat transfer conditions in such a manner to result in the upstream burnout conditions. An analysis of the results applied to the NPR indicated that the burnout safety factor would not be changed by these data.

Shielding Studies

A report describing neutron and gamma attenuation through the NPR shield has been written (HW-77174, "NPR Reactor Shield Calculations"). The calculations show that the side and top primary shield design is adequate to reduce the radiation level below design tolerances. The radiation leakage through the front shield was estimated to be higher than design tolerances. Two alternate biological shield materials were studied for use on the front face. These two materials were iron-serpentine concrete mixtures with densities of 245 lb/ft^3 and 265 lb/ft^3 (designated as I-S-245-P and I-S-265-P, respectively). Both of these concretes reduced the radiation below design tolerances. It was recommended that the present front face biological shield be changed from I-S-220-P to I-S-245-P. With this change the NPR shield is adequate according to these calculations. The calculations do not include leakage through penetrations in the shield. As a result of these calculations, the front face biological shield material was changed to I-S-245-P.

Continued effort is being made to compare experimental data with calculations using the new shielding computer code.

B. WEAPONS - 3000 PROGRAM

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

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

PRTR Project Management and Design

PRTR. The fuel element examination facility is not yet ready for service. Instrument calibration has been completed. Correction of faulty damper operation and completion of the air balance remain to be done, along with electrical repairs to the manipulator and profilometer 5X viewer controls.

The paving and landscaping contract was closed out. Shrub replacements were made in accordance with the inspection held September 21, 1961. All construction drawings for this contract were brought up to "as-built" condition.

Plutonium Recycle Critical Facility (Project CAH-842). The over-all project, excluding additional work covered in project proposal revision 3, is estimated to be 90% complete. The revised project proposal requesting additional funds and time to complete modifications requested by the General Electric Hazards Council is under review by the HOO.

Piping installation has been completed, and the systems are undergoing pressure tests. Electrical installation continued. Wire runs to the cell are about 80% completed. Connections on the cell ends of these wires is complete. Connections at the console are under way. Problems have developed in making connections to the relay cabinet because of the limited space provided. Installation of the source positioner has been completed.

Fuel Rupture Test Facility (Project CAH-867). The Fuel Element Test Facility is estimated to be 40% completed versus 43% scheduled predicted to October 31, 1961. The CPFF equipment installation work is estimated to be 46% completed versus 50% scheduled.

Major CPFF items completed during the month include mounting the instrument panel in the control room, installation of primary process pumps in the annex and heat exchangers in B Cell, and completion of the makeup system. Installation work continues to be delayed by welder shortage, experimental cell gas activity, and late delivery of certified materials.

The two electrical immersion heaters have not been shipped as yet. The latest liaison information indicates shipment of the first unit the week of October 30, and the second unit the following week.

All other GE procured material except for the motor control center and switchgear has been received. Shipment of these items is scheduled for November 8. Late delivery of certified stainless steel fittings, procured by J. A. Jones Construction Company, is still hindering piping progress to some extent.

Material certifications on the high pressure control valves have been received. One control valve required rework to replace welded reducers which were of unacceptable material. Design was initiated on a second sample line to permit future installation of NPR rupture detection instrumentation.

Construction on Contract AT(45-1)-1655, Water Treatment Plant and Hold-up Tank, is estimated to be 8% complete versus 15% on the official schedule or 8% on the contractor's schedule as of October 31, 1961. The contractor poured the clearwell walls and pump room floor. The pipe for the 10" filtered water line and the 4" lines to the hold-up tank was delivered to the job site and installation of the 10" filtered water line was started.

The shop drawings for the hold-up tank were reviewed and approved. Excavation for the hold-up tank was complete, lean concrete backfill poured, and resteel for the hold-up tank was placed. The instrumentation subcontractor for the water plant is Minneapolis-Honeywell.

In accordance with a letter from the AEC, design change 1655-2 was prepared to excavate the sand material from under the sedimentation basins and filter and replace with compacted gravel. The contractor completed excavation of the sand material and is placing compacted gravel backfill.

Design change 1655-1 was issued to change the hold-up tank exterior coating from coal tar enamel to tarset, resulting in a net savings to the project of $525.00.

Component Testing and Equipment Development

Primary Loop Mockup. The loop has been shut down to permit modifications necessary for testing the Rupture Loop process tube assembly.

PRTR Second Generation Shim Control. Several types of liquid shim control assemblies have been evaluated, and a scope drawing of one of the types has been prepared. Suitable materials for the poison have been evaluated. Various types of instrumentation and control equipment are being evaluated prior to preparation of a scope drawing of the control system.

Critical Facility Components. The source positioner was delivered to the reactor for installation by the contractor. The adjustable slip clutch and gear reducer for the weir drive assembly has been received and is being installed. The additional swivel joints ordered for the thimble have not been received. Testing and installation of the thimble will proceed as soon as the new swivel joints are available.

The drive mechanism for the first control rod was assembled and tested. Initial operation was satisfactory, and the unit is now being reassembled with a carbon steel ball bearing lead screw. The carbon steel lead screws ordered to replace the 17-4 PH stainless lead screws were received last week. The cadmium plating of the control rod tubing is under way at the vendor's plant, and it is anticipated that a partial shipment of plated tubing will be made the first week of November.

Drop tests were performed with prototype safety rod components, and it was determined that air cushioning of the rod drop requires machining a close fitting cylinder with diametrical clearances no greater than 0.010-inch over the last 12" of rod drop. Machining of the guide slot in the 15-foot long safety rod housing is being performed successfully by the J. A. Jones machine shop. The carbon steel ball bearing lead screws required to replace the 17-4 PH stainless lead screws have been received and are being prepared for assembly in the safety rod drive mechanism. Supplying power to the 12 volt DC magnet has been one of the major problems of the safety rod drive mechanism. A reel has been developed which will work over the required 7½-foot of rod travel; however, it has been decided that use of a spiral retractable cable produced by the Spectra-Strip Wire and Cable Corporation might prove more reliable. Safety rod design modifications are now being made so this retractable cable may be installed.

PRTR Operations

Reactor Operation. Continued improvements were achieved in most phases of PRTR operation during October. The reactor operated 19.2 days for a TOE of 61.9 percent. Included was a 10-day continuous run, concluded on October 31, which satisfies the AEC criterion for operability. MWD production during the month was at a record high of 1225 MWD's, resulting in an over-all operating efficiency of 56.5%.

Heavy water losses averaged approximately 50 pounds per day during the extended run period at the end of the month. Helium losses for the month were about 210,000 scf; the loss rate during the extended run was unusually high, approximately 9000 scf per day. It is intended to locate and repair the source of high leakage on the next shutdown.

During October there were three scrams and one extended shutdown. On October 5, the reactor scrammed from a flow monitor trip on tube #2051. Nothing wrong could be found and a scram recovery was successful. The reactor was shut down on October 7 to perform Power Tests 16 and 17, the measurement of the shutdown xenon transient, and to correct D_2O leaks amounting to approximately 100 pounds per day. This outage was prolonged approximately one week by D_2O and helium leak repairs, helium compressor failures, and primary coolant high oxygen content problems. One scram occurred during early attempts to start up the reactor; the trip was the result of low pressurizer level during a required cooldown of the primary system. Operation was resumed at 9:35 AM on October 19, 1961. The reactor scrammed from shutdown valve electrical problems at

8:10 AM on October 21, but a scram recovery was successful and operation was resumed at 9:08 AM that day.

Reactor Equipment Engineering

Primary Pumps. Repair of the high pressure mechanical seal of primary pump #1, which failed on September 13, has been deferred beyond the month of October in order that this work may be integrated with revisions to electrical leads to the pump motors. Pumps #2 and #3 have operated satisfactorily during the month. Erratic seal temperature indication on pump #3 in the latter part of the month appeared to signal an impending failure of the seal thermocouple. There is no corroborating evidence to indicate failure of the seal itself.

The seal injection control valve has been placed on automatic control, and new trim has been installed to improve control action of the valve.

Primary System. Design change 104 was initiated to provide wider gaskets for process tube nozzle caps and to eliminate possible impingement of the gasket between the plug and the nozzle gasket seat. Approximately eight cap assemblies are now being modified for trial use. A detailed procedure for nozzle cap installation was prepared and distributed.

Design change 105, providing for modification of packing glands of high pressure control valves in the primary system, was initiated. Valve packing will be redistributed, lantern ring repositioned, and packing leakage bleedoff part modified to provide more satisfactory bleedoff and collection of packing leakage. The original valve design provides too little packing between the valve body and the bleedoff port, and results in excessive leakage.

Secondary Coolant System. A steam sampling station was designed to provide continuous sampling of steam from the main 26-inch header. This station will be installed under design change 102.

The one-inch boiler feedwater bypass valve failed due to a broken bonnet. Replacement parts were put on emergency order but have not yet been received. The main six-inch boiler feedwater control valve has experienced severe vibration when operating at very low feed rates near its shutoff point, without the bypass valve in the system.

The bottom blowdown piping from the steam boiler, which has experienced severe vibration in the past, was braced securely to the boiler support.

A number of extension tools have been made to permit remote removal of corrosion coupons from the steam boiler.

Helium Compressors. The first and second attempts at repairing an oil leak between the second stage head and the cylinder of high pressure compressor #1 was not successful. At the present time provision has been made for returning the oil leakage to the compressor reservoir.

The diaphragm on the south head of low pressure helium compressor #1 was replaced twice during the month after short running times. Both penetrations were the result of foreign material in the head puncturing the diaphragms. The single diaphragm in the north head of L.P. compressor #2 was replaced after 600 hours of operation and still appeared to be in good condition. It is apparent that single diaphragms are satisfactory if foreign material is kept from entering the heads. Since there is a filter in the common suction line for both compressors, the foreign material must come from the short section of piping between the filter and the in-take suction valves on the compressor heads or be introduced during the actual installation of new diaphragms or check valves. Consideration is being given to installing fine screens just upstream of the in-take check valves.

The check valve adapter in the second stage head of high pressure helium compressor #2, which had been seal welded in place to stop a helium leak after the adapter galled and froze in the head, was machined out of the head, the threads in the head closed and new adapters, new check valves, and new diaphragms were installed during the week of October 9, 1961. During the week of October 16, 1961, these new diaphragms were reported leaking oil into the second stage gas stream. These diaphragms were replaced with new diaphragms. During leak testing following the installation, it was discovered that a gas leak existed between the gas head and the diaphragms. Removal of the head disclosed the presence of foreign material imbedded in the head surfaces which seal on the outer edges of the diaphragms. The apparent source of the foreign material was the air line used to seal the diaphragms against the oil side head with air pressure during installation of the diaphragms. The head sealing surfaces were cleaned of foreign material, new diaphragms installed and, on the second attempt, a gas seal was effected by using a thin coating of Permatex No. 1 sealant compound on the sealing surfaces. New replacement heads for both first and second stages of the high pressure helium compressors are on order.

Helium System. Design is nearly complete and the bulk of the material has been received for the HX-7 condensate automatic drain system. Installation of the automatic drain should materially ease the operations manpower consumed in condensate handling.

Design is nearly complete and portions of the material have been received for the installation of an automatic system for adding hydrogen to the helium pressurization system.

A number of replacement valves of improved design have been ordered to replace existing isolation valves and condensate drain valves. These replacements should reduce the helium losses from the reactor significantly. In addition, two diaphragm-operated valves are being ordered for installation as block valves in series with the existing purge valves from the helium system to the stack, to eliminate the possibility of helium loss through leakage of the purge valves.

Process Cell Noise Level. A rotary air blower in the building air sampling system discharges into a ventilation exhaust duct in the process cell. Exhaust noise from this blower is at a high enough level that communications within the cell are impaired significantly. A muffler is being ordered for installation in the blower exhaust line to reduce the noise level.

Process Tube Storage. A study is being made of the feasibility of using the dry storage pit for storage of spare process tube and nozzle assemblies, and also of process tube inspection equipment. Only minor modifications to the pit will be required to accommodate the process tube assemblies, and design of these modifications is under way. Some components of the tube inspection equipment, however, are subject to radiation damage. An investigation of expected dose rates in the storage pit is being undertaken to determine feasibility of storage of this equipment.

Neutron Flux Monitoring Instrumentation. During a shutdown the last week of September, five neutron flux monitoring chambers which had failed were replaced. These included one uncompensated chamber for the galvanometer circuit and one for high level channel #3; one compensated chamber for log N channel #1, and the two fission chambers for the startup channels. The chamber for the log N channel was replaced because of a leaking housing; failure of the other four chambers may have occurred either within the chambers themselves or in the connecting cables. Investigation is under way to determine the cause of failure.

Subsequent to replacement of the chambers, a D_2O leak developed in the packing glands surrounding the electrical lead tubes of the dual fission chamber assembly. A new packing assembly of modified design was installed in place of the original glands and successfully stopped the leak.

The flux instrumentation high voltage monitor has been modified to include monitoring of the high voltage supply to the log N #3 chamber.

Reliability of the flux monitoring instrumentation has been greatly improved during recent reactor operating periods and is now adequate for extended operating cycles.

Safety Circuit and DC Power System. The safety circuit was revised to incorporate an additional set of relay contacts which open the DC circuit on the negative side of the dump valve solenoids as well as the positive side. When the safety circuit is tripped, the dump valves are now completely isolated from DC power and cannot be held closed by any ground or combination of grounds in the DC system. This change eliminated a previous condition whereby one or more dump valves could be held closed by certain combinations of grounds in the system, even though the safety circuit had tripped.

A design change was initiated for moving the DC system ground detector to the control room and adding alarm features. The change also incorporated a DC system low voltage alarm and a ground detector in the flow monitor trip relay power circuit. The low voltage alarm lessens the potential hazard to critical circuits and also lessens the need for frequent checking of the battery chargers by maintenance personnel, freeing them for other work. The flow monitor ground detector is required to eliminate the danger that a pair of grounds could disable some or all of the flow monitors preventing them from tripping.

Fuel Element Rupture Detection. A defective UO_2 fuel element was located in process tube #1954 by the stagnant water sampling technique. (This technique, developed by GE-APED, San Jose, involves isolating suspect elements in stagnant water and taking one or more samples after a waiting period to permit buildup of fission product concentrations.)

A sample from tube #1954 and three other samples were subsequently routed to a four-point gas sampling system in the rupture monitor to evaluate its performance in locating the defect by the gas sampling technique. Instrumentation was set up on these four channels counting gamma above 0.75 Mev. Initially during startup the system showed several bursts of gaseous activity from tube #1954 followed by considerably smaller increases in the other three samples. Signal to background ratios as high as three were observed during these bursts. Between bursts, the activity level of #1954 was not significantly different than background. It was also noticed that peak activities in channel 1954 correlated with peak activities in helium storage. However, this situation changed when the system was again put in operation after a three-day period of operation at full power. At this time, tube #1954 gas indicated steadily off-scale on the least sensitive range. On the same range, the other three channels indicated between 50 and 70 percent of scale. To make certain that the observed effect was not caused by differences in the instrumentation channels, all four were checked and set up with a 200 channel analyzer. Also, the detectors were permutated between sample chambers to further verify that the sample from tube #1954 was higher in activity. These tests showed that the gamma activity (above 0.75 Mev) in tube #1954 gas was consistently at least twice that in the other three gas samples. This condition persisted unchanged for 22 hours after the system was put in operation when a failure in the recorder monitoring tube #1954 caused it to indicate downscale. Subsequent checks showed that the activity in #1954 remained consistently higher than that in the three other tubes with the test still in progress as this report was being written.

The rupture monitor tests to date show that the gas monitoring system is capable of locating the defect in process tube #1954, both during steady state operation and during bursts. The magnitude of the defect is not yet known, so little can be said about the ultimate sensitivity of the gas monitor. However, other data(1) indicate that the observed activity is equivalent to about 150 grams of uranium which could be accounted for as a defect in a single rod.

(1) HW-70980, Perkins & Thomas, "Radioisotope Concentrations in the PRTR Primary Coolant and Helium System During Operation with a Failed Fuel Element(s)," 9/7/61.

The four-channel sampling system used in the above tests included an improved gas separation technique designed to eliminate fouling of the gas sampling system with water. The system has operated for periods as long as five days without requiring adjustment of flows during operation. Minor modifications are being made to eliminate condensate fouling during and following shutdowns.

Gas Moisture Detection System. In order to improve the flow of reactor core blanket gas through the gas moisture detection system, a design change has been initiated to modify routing of the line returning the sample gas to the reactor. The change should maximize the pressure drop available for flow through the dewpoint apparatus and should eliminate the need for a sample blower which is currently out of service because of oxygen in-leakage problems.

Procurement. Extensive effort has gone into procurement of parts for the process tube assembly. During the month coded cap screws of satisfactory quality were received, resolving a long-standing problem. Emphasis is being placed on the procurement of outlet nozzles and inlet gas bellows assemblies to build spares inventories beyond the present minimum quantities.

Spare instrument assemblies ordered on AR funds have been received, except for a Keithly micro-microammeter which is in the final stages of construction. Equipment received provides spare equipment for the data processing system.

Preventive Maintenance. Preventive maintenance procedures are now set up to cover all process pumps (except the primary pumps), the helium compressors, and the air compressors. PM inspections to date have turned up a number of needed repairs; additional operating experience is needed to provide maximum effectiveness of the PM program.

Equipment Records. A card index has been started as a preliminary step to preparing an alphabetical listing of plant equipment. This listing will supplement the existing Material and Equipment List, which is arranged by equipment piece (EP) number and should facilitate the location of equipment.

Training Program. Training classes conducted for Operations personnel continued during the month. Classes on the primary system and the first series of classes on the helium system have each been presented to all four shifts. The second session of helium system training was presented to two shifts.

Reactor Process Engineering

Planning and Procedures. Issuance of combined PRTR Operating Standards continued during the month. The standards were officially issued as HW-67100 on October 1. Revision of the PRTR Operating Procedures continued as part of a program to update all procedures.

Preparation of the reactor and associated facilities schedules for the remainder of the fiscal year was completed and the proposed schedule was circulating for comment at month-end.

Power Tests #16 (Xenon Poisoning) and #17 (Long Term Reactivity) were completed during the month. The data obtained will be used to revise the PRTR Xenon Tables to permit better prediction of xenon override time and minimum outage time. The majority of the data for Power Test #11 (Photoneutron Flux) was obtained and is currently being analyzed. The remainder of the data will be obtained during the performance of Power Test #14 (Power Decay).

PRTR Test #8 (Use of Monosodium Phosphate in the Steam Generator) was completed and was not successful in lowering the pH in the steam generator. Extensive discussions were held with representatives of IPD and the Betz Laboratories on the problems of the secondary coolant system water quality and firm recommendations were being prepared at the end of the month.

The piece of "coffee can" recovered from the inlet jumper of Process Tube #1744 weighed approximately seven grams. The total recovered weight is now 163 grams out of an estimated 192 gram total can weight.

The primary system coolant pH fell to approximately 6.0 on October 17. Addition of 40 grams of LiOD brought the pH back to its normal value in the range of 9.5 to 10.5. Special analyses of the coolant showed that the pH drop was caused by the lack of a lithium residual in the coolant. Additional analyses are being performed in an attempt to determine what caused the loss of the lithium residual.

A set of unit motion readings for the top primary shield and the top of the calandria were taken on 9/25/61. No movement of the top primary shield or the calandria top plate has occurred since the previous set of readings. The unit motion data to date shows that the top primary shield has moved to the northeast following the initial target installation, but that the calandria top plate has not moved. At this time no explanation is offered as to why the calandria top plate did not follow the top primary shield. If no further movements are noted, it will be assumed that the initial target readings were in error.

Efforts to reduce heavy water losses from the PRTR have continued. Specifically, these efforts were directed toward improving leak detection methods, isolating areas of localized leaks and eliminating the leaks. The following work was performed:

1. Improved stack sampling equipment, leading to continuous monitoring of stack D_2O content and to more accurate determinations of loss rate, was installed.

2. A sampling point on the main exhaust duct was provided to confirm the D_2O loss rate determination from the stack gas analysis.

3. A system to obtain moisture samples from selected locations throughout the process cell was installed.

4. Several high leak potential areas in the process cell were shrouded with plastic sheeting for detecting losses which may emanate from selected pieces of equipment. Condensate samples will be taken from inside and outside the shrouds.

5. Water effluent from the steam generator (HX-1) is monitored continuously to detect D_2O losses, if any, from the primary to the secondary system.

6. The D_2O recovery system was pressure tested and detectable leaks were sealed to reduce losses originating from the reactor faces. The upper and lower access space pressures were balanced to minimize pressure differentials between the access spaces and the surrounding air.

Analysis of data and observations made during the past month indicates the following:

1. Calculated stack D_2O losses during the operating period of October 1 to 7 shows a D_2O loss of 80 to 110 pounds per day. However, it is believed that ambient air leakage into the sampling system may have occurred resulting in a calculated loss of perhaps 40 to 50 percent less than that which actually occurred. Calculated D_2O losses from the stack for the current operation period (from October 19 to 24) indicate a D_2O loss rate of about 40 to 60 pounds per day. Preliminary data on main exhaust duct D_2O content verify this rate of loss.

2. Tritium analysis of the stack condensate sample indicates that the D_2O loss to the stack is predominantly from the primary system. The moderator-reflector contribution to D_2O losses appears to remain constant at about 10 pounds per day during both operation and shutdown.

3. The ventilation system appears to remain the primary path for D_2O losses from the PRTR.

4. There is no apparent single large source of D_2O leakage during either reactor shutdown or operating periods. Tygon tube samples show no specific location in the process cell which has a significantly higher D_2O content.

5. Shutdown losses based on stack samples are from 20 to 40 pounds per day. Losses during shutdown may result from helium leakage, purging from open systems (D_2O recovery system, for instance) and from system maintenance. Some of the foregoing losses will be incurred during operation, while others will not.

6. During the run of October 1-7, the D_2O recovery system yielded an average condensate collection rate of about 70 to 75 pounds per day. The isotopic purity of the collected condensate was 82%. Based on the above and on other assumed information, D_2O losses from air leaks in the recovery system were calculated to be 20 to 25 pounds per day. However, the calculations are sensitive to small changes in some of the values which were assumed. Hence, the actual loss could have been as high as 50 pounds per day. The present information is of value only in indicating the significance of the D_2O recovery system as a major contributor to the total D_2O losses further.

PRTR Second Generation Shim Rods. An evaluation of the in-reactor performance of a hydraulic rod as a "second generation" shim rod for the PRTR has been completed. The suggested design employs two variable liquid column segments of cadmium sulfate solution which are black to thermal neutrons. A rod diameter of 1.2 inches has a maximum reactivity worth of 9.8 mk and a minimum life of 1.0 month during continuous exposure (without solution regeneration).

Plutonium Recycle Critical Facility Physics Calculations. Further physics analysis of the Plutonium Recycle Critical Facility in support of additional hazards evaluations are being performed. Final debugging of the modified SWAP Code was completed, and initial results have been obtained. Evaluation of these results is proceeding.

Thermal Hydraulics Studies

Steam Voids in the Plutonium Recycle Critical Facility Following the Accidental Insertion of a Fuel Element. A possible but highly improbable hazard in the operation of the PRCF is the accidental dropping of a fuel element into the core when it is critical or just subcritical, followed by a failure of the safety system to function and shut down the reactor. Preliminary calculations of the consequences of such an incident made previously showed that the fuel elements would melt and would release fission products to the environs at ground level. A study was started to refine these calculations.

The preliminary calculations assumed no heat transfer from the fuel elements to the moderator. The only shutdown mechanism which would terminate the power excursion following the fall-in of the fuel element was the Doppler effect associated with the increase in uranium temperature. While the heat transferred would be a small fraction of that generated and therefore would not significantly reduce fuel element temperatures for a given excursion, it would be sufficient to cause local boiling of the moderator on the fuel element surface. The steam voids of this local boiling should contribute to the reactor shutdown and thus tend to limit the severity of the excursion. The Borax and Spert reactor experiments give evidence of this.

A review of the reports of the Spert and Borax experiments has yielded an equation which approximates the steam void volume. Plans were made to use this equation with appropriate nuclear relations in analog studies to determine the maximum fuel element temperatures which might be expected in this case.

Plutonium Fuels Development

PRTR Aluminum-Plutonium Fuel Elements. Seven Mark I-H 19-rod cluster fuel elements were transferred to the PRTR this month. Two of the elements were completely fabricated in one week. These two elements are attempts to eliminate the wire loosening problem existing on the aluminum-plutonium spike elements in the PRTR. All the data taken up to this date indicate the fuel element rods are shortening. The rate is not known. The cause would seem to be a bonding mechanism between the core and the cladding. Two approaches have been taken to correct this:

1. One element uses graphite dag on the cores to eliminate bonding or gripping.
2. One element has an increased cold minimum gap between core and cladding. During thermal cycling this should let the core stay in contact with the cladding a shorter length of time.

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 Al-Pu master alloys were made by the cryolite reduction process. Isotopic analysis on four of the six batches showed that a uniform blend was obtained, and incomplete chemical results indicate that a satisfactory recovery of plutonium was achieved. In addition, another master alloy of a separate batch of high exposure plutonium oxide was made by the cryolite reduction process; this alloy will be used for making spike fuel elements for PCTR tests.

Phoenix Experiment. The first irradiation cycle for the 6.25 w/o Pu-240 Phoenix capsule (GEH-21-1) has been successfully completed in the MTR and after a ten-day cooling period, reactivity measurements were made in the ARMF. The irradiation was performed without incident at a power generation of about 40 kw/ft and a surface heat flux of about 1,000,000 Btu/hr-ft^2. An underwater examination of the capsule was made which appeared unchanged. A decrease in reactivity was measured in the ARMF.

The Phoenix capsule containing plutonium with 27.17 w/o Pu-240 (GEH-21-9) has also successfully completed its first cycle of irradiation and will be measured in the ARMF after an appropriate cooling period.

Irradiation of the 16.33 w/o Pu-240 capsule (GEH-21-3) is proceeding at the present time. ARMF measurements on this capsule will commence as soon after irradiation as possible so the reactivity effect of the short-lived fission products can be determined. It is estimated that ARMF measurements can be started about five hours after the reactor has been scrammed.

The aluminum capsule holders have been altered to make underwater disassembly easier and more clearance has been provided in the flux monitor holes. An underwater handling box has been designed and is being fabricated that will permit easy cutting and segregation of the Al-Co flux monitors. Also, design changes have been made in the ARMF calibration standard which will permit determining flux spectrum changes in the ARMF due to the presence of the sample.

Irradiation Testing. The Al-Pu intentional rupture element is being examined in Radiometallurgy. An examination of the element indicated that none of the wires had loosened and it was generally unaffected as a result of the irradiation. The ruptured rod of the seven-rod cluster was sectioned through the 0.035-inch diameter hole in the Zircaloy-4 cladding. A small amount of corrosion of the Al-Ni-Pu core has occurred as a result of the 48-hour post-rupture operating period. However, no corrosion product was observed in the defect area. Some corrosion product was observed in areas removed from the point of rupture. Ex-reactor defect tests conducted in static and dynamic systems has shown that the corrosion products tend to plug the holes and prevent further corrosion. There was no indication of bonding or sticking between the core and its cladding. Also, a metallographic examination of the cladding indicated that no hydriding had occurred even in the immediate vicinity of the rupture.

The end caps were removed from the center rod of the cluster which contained a core with an average diametral core-to-clad gap of about 0.007 inch. The core was completely unbonded and slipped easily from its cladding. Core measurements indicate that its diameter has increased uniformly about 0.001 inch and its length has decreased about 0.077 inch.

The two irradiated Zircaloy-clad capsules (GEH-14-27, 28) containing Al - 2.1 w/o Pu - 2.0 w/o Ni alloy fuel cores fabricated by injection casting were examined. Capsule GEH-14-27 was sent back to the MTR for additional irradiation. The goal for this specimen is a minimum of 50 percent burnup of the plutonium atoms. The two specimens have received to date an exposure of 32×10^{18} fissions/cu cm or a burnup of the plutonium atoms of 22 percent. The capsules operated with a specific power of 25 kw/ft and had an associated heat flux of 588,000 Btu/hr-sq ft. Dimensional changes on the 9/16-inch diameter by 3-1/2-inch long pieces were less than 0.45 percent on diameter and 0.55 percent on length. Metallographic examination revealed that a metallurgical bond had been retained over half of the circumference of a transverse section. No hydride indications were observed in the

Zircaloy-2 cladding. Photomicrographs of the fuel core showed, as anticipated, a slight amount of segregation and the presence of two phases could be noted clearly. The cladding hardness (KHN) showed an increase from 175 to 203 (16 percent) from OD to ID. From the fuel core OD to center the hardness(KHN) decreased from 78 to 65 (16 percent). All hardness measurements were made on a transverse section and employed a Knoop Indenter with a 100-gram load. The end cap area on GEH-14-28 had been hit by an off-center but heavy direct blow at some time prior to the radiometallurgical examination. The blow was severe enough that the stamped identification number on the end cap was completely missing. The depressed area (about 50 percent of the cap) was estimated to be 1/32-inch deep. No evidence of weld or cladding failure was visually noted on the specimen.

Examination of the irradiated UO_2-PuO_2 element has also commenced and indicates that virtually no changes have occurred as a result of the irradiation. The fuel material in this 42-inch long element consists of UO_2-PuO_2 sintered and ground pellets. Full-length autoradiographs of the rods are being made on glass. The darkened glass will be scanned with a densitometer to determine the exposure variation along the length of each rod. The fuel rods are also being sampled for fission gases.

Fabrication of the heterogeneously enriched swaged UO_2-PuO_2 seven-rod cluster is progressing. The fuel rods have been inspected and autoclaved and will now be assembled into the cluster. The fuel basket hardware has been completed, and the irradiation proposal writeup is being reviewed by project engineering. It is scheduled for insertion in the ETR on November 13.

Four high density, UO_2-PuO_2 capsules and one low density capsule were discharged from the MTR this month. There are now eleven discharged oxide capsules at the MTR awaiting shipment to HAPO. Goal exposure for all capsules was on the order of 10,000 MWD per ton of fuel material. Flux-monitoring wire measurements have not been received yet to verify attainment of the goal exposure.

The four specimens, each containing high density (94 percent of theoretical value), UO_2 - 0.154 a/o PuO_2 and UO_2 (1.00 a/o U-235) pellets, for the tests in the MTR Hydraulic Rabbit Facility (VH-4) required slight modifications at the MTR and are being processed for irradiation during MTR Cycle 164. The modifications consisted of increasing the end radius on the aluminum outer jackets and providing a more positive attachment of the required cobalt flux-monitoring wire sections.

Oxide Fuel Development

Two seven-rod clusters have been fabricated for irradiation testing in the ETR. The core material was depleted fused UO_2 containing 0.51 w/o high exposure PuO_2. The fuel rods were loaded by the incremental loading process. The actual loading and vibrating of the fuel material took 6-8 minutes per tube. Total loading time including bagging

procedures averaged 17 minutes per rod. The total deviation in the PuO_2 content between fuel rods was less than ± 1.25%. Following is a table showing the total PuO_2 content in the individual rods fabricated for the second cluster.

VARIATION IN TOTAL PuO_2 CONTENT IN INCREMENTALLY LOADED TUBES

Rod	Coarse (UO_2)	Fine (UO_2 & PuO_2)	Total	% PuO_2
12	962.8	123.3	1086.1	0.525
13	961.1	121.9	1083.0	0.519
14	978	122.3	1100.3	0.514
15	962.9	122.3	1085.2	0.521
16	966.8	122.7	1089.5	0.520
17	970.4	121.1	1091.5	0.513
18	976.7	124.2	1100.9	0.522
19	964.9	121.7	1086.6	0.517
20	963.0	122.5	1085.5	0.521
21	967.1	123.2	1090.3	0.522
24	966.3	122.7	1089.0	0.520
25	974.8	123.6	1098.4	0.520

Welding techniques have been developed in connection with the swageable end cap for making closures in the immediate vicinity of the loose oxide. Successful welds have been made with the oxide material within 1/4 inch of the top edge of the tube.

A nondestructive testing method for determining lonitudinal plutonium segregation in a fuel rod is being investigated with the cooperation of the Physics & Instrument Research & Development Operation. Initial tests, utilizing the PCTR have indicated that the level of detection is within the sensitivity range required. Additional tests, using oxide capsules and swaged fuel rods, are planned.

Considerable effort has been expended during the month to develop a technique by which the end of the tube remains free of contamination during loading and vibratory compaction. The present technique employs a rubber hose which runs from the loading assembly down to a funnel taped to the top of the tube. The natural resonances of the rubber tubing work the funnel to the point where it wears through the protective stripcoat layers on the end of the tubing. In an effort to isolate the vibration of the tube from the filling hose a low mass vinyl expansion bellows has been designed and is currently being built. This will allow dust-free filling without the attendant contamination of the tube end.

Extrusion Presses. Installation of the 280-ton hooded extrusion press and the 125-ton unhooded extrusion press, relocated from the 231-Z Bldg., has been completed. The relocation of this equipment improve the fuel fabrication capability of the 308 Building but has not previously been moved because of fabrication commitments.

Fuel Recycle Pilot Plant (CAH-916). A shielded facility for limited reprocessing of PRTR fuel elements has been scoped and is now in the detail design stage. The pilot scale laboratory (324 Building) to be located east of the 308 Building, will include high level cells for chemical processing and metallurgical fabrication, a low level canyon for plutonium tracer work, and a cold uranium canyon. A ten and a half (10-1/2) months design schedule has been established, and design is on schedule with eight percent completion. The construction schedule has not been firmly established as yet, but completion will most likely be about mid-year, 1964.

Plutonium Fuel Fabrication in Support of Physics Program. The aluminum-plutonium fuel for the temperature coefficient experiment has been completed and delivered to the Reactor Lattice Physics Operation. This job consisted of 60 elements, 20 inches long, and clad in 0.495 ID Zircaloy tubing. Twenty elements used aluminum cores with inside and outside thermocouple attachments. The other 40 used aluminum-plutonium cores, 20 with high exposure and 20 with low exposure plutonium. Operational temperature on these elements in the Physical Constants Testing Reactor is 600 C.

UO_2-PuO_2 fuel is being fabricated for a PCTR loading. Ceramic grade UO_2 pellets were pressed to 52 percent green density in a 19/32-inch drill bushing. These pellets will be used to determine shrinkage during sintering so that dies can be designed for the automatic pellet press to produce pellets that will sinter to the required diameter. Several binders and lubricants are being evaluated in an effort to optimize the pellet making process, since over 15,000 one-half-inch long, finished pellets will be required for the loading. Paraffin oil, applied to the punches and die, appears better than a lubricant which is added to the powder mix. A method of continuously applying the oil to the bottom punch of the automatic press is being investigated.

Fabrication of Physics Test Standards for Bettis. Bettis requested the fabrication of Al-Au, Al-U, Al-Pu, Al-B, Al-U-B, and Al-Pu-B alloys clad in zirconium for physics experiments. The Al-Au, Al-U, and Al-Pu alloys are nearly completed; with the exception of one plutonium alloy, the compositions of these alloys are within three percent of the intended compositions, and the homogeneity of the alloys is within two percent of the mean composition. One plutonium alloy showed a gradation of ten percent in plutonium concentration. Intermediate points on the alloy are being checked.

The Al-B and Al-Pu-B alloys have been cast and the extrusion of these alloys has begun. The Al-U-B alloys have not been cast for only a small excess of enriched uranium is available. The homogeneity of the other boron alloys will be determined before casting the Al-U-B alloys.

UO_2 Fuels Development

PRTR Fuel Elements. Four PRTR 19-rod cluster cold swaged fuel elements were inspected during a reactor outage. The fuel elements were in excellent condition after an exposure of approximately 500 MWD/T of UO_2. There was no evidence of loosening of wire wraps, crud buildup, or serious surface damage. Some minor surface scratches which probably occurred during discharging were observed on fuel rods of all four elements.

An inspection of the thermocoupled fuel element which was discharged from PRTR last May revealed stress corrosion cracks in the stainless steel thermocouple sheaths at the point of egress from the Conax compression seal. Because of the possibility of similar corrosion at the diffusion joint between the thermocouple sheath and the Zircaloy-2 end cap, recharging of the element into the reactor was postponed pending further examination.

Vibrational Compaction. A new vibrational compaction technique is being investigated. Vibration is applied to the top end of the fuel cladding which is suspended from a resonant structure, rather than to the bottom end that is ordinarily coupled directly to the vibrator. Uniform bulk UO_2 densities greater than 90% TD were achieved by this method. The new

Hydriding of Zircaloy. Irradiation of the third Hanford Defect Test (HD-5) began successfully. The element is generating a surface heat flux which presumably could cause catastrophic hydriding within a short period. The four-rod cluster element contains two rods clad in Zircaloy-2 and two clad in Zircaloy-4. One each of the Zircaloy-2 and Zircaloy-4 clad rods were deliberately defected by drilling a 0.006-inch diameter hole through the cladding. A large burst of fission gas was released from the element during the initial power level increase (from 5% to 35% of full power). Subsequently, gamma activity in the effluent coolant decreased quite rapidly, as expected. Subsequent power level increases produced only moderate increases (each followed by a gradual decrease) in effluent gamma activity.

Enrichment Test. A Zircaloy-clad UO_2 fuel element containing large particles of 93% enriched UO_2 is successfully undergoing irradiation in the MTR. Each 0.565-inch diameter rod of the four-rod cluster (GEH-4-62) contains a large particle (approximately 1/8-inch diameter) of 93% enriched UO_2 positioned adjacent to the cladding at the fuel element midpoint. The remaining fuel comprises natural UO_2 blended with 93% enriched UO_2 (-10 mesh) to achieve an average fuel enrichment of 1.6% U-235 in U. A different type of natural UO_2 was used in each of the four vibrationally compacted rods. One rod contains sintered and crushed UO_2, one contains fused UO_2, one contains electrodeposited UO_2, and one contains high-energy impact-formed UO_2. Bulk fuel density averaged 87.3% TD. Surface heat flux at the hot spot was estimated to be initially about 1,800,000 Btu/hr-ft^2.

Remote Fabrication Studies. A nested tube fuel element design will be used for initial experiments in remote fabrication of a full-size PRTR fuel element. As far as possible, cladding components and hanger fixtures will be assembled and tested prior to loading and compaction of fuel material within the remote operation facility. Remote handling will then be required only for the final end closure and hanger welds. A turn-table and an inert-gas welding chamber are being designed for automatic, remote welding operations. The cladding material is on hand. Zircaloy wire for spacing members is being fabricated. The basic fabrication units such as the vibrational compactor are available.

Corrosion and Materials Studies

Effect of Thermal-Cycling on Corrosion of Zircaloy-2. The standardized Hanford procedure for autoclave corrosion testing in 400 C steam involves removing each sample for weighing at 3, 7, 14, 28, 42 and 56 days. Since this procedure thermal-cycles the samples a number of times, a special test to evaluate the importance of the thermal cycling was conducted in which the samples were removed only twice - at 16 days and 60 days. The weight gains at 16 days (27 mg/dm^2) agreed well with normal Hanford (thermal-cycled) test results. However, after 60 days and an average weight gain of 44 mg/dm^2, the samples had not experienced breakaway. For samples exposed to multiple thermal cycling by the standard test procedure, the average breakaway time is about 44 days at a weight gain of approximately 40 mg/dm^2, and the weight gain at 60 days is about 55 mg/dm^2.

Although the effect is not a large one, frequent thermal cycling apparently does accelerate the onset of breakaway corrosion.

High Temperature Oxidation of Zircaloy-2. Zircaloy-2 specimens were oxidized at high temperatures (700, 750, and 800 C) in 4 mm Hg water vapor partial pressure for comparison with previous runs made at 25 mm water vapor pressure. Reducing the pressure of the oxidant affects the oxidation kinetics in several ways:

(1) It reduced the weight gains during the initial cubic stage by about 10 percent from those obtained using a pressure of 25 mm Hg.

(2) Though the final "fast" linear rate still occurs at about 300 mg/dm^2, this weight gain is achieved in twice the time for low pressure (4 mm) 800 C test conditions.

(3) The "fast" linear rate is approximately half as fast at the low pressure.

It appears likely that the rate-controlling factor in the late linear state is gaseous diffusion through discontinuities in the oxide film.

PRTR Water Quality and Decontamination Studies. The water quality requirements for the PRTR secondary system are being reviewed, and changes in the specifications will be recommended in the light of operating experience to date. The design is now complete for installation of a gas chromatograph to monitor the impurities in the helium gas.

Proposed procedures for decontaminating the primary system and the PRTR Rupture Loop were reviewed and updated to facilitate planning by operating personnel.

Caustic Cracking Studies. A test evaluating the effect of concentrating LiOH on stressed 316 stainless steel continued during the month. Another test was initiated in TF-5 in which stressed samples of 304 stainless steel and Zircaloy-2 are exposed to 1 g/l LiOH solution at 290 C. After two weeks, examination of the samples revealed no cracking or visible hydriding. The test is continuing.

Stress Corrosion Cracking of Various Steel and Nickel Alloys. The susceptibility of "U" bend specimens of various steels and nickel alloys to chloride stress corrosion cracking is presently being tested in boiling 42 percent $MgCl_2$ (154 C). Testing has been completed on approximately 17 alloys which include austenitic stainless steels, Hastelloys, Inconels and iron-chromium-aluminum alloys. All of the austenitic stainless steel samples failed in less than 19 hours. One Hastelloy "F" sample also failed in less than 19 hours, and one Fe-Cr-Al-Y sample failed in 47 hours. The remaining alloys showed no stress cracking after 160 hours of exposure. Several of the alloys, namely

406 stainless steel, Ferrals, Fe-Cr-Al-Y and Fe-Cr-Y, demonstrated pitting-type corrosion ranging from very light to catastrophic. The 406 stainless steel samples had the lightest attack, whereas the Fe-Cr-Al-Y and Fe-Cr-Y samples were catastrophically pitted. The remaining Hastelloy and Inconel alloys showed virtually no signs of corrosion.

PRTR Process Tube Monitoring. Eight PRTR process tubes were visually examined and the ID and gas gaps were measured. Visual examination showed new wear-corrosion marks in all eight tubes. One of these eight tubes was operated with a Pu-Al element fitted with large contact area spacer lugs at the end brackets. Wider than normal fretting marks were apparent in this tube. This tube was removed for destructive analysis. Inside diameter measurements indicated that two tubes were approximately 15 mils elliptical in cross section at about nine feet from the flanged end of the tube. Gas gap measurements indicated no appreciable change since the last inspection. The tube in channel 1857 was moved to channel 1756 and a new tube was placed in channel 1857. These changes provided acceptable gas gaps in channels 1857 and 1756.

Pre-irradiation evaluation of Process Tubes. Of the 11 replacement PRTR pressure tubes that have been autoclaved, four have passed inspection and are ready for straightening, and seven have scratches in the autoclave film or questionable areas that may require rework. Of the remaining tubes, 18 are ready for etching and autoclaving, two tubes require rework before etching, and two tubes are being held as potential rejects.

Post-Irradiation Examination of PRTR Process Tubes. No evidence of hydriding or white corrosion product was found at the base of the deepest wear-corrosion groove (approximately 5 mils deep) at the bottom fuel support in PRTR process tube 1154 which was removed from the reactor in July. As reported in August, hydriding had been observed at the base of a three-mil deep groove at the upper fuel support location in this tube.

04 Program Radiometallurgy Studies

A 10 w/o ThO_2 - 90 w/o UO_2 fuel in capsule GEH-4-61 had sintered during its MTR irradiation except for a thin layer adjacent to the cladding. A central core was present and evidence of a melt was observed in one end of the core (RM 631).

Visual examination of the nested tubular element GEH-12-22 which was irradiated to about 600 MWD/T in the ETR revealed no visible deformation in any of the components. A rupture on the inner surface of the inner tube was found to be a 3/8-inch diameter hole (RM 637). Examination was completed on the seven-rod cluster Al-Pu rupture test, GEH-11-5. No significant concentration of hydrides was found in the cladding of the defected rod or the center rod. The entire core of the center rod was removed from the cladding and the dimensional changes occurring in the core are being determined (RM 672).

Examination has begun on a seven-rod UO_2-PuO_2 cluster irradiated under GEH-11-3. A new technique has been developed for making autoradiographs along the full length of the rods, wherein strips of uniform glass are browned by radiation (RM 668).

It has been demonstrated that sections of 12 w/o Si - 15 w/o Pu-Al alloy, coextruded in Zircaloy-2 can be declad in 14 M HF at room temperature with only surface corrosion damage to the exposed cut surfaces of the fuel. A section of the declad core may then be removed for density measurement. Unirradiated sintered 86% ThO_2 - 14% UO_2 has been found to be insoluble in concentrated H_2SO_4 at 200 C, the only solvent recognized in classical literature. X-ray diffraction studies on three cold standards and three irradiated zirconium samples have been completed, and the data reported to Physical Metallurgy.

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

2. PLUTONIUM CERAMICS RESEARCH

Plutonium Oxides

A set of oxide pellets pressed from powder derived by a 550 C air calcination of the oxalate was heated to various temperatures in high vacuum (approximately 3 - 5 x 10^{-5} mm Hg) in order to study the thermal compositional stability in very low oxygen pressures. Reduction occurred slowly with temperature giving O/Pu values between 1.98 and 2.00 for one hour at temperatures in the interval 1000 to 1740 C. Increasing the temperature to 1900 C gave a considerable increase in reduction, the O/Pu being 1.85. Densities were somewhat lower than normally seen in hydrogen sintering, reaching 89 percent of theoretical after the 1900 C one-hour treatment. The reduction in vacuum appears quite insensitive to temperature relative to that seen during hydrogen or helium heat treatments. Thermodynamic calculations are presently being performed in effort to correlate these effects with partial pressure of oxygen.

Additional metallographic examination has been performed on reduced plutonium oxides with the following microstructural features noted:

$PuO_{1.72}$	Gave a rather mottled grain structure with large irregular grains
$PuO_{1.82}$	Lamellar type structure typical of pearlite-eutectoid phase
$PuO_{1.90}$	Difficult to resolve grain structure due in part to porosity, however, material did appear single phase.

Quench tests will be run during the next month to determine elevated temperature structural details.

Gas Evolution Studies

Calibration and trial runs of gas evolution equipment were made using UO_2 large, approximately 3 mm, particle size. As much as 0.2 - 0.5 cc/g of gas were evolved in 30 minutes at 1500 C. The data do not yet permit a conclusion on the origin of the evolved gas. The reaction chamber can now be isolated from the rest of the system; this allows evolved gases to build up sufficient pressure, greater than 200 microns of mercury, to circumvent the undesirable effects of a gaseous discharge within the high frequency induction coil. Sample mass is also carefully governed in order to control the gaseous discharge.

The tantalum reaction crucible is first outgassed at the maximum operating temperature, 2000 C. Then the pressure in the reaction chamber is increased to one atmosphere of helium. A monatomic gas such as helium will readily escape the surface of the crucible when again heated in vacua. This amount, the blank value, should be a constant over a given experiment. The process is then repeated as several different masses of a specific UO_2 sample are run. As explained earlier, this blank pressure is found from a plot of McLeod pressures squared versus specimen weight. Also, the amount of gas evolved from a given weight of UO_2 is calculated directly from this plot.

Plutonium Carbides

An additional set of PuC alloys extending from 34 to 54 a/o C was arc-melted to provide confirmation on the compositional limits of the PuC phase. Densities varied as expected with composition and PuC gave 97.7% of theoretical density. Low temperature anneals and metallography are planned to provide data on phase relations near the zeta range.

Plutonium Silicides

Plutonium dioxide and silicon powders were blended in a 40:60 a/o ratio in an attempt to form Pu_2Si_3. The blended powder was then compacted into pellets and heated to 1385 C in a vacuum resistance furnace; the pressure was 4.6×10^{-5} mm of mercury. X-ray diffraction analysis of the product shows the product to be $PuSi_2$. Its melting point as previously determined is 1795 ± 23. Since $PuSi_2$ is 33-1/3 a/o Pu, it is evident that plutonium is lost during the reaction. An excess of plutonium dioxide will be added in an effort to maintain stoichiometric balance.

ZrO_2-PuO_2 and MgO-PuO_2 Fuel Capsules

Work is progressing on fabricating the sixteen ZrO_2-PuO_2 and MgO-PuO_2 capsules for irradiation testing in the MTR. The status of the capsules is as follows:

1. ZrO_2-2.18 w/o PuO_2. The pellets for the four capsules have been sintered to about 90% of theoretical and are ready for canning. Some difficulty was experienced with porosity and

cracking. These troubles were rectified by reducing the amount of binder and lubricant and heating at a slower rate during sintering.

2. ZrO_2-10.39 w/o PuO_2. The four capsules are completed with the exception of autoclaving. These pellets sintered to about 90% of theoretical.

3. MgO-3.05 w/o PuO_2. The pellets are being sintered at the present time. It was necessary to ball mill the MgO before adequate densities could be obtained. Cracking of the pellets was also encountered.

4. MgO-13.53 w/o PuO_2. The pellets have been sintered to a density in excess of 90% of theoretical and are ready for canning.

The 0.567-inch OD Zr-clad MgO-PuO_2 capsules will be assembled by shrink-fitting a 1.120-inch OD aluminum sleeve over them. This will permit a maximum power generation of 40 kw/ft without excessive temperature on the capsule surface. Because of the good thermal conductivity of MgO, a high power generation is required in order to obtain the desired center core temperature.

3. UO_2 FUELS RESEARCH

Fuel Evaluation

Preliminary examination of a UO_2-ThO_2 fuel specimen (GEH-4-61) successfully irradiated with a surface heat flux of approximately 700,000 Btu/hr-ft^2 indicates that the element operated with a molten core. A central cavity filled with sponge-like fuel material was formed during irradiation. The cavity is surrounded by large columnar grains which extend nearly to the cladding. In general, the fuel cross-section appears similar to previously irradiated UO_2 and PuO_2-UO_2 "ash-can" elements. The vibrationally compacted (86% TD) mixture of 10 w/o ThO_2-90 w/o UO_2 was enriched to 1.38 w/o U-235 in U and was clad in 1.115-inch OD by 0.030-inch wall 304-L stainless steel.

A capsule containing swaged UO_2 was discharged from the MTR core after reported irradiation to 53,000 MWD/T_U. A second, similar capsule was discharged at a reported exposure of 38,000 MWD/T_U. These capsules are being returned to Hanford for examination.

A single crystal of fused UO_2 was discharged from the ETR core after irradiation to a reported exposure of 8900 MWD/T of uranium. This crystal will be returned to Hanford for metallographic analysis and complete characterization of its physical and mechanical properties. Irradiation of a second, similar crystal continues. This crystal will be discharged after it has attained an exposure of approximately 40,000 MWD/T of uranium.

Nitrides in Fused UO_2

Evolution of nitrogen gas when fused UO_2 is heated in vacuum is believed to be the result of decomposition of higher uranium nitrides; i.e., U_2N_3 and UN_2, to UN and N_2. The decomposition of higher uranium nitrides in sealed fuel capsules at any given temperature is limited by the pressure of nitrogen in equilibrium with material having the particular N/U ratio under observation. Nitrogen gas pressures in fuel elements thus should be considerably lower than those calculated from gas volumes extracted in vacuum from fused UO_2 samples.

A proposed mechanism for nitrogen fixation in fused UO_2 was verified in the laboratory. It has been suggested that uranium nitrides are formed by the reaction of nitrogen with the uranium metal inclusions frequently found in fused UO_2. The reaction could occur in the cooler portion of a billet during fusion if the fusion is performed in a water cooled steel vessel in an air atmosphere. Fused UO_2 containing uranium metal inclusions was heated in nitrogen at 1000 C for three hours. The nitrogen content, determined by the Kjeldahl method, increased from 220 to 540 ppm. X-ray diffraction analysis showed the presence of a new component, tentatively identified as UN_2. Metallographic examination of nitrided inclusions revealed a characteristic structure which has been observed in several lots of fused UO_2.

Internal pressure variations as a function of temperature will be measured in fuel capsules filled with nitrided fused UO_2. The results will be correlated with gas volumes extracted from the same samples in vacuum.

Fused UO_2 containing uranium metal inclusions was metallographically examined following steam autoclaving 72 hours at 400 C. Complete protection of the uranium inclusions from oxidation by the steam was provided by thin (less than one micron thick) layers of UO_2. This observation is encouraging with respect to the use of such material as reactor fuel. There are indications that fused UO_2 containing uranium inclusions may be fabricated more economically than stoichiometric UO_2.

UO_2 Melting Studies

An induction heater coil was adapted to the 60 KW Thermatool welder power supply. A temperature in excess of 2200 C was obtained on a 1/2" ID by 5/8" OD tungsten tube heated by induction in an argon atmosphere with a one-turn coil. A three-turn coil is being fabricated to be used for higher temperature tests of UO_2 melting in tugnsten tubes.

Irradiated UO_2 Examination

A polished section of a 1.44-inch OD irradiated UO_2 fuel core was dissected to provide small specimens from accurately known areas. Specialized in-cell sampling techniques were developed. The samples will be used in measuring the change of various properties, such as melting point, O/U ratio, impurity concentration, metallography, etc., that occurred during irradiation.

Thermal & Electrical Conductivity

A summary report on thermal conductivity and electrical conductivity of UO_2 was presented at the Pacific Coast regional meeting of the American Ceramics Society, San Francisco, October 17, 1961. A detailed report of the entire HLO/BMI UO_2 conductivity research program to date is in preparation.

4. BASIC SWELLING PROGRAM

Irradiation Program

Two capsules that have been under irradiation since March 1961, as part of the basic swelling program, will be discharged in November of this year. One capsule has been operated at a constant temperature of 525 C, and the other capsule has been operated at a constant temperature of 575 C regardless of reactor operating conditions. Recently, an accidental trip and subsequent re-establishment of electrical power to the capsule heaters by reactor operating personnel caused a momentary temperature excursion into the beta range on both capsules.

Four additional capsules have been completely assembled, bench tested, and are ready for charging into a reactor. These four capsules will be charged in tandem, two to each test.

Checkout tests are continuing on a new capsule instrumentation and heater supply facility at the reactor with another completed capsule under simulated reactor operating conditions. This new instrument facility will be used on the capsules to be charged in tandem and on future capsules on this program. One additional capsule has been assembled and an open circuit in its heater has been found and corrected. However, this capsule contains a small leak that will require location and repair before it is ready for irradiation.

A specification is being prepared for off-site fabrication, assembly and laboratory testing of additional capsules for continued work on the basic swelling program. An order for heaters for these future capsules has already been placed.

Post-Irradiation Examination

Two unrestrained spherical specimens of uranium, irradiated to a burnup of 0.05 a/o at 575 C and 0.28 a/o at 575 C, have been annealed at 575 C for 100 hours and are being processed for metallography. Both specimens show little change in porosity by qualitative comparison. Porosity is non-uniform both with respect to pore sizes and location of pores. Detailed comparison by quantitative metallography will be made. Microhardness measurements on these specimens before and after annealing have been taken. The data will be analyzed to determine the utility of microhardness as a qualitative measure of swelling.

A replica of an etched surface in a spherical specimen of 3% U-235 irradiated in NaK to a burnup of 0.16 a/o at a temperature of 800 C has been examined in the electron microscope. In line with observations made by optical microscopy, the peripheral band around the specimen contains only small pores relatively few in number, whereas the interior contains many pores some of which have contacted each other and have agglomerated. Bands which permeate the interior show no small pores, only large pores in the center and edges of the bands. Within the matrix between bands, profuse porosity exists. Microhardness traverses across these bands indicate that the bands are significantly harder than the matrix.

Metallography on two specimens from capsule #6 irradiated at 300 C to a burnup of 0.034 a/o has been completed. Extensive electron microscope examination has revealed no evidence of microcracks or porosity in these specimens.

A solid cylindrical specimen of normal uranium, GEH-14-36, which had been irradiated unrestrained in NaK at < 200 C to a burnup of 0.26 a/o has been annealed at 600 C for one hour. This specimen had undergone a density change from 19.01 g/cc to 18.61 g/cc during irradiation and disclosed relatively few pores by electron microscopy in the as-irradiated state. Prior to the anneal, the specimen was repolished and two Knoop hardness traverses were made along two perpendicular directions on the specimen. The Knoop hardness numbers vary considerably from point to point and reflect a much greater scatter in hardness after irradiation than before. Hardness numbers are in general in the range 0-200 units higher than the pre-irradiation values. After annealing, the density of the specimen decreased to 18.51 g/cc indicating only a slight increase in swelling. Knoop hardness was again determined on a polished surface of the specimen, and the hardness numbers in general had decreased to the pre-irradiation values. However, scatter among the hardness values was still appreciably greater than in the specimen prior to irradiation. Since surface preparation can affect hardness values and since hardness differences between neighboring grains can be as large as 50 units, these values will serve as a qualitative index.

Replicas of this specimen after annealing have been subjected to a preliminary electron microscope examination and show that an increase in the size and number of observable pores has occurred. The specimen has apparently recrystallized in many regions and formed new equiaxed grains, approximately four microns in diameter. Within such grains porosity is essentially absent, but pores as large as 0.25 microns in diameter are located at the boundaries. Also present are large elongated grains which show little, if any, porosity in their interior and at their boundaries. A tentative explanation for the changes observed is that nucleation and growth of recrystallized grains is accompanied by sweeping of gas atoms as the new grain interfaces move through and consume the matrix. Those grains which recover during the anneal without recrystallization contain essentially the same original distribution of pores. Extensive metallographic study of replicas of this specimen are in progress. The annealed specimen will now be subjected to a chemical determination of burnup.

Pore Size Distributions

Electron micrographs suitable for use in a Zeiss Particle Size Analyzer have been prepared from replicas of specimens irradiated in capsules #4, #5, and #6. Pore diameter data are being entered on computer input sheets and will be programmed to yield pore void fraction and density distribution information.

Fission Product Mobility

U-U diffusion couples, GEH-14-281 and 282, consisting of enriched uranium in contact with depleted uranium, are being processed for microhardness. The specimen will then be annealed and metallography and microhardness measurements will be repeated to establish the extent of fission gas and fission product mobility across the U-U interface.

5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

The gamma heating of the specimen and pull rods of capsule III-2 produced a maximum specimen temperature of 515 C with the reactor at full power. In order to conduct a creep test with a minimum of temperature fluctuation the specimen temperature must be controlled electrically; therefore, power was applied until the specimen temperature approached 600 C. The distribution of gamma heat, however, would not allow the elimination of a temperature gradient along the specimen. An in-reactor creep test was conducted with one end of the specimen at 615 C, the middle at 593 C, and the other end at 588 C at a stress of 5800 psi. A test was also conducted in a standard creep machine under identical conditions for comparison. The creep rates for the data obtained, between 20 hours and 300 hours, were the same for the two specimens. This agreement shows no significant influence of neutron radiation at 600 C. The creep rate during this period of time was 3 ($\pm$1) x 10^{-4} in/in/hr for both specimens.

Capsule and Instrument Development

In order to conduct creep tests in the 250 to 400 C temperature range, future capsules of the third generation type must be water cooled. Capsule III-3 has been modified in the past month to provide internal water cooling, decrease the mass of the strain measuring system and remove any insulating material which might contaminate the helium atmosphere. Laboratory checkout of capsule III-3 shows that with the cooling system three times as much power is required to maintain 250 C than that required for 250 C in capsule III-2 which has no cooling system.

Tests of the effect of simulated gamma heating on the thermal properties in a mockup of the in-reactor creep capsule have been completed. The results agree with prior predictions that the convection of helium is the controlling mode of heat transport. It has also shown that the gamma heat simulated in the capsule could not account for the excessively high

temperatures encountered during in-reactor creep tests. There was reason to believe that the atmosphere of helium in the creep capsule had been contaminated. Freon was, therefore, introduced into the mockup as a contaminate but failed to show any change in the heat transport of helium as a function of pressure. However, specimen temperatures were slightly higher at all pressures. It was also believed that the contamination source could have produced combustion products which condensed on the wall of the in-reactor creep capsule resulting in lower heat transport. An oil and dag coat deposited on the inside wall of the mockup failed to cause a significant change of the specimen temperatures.

6. GAS-GRAPHITE STUDIES

EGCR Graphite Irradiations

The H-3-3 capsule has operated successfully for three GETR cycles. The total maximum exposure received by samples previously irradiated in H-3-1 and H-3-2 has reached approximately 8×10^{21} nvt ($E > 0.18$ Mev). All thermocouples are operating satisfactorily.

Oxidation of Large Blocks of Graphite

Although very small graphite samples used in laboratory oxidation experiments may be assumed to oxidize uniformly throughout, the depth of oxidation in large blocks is diffusion controlled and depends on a number of variables which control this diffusion. Thus, in the real case with large blocks, the reaction rate decreases as a function of depth. However, for the purpose of calculating the heat generation during oxidation, the effective reaction zone may be thought of as a hypothetical sharply defined surface layer which reacts as a uniform rate equal to that measured on small samples of the same type of graphite. Also, the reacting fraction of a large sample (of the same type graphite) can be determined experimentally by oxidizing a large sample at a given set of conditions. From these data for small and large samples of the same type of graphite, the "effective depth" of reaction, ℓ, for the large block can be calculated directly, assuming the above hypothetical sharply defined reaction zone at the outside surface.

However, "ℓ" also appears in the following relationship, derived on theoretical grounds:

$$\ell = A \left(\frac{T}{293}\right)^{0.38} y^{-1/2} \text{ cm}$$

where A = a combination of constants including the diffusion constant
y = fraction weight loss/hr
T = absolute temperature °K.

Having an independent experimental value for ℓ it is possible to solve for A rather than considering it to be a constant, 0.033, as has been previously assumed in the EGCR combustion analysis. For EGCR graphite

A was found to be about 0.002 for samples which had not been previously oxidized, but increases essentially linearly as the amount of oxidation increases. The values of A thus determined were not affected by changes in temperature in the range 535 to 660 C or by changes in the shapes of samples. Once having established A as a function of the degree of oxidation, it is thus an easy matter to calculate ℓ for any geometry, temperature, and amount of oxidation. The net effect of this new analysis is that the effective depth of oxidation (and hence the heat released in oxidation) of large EGCR graphite pieces is on the order of half, or less than previously believed. This information has a favorable effect on interpretation of any potential EGCR burning hazard.

Graphite Compatibility with Helium Containing Water Vapor

The recording vacuum balance has been modified extensively so that it has recently been possible to outgas a sample of TSX (NPR core graphite) at approximately 8 μ of Hg and 800 C before oxidation. The sample was subsequently exposed to dry (< 15 ppm of H_2O) helium at 800 C and showed no weight loss for a period of 13 hours. The sample was then exposed to helium containing approximately 250 ppm of H_2O. The average weight loss rate over a period of 19 hours was 6.9×10^{-6} g/g/hr at 800 C. This is higher, by about a factor of two, than previously reported results. This higher rate may be due to the removal of adsorbed gas which could inhibit the reaction.

Graphite-Water Vapor Reaction under Gamma Irradiation

A second series of rate measurements on the reaction of graphite with He containing a small partial pressure of H_2O vapor has been completed in a Co-60 gamma facility. For these measurements a TSX graphite sample weighing 8.3 grams was employed. The H_2O vapor concentration was 155 ppm. As before, oxidation rates were compared at each temperature to those obtained with dry He to determine the effect of residual oxygen. The results are tabulated below.

RATES IN PRESENCE OF 9×10^5 r/hr GAMMA FLUX

Temp. °C	Rate with Wet He mg/hr	Rate with Dry He mg/hr	Net Rate mg/hr
600	-5.36×10^{-2}	-4.92×10^{-2}	-0.44×10^{-2}
700	-6.16×10^{-2}	-5.42×10^{-2}	-0.74×10^{-2}

The activation energy calculated from these data is 8.8 kcal/mole, which is in good agreement with the value 9.4 kcal/mole found for CSF graphite in the same temperature range. The oxidation rates for the two graphites have been normalized to the same H_2O vapor concentration by assuming a linear dependence of the rate on the H_2O vapor concentration, as is found for the thermal reaction. The resulting rate of TSX graphite is about twice that for CSF graphite at a given temperature. In an attempt to explain the difference, measurements were made of the specific surface

area, He density, bulk density, and available void volume for the two graphites. Results are as follows:

Graphite	Specific Surface Area m^2/gm	He Density gm/cm^3	Bulk Density gm/cm^3	Available Void Volume cm^3/gm
TSX	0.486	2.187	1.748	0.115
CSF	0.478	2.108	1.660	0.128

Because differences in the surface areas and in the available void volumes are not great enough to account for the two-fold difference in oxidation rates, it appears that the assumed linear dependence of the rate on the H_2O vapor concentration may not be valid for the radiation-induced reaction. Further measurements are planned to clarify this point.

Thermal Cycling of Coated Graphite

The first piece of pyrocarbon coated 901-S with a Si-SiC coating has been received from Minnesota Mining and Manufacturing Company. The purpose of the pyrocarbon undercoat is to retard diffusion of the Si into the graphite; a process which can result in eventual failure of the coating. The sample has been thermal cycled in air over a temperature range of 250 C to 1200 C. After 150 hours and 900 cycles, it is still intact. A weight gain of 0.0012 g or 0.062 percent has occurred. This is the first sample of this type to be tested; others will be included in future tests.

Ex-Reactor Creep Experiments

A second tensile creep machine is now operating. This machine has had a modified Tuckerman optical strain gage installed in place of the dial gage, to permit measurements in the micro inch range. The system appears to be working satisfactorily but as yet no creep has been detected. The current experiment is with EGCR graphite at 590 C and under a tensile load of 1000 psi.

Five HAPO 300 psi ex-reactor compression boats have been removed from a furnace at 635 C and length measurements obtained on all samples. These boats are identical to those used in the in-reactor experiments and include some unloaded samples. An unexpected growth in length was noted for the unloaded samples. All samples were annealed to 3000 C in vacuum prior to the initial measurements. Annealing experiments are under way on other samples to see if an explanation for these observations can be obtained.

In the meantime the low exposure data obtained from the in-reactor experiments must be held as questionable. The results of these tests were essentially the same as the ex-reactor tests; growth of unloaded samples, and no growth of loaded samples.

Gas Loop Project Management and Design (CAH-822)

The Gas Loop construction remained at 92% completed during the month. Electrical acceptance tests were performed and modifications to the seals of the annulus blowers completed. Installation of the prototype in-reactor tube in the experimental cell was started. This installation will permit testing at design temperature conditions (1500 F), supplementing the former tests which were limited to 1200 F. The NaK heater was removed from the experimental cell as recommended by the General Electric Technological Hazards Council. Numerous substitute heat transfer materials are being investigated in an effort to re-use the present vessel.

The earliest promised delivery date for the main blowers remains at December 31, 1961, although the absence of test results requested following the latest blower modifications would indicate that the December delivery date is optimistic.

Design tests of electrical, instrumentation, and the make-up and vacuum systems have been issued for comment.

Acceptance tests of the electrical system modifications, including DC stopping power for the main blowers, have been completed.

Component Testing. After 150 hours of operation, the second stage diaphragm of the prototype CO_2 compressor ruptured. An inspection of the diaphragm head disclosed that the rupture was caused by metal particles on the oil side of the diaphragm. The metal particles were present because of improper cleaning of the compressor head oil chamber after machining. The compressor has operated 100 hours since the diaphragm was replaced.

7. GRAPHITE IRRADIATION DAMAGE STUDIES

Electron Microscopy

Electron micrographs taken from areas approximately 0.1 mm square on samples being prepared for irradiation in the GEH-13-8 capsule have been assembled in mosaics for the comparison before and after irradiation of relatively large areas magnified 5000X.

The area selected on a graphite prepared with a natural flake filler and coal tar pitch binder contains several thin flakes separated by binder regions. In one instance the interface between binder and the edge of a flake can be distinguished. The layered structure shows much greater continuity than is typical of petroleum coke fillers. Several small folds or kinks are present, including a tight fold of a flake 12 microns thick. The angle of the sides of this fold varies from 20° to 45°, and only at the lowest angle is there an indication of rupture across the layers at the apex.

The area selected on a sample of CSF graphite is near the center of an elongated filler particle having a layered structure arranged in a series of chevrons. The end of a similar elongated particle was selected for study on a sample of TSX graphite, and approximately half of the area includes binder material.

Irradiation of Lampblack Graphite

After an exposure of 1200 MWD/AT at 500 to 600 C, samples of lampblack graphite heat treated to 1400 C had contracted 0.6 percent while samples of lampblack heated to 3000 C before irradiation had contracted 0.2 percent. In an effort to trace the cause of this difference, samples of unirradiated 1400 C lampblack were heated to 3000 C. An average length change of -1.70 percent was observed on eight samples. Therefore, the higher contraction rate of the 1400 C lampblack may partly be due to radiation activation of processes which are normally thermally activated between 1400 C and 3000 C.

Titanium Flux Monitors

A counting procedure for Ti flux monitors has been established, and initial results have been received for an irradiation performed in the Snout facility at KW. Evaluation of the data yielded an effective cross section for a fission spectrum of 13 mb for the Ti^{46} (n,p)Sc^{46} reaction. This compares with a current best value of 9 mb.

8. ALUMINUM CORROSION AND ALLOY DEVELOPMENT

Aluminum Corrosion

Corrosion data have been analyzed from samples exposed to 300 C water adjusted to a pH of 4.5 with H_2MoO_4. After 3097 hours the corrosion rate of X-8001 at 25 fps was 0.34 mil/mo and at 40 fps was 0.57 mil/mo. For comparison purposes this rate is: (a) approximately the same as in water at pH 4.5 with HNO_3, (b) about 10 times as high as the rate in water at pH 4.5 with H_3PO_4, and (c) about 0.1 the rate in deionized water at pH 6 to 7. In-reactor testing in C-1 Loop is planned to determine whether HNO_3, H_3PO_4, or H_2MoO_4 is best from both corrosion-inhibition and crud-formation considerations. Corrosion rates of Zircaloy-2 and sensitized 304 stainless steel in the H_2MoO_4 test were very low (3×10^{-6} in/mo), and agree quite well with data for pH 4.5 with HNO_3 and H_3PO_4 systems.

Corrosion Under Heat Transfer Conditions

Corrosion testing of X-8001 cladding under conditions of high heat transfer was initiated in TF-3 during the month. The first test was operated in high purity water at a heat flux of 228,000 Btu/hr-ft^2 with a bulk water temperature of 660 F and an aluminum surface temperature of 700 F. As the cladding corroded, the aluminum temperature increased. During the first 90 hours an increase of 5 F was obtained; however, extensive intergranular corrosion began occurring after this time. An additional

increase of 116 F was obtained over the next 40 hours before the specimen failed. Examination of the heater rod showed severe corrosion on the surface of the clad; and, as a result of a weld failure, corrosion of the inside of the clad. Temperature conditions were apparently too severe for the X-8001, and therefore, a similar test has been initiated with the bulk water temperature restricted to 600 F. During the first 24 hours of operation the aluminum temperature had increased 15 F. Evaluation of the temperature increase at the end of the test will enable the thermal conductivity of the aluminum corrosion product to be determined. Also, the corrosion will be compared with the corrosion of non-heat-generating samples.

H-1 Loop

Replacement pumps are nearly installed in the loop, and corrosion coupons have been prepared for the first test. Testing with non-fueled coupons is expected to start in November to measure the corrosion and crud pickup of aluminum, 304 stainless steel, and Zircaloy-2.

9. USAEC-AECL COOPERATIVE PROGRAM

Ultrasonic Testing

Some of the basic parameters of the ultrasonic test for sheath tubing are being determined using Electrojet machined grooves to represent defects of various sizes and orientations in the inner and outer surfaces of the tubing. Using a crystal that focuses the ultrasound along a 0.3-inch line parallel to the tube axis, a reduction in response was obtained when the length of the defect was reduced to less than 0.3 inch. An almost linear relationship was measured between percent of full response and percent of crystal length. The test for longitudinal defects is insensitive to defects oriented 20° to the tube axis while the transverse test becomes insensitive if the angle of the defect with the tube axis becomes much smaller than 90°. Apparently there is a large blind area (not yet well defined) in the center of the region between 0 and 90°.

Varying the angle with which the defect enters the tube wall caused a measurable but less drastic decrease in ultrasonic response. For example, a 90% loss in response was observed at an angle of 45°. The tests are continuing.

Boiling Burnout in 19-rod Fuel Elements

The fabrication of an electrically heated 19-rod bundle with 0.074-inch spacing between rods was completed and the experimental program using it was started. This test section is identical except for length to the Hanford PRTR 19-rod element geometry (0.564-inch OD rods, 0.074-inch rod spacing in a 3.25-inch ID tube) and has a heated length of 18 inches.

Since the test section was difficult and expensive to build and past experience with test sections of this type has shown them to be rather fragile, an experimental program was devised to provide considerable

information without undue risk of destroying the test section. The initial series of experiments were planned to identify and demonstrate a large range of conditions anticipated to be close to but free of boiling burnout. Even though such data do not identify exact conditions of boiling burnout, they are valuable for design and hazards analysis purposes. It was planned that if the test section survives the initial series of experiments, further experiments would specifically determine boiling burnout points. The test section will probably be destroyed in the actual burnout runs.

Seventeen of these points close to, but free of boiling burnout were established. The maximum heat flux investigated was 970,000 Btu/hr-ft^2. This was at a mass flow rate of 3,000,000 lb/hr-ft^2 and at about 12 F subcooling. At the other end of the spectrum of conditions, a quality of about 20% was established at a mass flow rate of 500,000 lb/hr-ft^2 and a heat flux of 310,000 Btu/hr-ft^2. Boiling burnout conditions as would be indicated by surges in temperatures of the heated surfaces were not detected for any of these conditions.

Extrapolating these raw data to the current PRTR operating conditions indicates safety factors of at least three for boiling burnout conditions.

Magnetic Force Welding of SAP

Tests of magnetic force closure butt welds on 0.551" OD x 0.020" wall thickness SAP material revealed the weld to be stronger than the tube. The internal upset produced during welding provides a weld cross sectional area approximately twenty percent larger than the tube cross sectional area. Internal pressure test split the tube at 42,000 psi hoop stress. Failure of the tube material in tension occurred at 35,000 psi.

Attempts to weld closures on 0.618 " OD x 0.025" wall thickness SAP were unsuccessful due to insufficient machine capacity. The maximum usable welding current of the machine is 60,000 amperes, equivalent to 1.3 x 10^6 amperes per square inch for the larger tube. It was demonstrated on the smaller diameter tubing that 1.5 x 10^6 amperes per square inch is required to produce a weld. The 0.618 " OD material was swaged to 0.515" OD for further weld evaluation.

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. An environment of high temperature water is of interest.

Six specimen quadrants, each containing eighteen Zircaloy-2 tensile specimens, were successfully removed from the ETR 6x9, hot water loop after cycle 40. The tools for accomplishing this task were used for the first time and performed very well. The removed quadrants were concurrently replaced with tensile specimen quadrants containing types 304 and 348 stainless steel. Specimen quadrants scheduled for insertion at the conclusion of cycle 41 were assembled.

A Fortran program written to process tensile data through the 7090 computer was used for the first time in computing stress-strain parameters for 32 tests. The results represent both unirradiated control specimens of Zircaloy-2 and similar specimens irradiated at approximately 75 F (while exposed to water) to integrated fast neutron fluxes of 0.84×10^{19} and 1.2×10^{20} nvt. It was found that the unirradiated, annealed specimens exhibited the normal effects of directionality; namely, the transverse direction (with respect to rolling) had a higher yield strength, lower tensile strength, and lower uniform strain than did the longitudinal direction. On the other hand, directionality effects shifted with cold work. A cross-over in yield strength occurred prior to 10 percent cold work such that the longitudinal direction displayed the higher yield strength with increased amounts of cold work. Cross-over effects with increased amounts of cold work were also observed in the case of tensile strength and necking strain; however, practically no difference due to directionality was observed for the uniform strain at all cold work levels investigated (up to 70% reduction in thickness by rolling).

Sizable increases in strength and decreases in ductility result from irradiation. In addition, the effects of directionality generally persist at the two exposure levels investigated. An exception to this is uniform strain, which is strongly directional dependent in the annealed state, but nearly directional independent in the cold-worked state. For example, the true uniform strains for the longitudinal and transverse directions in the annealed state are 0.047 and 0.007 in/in (in 2.125 in.), respectively, for an exposure of about 10^{19} nvt. Corresponding values for the 70% cold work state are 0.0235 and 0.0244, respectively. It would appear, therefore, that cold work has a beneficial effect in reducing the effects of directionality on uniform strain, as well as reducing the degree of plastic instability in the transverse rolling direction due to fast neutron irradiation.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

In support of studies of neutron damage to molybdenum, a limited investigation has begun on the effects of rapid quenching, which introduces a defect structure quite different from that resulting from heavy particle irradiation. An apparatus has been assembled which will permit gas quenching of molybdenum wires heated to 2000 C in vacuum. The decay of the quenched-in vacancies will be followed by means of electrical resistivity measurements made at -196 C, after isochronal annealing. The first trial run with this apparatus resulted in melting of the wire specimen at a minute region of reduced cross section. Temperature of the wire was calculated from the current and voltage input, and from the temperature coefficient of resistance. The apparatus is now being modified to measure temperature by means of a radiation pyrometer.

Extensive effort has been directed toward preparation of a laboratory for high vacuum, high temperature work with molybdenum. Examples of equipment to be included in this laboratory are a zone leveling apparatus, stored energy calorimeter, and high temperature annealing furnaces.

Back-reflection Laue diffraction patterns have been made from the cylindrical surface of the single crystal molybdenum rods. These patterns are free of asterism and show no diffuse maxima. Insofar as this surface is concerned, there are no gross flaws in crystallinity. (100) faces ground and polished on a low carbon crystal did, however, show small extraneous grains, as well as voids. Other crystals have no voids or flaws, but an intricate etch pit pattern develops upon electropolishing. It would appear that each single crystal test specimen, after forming, will have to be carefully evaluated prior to irradiation. Orientations for the high carbon, single crystal molybdenum rods are being determined.

Reactivation of the hot stage microtensile equipment to be used in conjunction with deformation and irradiation damage studies on molybdenum is currently in progress. The hydraulic loading system, load cell, and linear differential transformer have been recalibrated. A room temperature microtensile fixture for single crystals, to be used interchangeably with the metallograph and x-ray diffraction equipment, is presently being fabricated. Receipt of molybdenum polycrystalline foils, with carbon impurity levels corresponding to those in the single crystals, is expected in the very near future.

Rolled molybdenum foils, 0.003" thick, of nominal 99.99% purity, have been irradiated to approximately 10^{17} nvt (fast). After electrolytic thinning they have been examined in the electron microscope and show no apparent change from the pre-irradiation state. No apparent increase in dislocation loops or lines has been detected. Foils are currently being irradiated to higher exposure levels in a Hanford Snout Facility.

Survey experiments aimed at studying the susceptibility of molybdenum to fission fragment damage are being planned. On the basis of results obtained on fission fragment and neutron damage in aluminum, a metal having a relatively low melting point, damage in a high melting point metal such as molybdenum should provide a more comprehensive understanding of radiation damage. Aluminum foils having a tapered section were irradiated at a distance of 0.002" from a carbon coated, UO_2 fission source, to an exposure equivalent to 10^{18} nvt (thermal) in the source. The target showed a typical fission product spectrum, as detected by gamma ray spectrometry. Electron microscope examination of the thin sections in the foil revealed fission fragment tracks with lengths less than one micron and widths of approximately 200 A. No evidence of impaired motion of dislocations due to interaction with fission fragment damage regions was observed.

E. CUSTOMER WORK

Testing of Fermi Reactor Graphite

Samples of Enrico Fermi Reactor shielding graphite were outgassed at 650 C to determine the volume and kind of gas released on heating prior to irradiation. The samples were: (1) Great Lakes Carbon Company unborated, (2) Great Lakes Carbon Company seven percent borated ($Na_2B_4O_7$), (3) ANL three percent borated (B_4C), and (4) Carborundum five percent borated (B_4C). All samples released considerably more gas than conventional graphite. The GLC unborated and Carborundum material were especially high in gas release and it was not possible, due to volumetric inadequacy of the vacuum system, to measure quantitatively the gas output. The heating chamber containing the Carborundum sample refluxed a liquid during initial heating. The gas collected from the GLC seven percent borated and the ANL three percent borated samples was 8.5×10^{-5} and 7.7×10^{-6} gram moles per gram of carbon, respectively.

Radiometallurgy Service

Examination of two overbore fuel elements from C Reactor revealed that four support straps had been broken off mechanically from one element and not corroded or worn off (RM 433), and that the profile of element X-35 previously reported as "barrel" was caused by non-uniform corrosion of the cladding. The fuel dimensions were uniform (RM 431).

Six uranium metal or uranium dioxide samples have been dissolved for burnup analysis, and four samples have been declad for density measurement. Fission gas has been collected from three elements, and tensile tests have been completed on eight specimens at room temperature. Densities have been measured on four samples and microhardness data obtained from five. Photomicrographs were taken of some of the microhardness traverses. Twenty-two carbon steel corrosion coupons were cleaned, examined, and weighed.

Metallography Service

During the course of a metallographic study for FPD of pressure-bonded coextruded fuel elements, very small platelets were observed at the interface of the uranium and Zircaloy-2. These platelets were located at both the cap-to-core and can-to-core interfaces, and at low magnification (less than 500X), had the appearance of cracks. Careful examination at high magnification and with various types of illumination revealed that these platelets have the optical characteristics of zirconium hydride. Positive identification has not yet been made but will be attempted both at Hanford and at BMI.

Electron microscopy service for the month included examination of Al_2O_3 powder blown through a "plasmajet torch" to determine whether the powder particles, originally flat crystals, had been spheroidized. Examination by direct observation and by replica techniques showed that successful spheroidization was accomplished.

In conjunction with Nonmetallic Materials Development, work continued on a program to study graphite damage under neutron irradiation. Specific areas on graphite are pre-characterized so that electron micrographs of identical areas can be compared before and after irradiation.

Samples Processed During the Month:

Total Samples	447
Replicas	64

Photographs:

Micrographs	546
Macrographs	58
Electron Micrographs	141
Total	745

NPR Charging Machine

The entire electrical portion of the charge machine is estimated to be 93% complete. The mechanical portion of the machine is estimated to be 96% complete. Some mechanical modifications found necessary during testing have been started. During the month, three separate demonstrations of the machine were given. The machine was operated from the consoles by using temporary jumpers in the electrical system. A reviewing stand was built on the swaging room roof in the northwest corner of the building for use at such demonstrations.

Wiring of the consoles and panels and wiring from the panels to valves is estimated to be 95% complete. Several limit switches and photo cells have not yet been connected. The power track has been installed and the cables for the power track have been fabricated and installed. The auxiliary control panel has been completed. The hydraulic system is nearly complete, except for some additions to the original system. The high pressure water system is 70% complete.

Test equipment, to determine the effect of fuel elements sliding through the front and rear nozzles, has been fabricated. This test is in progress and is estimated to be 30% complete.

Fuel Element Fabrication Economics Study

The fuel element fabrication economics study was completed during the month. A draft of the completed work was transmitted to Programming Operation, sponsors of the study.

The final tabulations showed much smaller price differentials between enriched uranium fuel elements and plutonium enriched natural or depleted uranium fuel elements than had been anticipated. Total fuel element prices were also low, in the $65 per kg U range for a 19-rod cluster

element. Two factors contributed to the low total prices: (1) The basic premise of the study, contained in the problem assignment, that 10 power reactors using similar fuel elements are customers of the plant, implies that process and product development costs will be those of a mature industry. These costs amount to about 8-10% of profits, instead of being far greater than profits as in most present production. (2) The yields used in the various process steps were taken from actual HLO experience in production of fuel elements for PRTR. These yields are high compared with observed and published yields elsewhere.

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

OCTOBER 1961

FISSIONABLE MATERIALS - 02 PROGRAM

REACTOR

Optimization of C-Pile Retubed Lattice

The exponential pile mockup of the C-pile lattice was built with seven vertical safety rod channels and provisions for inserting hydrogenous moderator around the graphite tube blocks. Six of the rod channels have the C-pile safety rod spacing, and the other channel is in the center of the pile. The experiments will help establish the safety of the overbored C-Reactor during a flooding accident. The diffusion length of the mockup was measured with standard process tube holes in the graphite. The diffusion length with streaming was 62.7 cm. The diffusion length with streaming was calculated from Behren's theory to be 58.9 cm based on measurements in the Hanford Standard Pile. The measured diffusion length may be high since the neutron counter was placed only 4 inches from the center safety rod channel.

The wet C-II-N fuel elements have been loaded in the pile, and measurement on the material buckling has begun.

Data Correlation and Analysis

The data taken on exponential piles during the last three years needs to be evaluated and analyzed to be of maximum use in reactor design and future research planning. The exponential pile methods of analysis have been evaluated and modified to obtain agreement between the several past methods of taking and analyzing data. This work will remove systematic differences and form the basis for analysis and correlation of the nuclear variables alone. A quarterly report was written on the comparison of various experimental and analytical methods.

Effectiveness of Internal Surfaces

The study of the lattice parameters (k_∞, f, p, ϵ) for concentric tube fuel has been extended in the Physical Constants Test Reactor (PCTR) to a 14.5-inch graphite lattice. The fuel elements were natural uranium, 2.5 inch by 2.0 inch and 1.66 inch by 1.12 inch outside and inside diameter, respectively, and measurements were made with both air and water as the coolant. The measurements were made to check the unusual shape of the buckling curve for this fuel, extend our knowledge of concentric tube fuel in support of N-Reactor, provide data on resonance capture for internally moderated fuel, and find out whether a lattice this large could be studied in the PCTR.

Previous measurements for this fuel element have been made in 8.375-inch and 10.5-inch lattices.

The large lattice spacing made the normal flux matching procedure impractical. The flux ratio could not be matched with the fuel loading facilities in the PCTR, so measurements were made after the adjoint ratio had been matched. This is the first time that an experiment has been done with the adjoint ratio match used as the criterion of minimum error in k_∞.

The foils irradiated during the course of the experiment were counted on a NaI(Tl) crystal using a 256-channel analyzer to check the stability of the counters. The analyzer was used to set the bias and window widths for all of the materials which were irradiated. For coincidence counting the analyzer was used as the recorder and the results of the counting were recorded on printed tape, taking advantage of the new addition facility which gives the running total of the counts recorded per channel.

Exponential Pile Measurements for NPR

The exponential pile mockup of N-reactor was constructed with control rod channels in the vertical direction. Measurements of control and safety system strength are to be made in support of N-Reactor startup and hazards analysis. The control rod spacing is 32 inches by 36 inches. The strength of a column of samarium oxide balls was measured in the center of the mockup exponential pile. The radius of this column (which is the largest that can be inserted in the mockup) is 3.61 cm whereas the actual N-reactor ball column is 3.81 cm in radius. The strengths of two other ball columns, 3.19 cm and 2.44 cm radius, were measured so that the strength of a 3.80 cm column could be estimated from a plot of ball strength vs. radius. The local strength of the balls was measured at the control rod spacing and need correction to the actual (and different) ball column spacing to allow comparison with design calculations. The results of the ball strength measurements are given in Table I.

TABLE I

BALL COLUMN STRENGTH

Column Radius (cm)	Location	$\Delta B^2 (10^{-6} cm^{-2})$
3.60	Pile Center	63 ± 1.5
3.19	Pile Center	53 ± 1
2.44	Pile Center	43 ± 3
3.81	Pile Center	68 (estimated)
3.60	Control Rod Spacing	148 ± 3 (6 columns)

The local ball strength corrected to a column radius of 3.81 cm is 160×10^{-6} cm^{-2}. The local control rod strength previously reported is $222 \times 10^{-6} cm^{-2}$. Thus the ratio of ball strength to rod strength at this spacing is 0.721 compared to the estimated ratio of 0.71 (W. Nechodom - private communication).

Migration Area of N-Reactor

The migration area (M^2) of N-Reactor needs to be known to predict leakage and control properties. A value of M^2 is already available from comparison of measured values of k_∞ and buckling. In principle, another method is available to determine M^2 and has been used in many studies of water lattices. This

method is the study of the variation in buckling with fuel enrichment with other parameters held constant. The principle of the measurement is derived from the equation $\eta f p \epsilon = 1 + M^2 B^2$. The values of ηf are plotted versus B^2 for the various enrichments and the slope of the resulting line is M^2. The change in η is calculated and the change in f is measured in the PCTR. Two enrichments of N-Reactor fuel have already been studied (natural and 0.947% U^{235}), and a third is available (1.0% U^{235}) which might be measured. However preliminary calculations indicate that this method could yield M^2 only to ± 60% with the usual uncertainties of ± 0.003 in f and ± 5 x 10^{-6} cm^{-2} in buckling. Thus the method is not practical and will not be considered further. Larger variation in the enrichment would reduce the error in the slope of ηf versus B^2. However, this would make the change in η more difficult to calculate since the neutron spectrum would change as well as the U^{235} concentration. Thus the variation of enrichment is a poor way of determining M^2 under any conditions unless η can be measured by comparing reaction rates in U^{235} and U^{238} in the lattice spectrum to reaction rates in a Maxwellian spectrum, but this method is not yet fully developed.

The measurement of M^2 is best performed by measuring both k_∞ and B^2 as long as k_∞ is not too close to one.

Green's Function Treatment of Exponential Piles

An approximate solution for the flux in an exponential pile with vertical fuel rods has been derived in the small source approximation. The resulting solution has a gross flux distribution similar to the two-region exponential solution reported on earlier. Superimposed on this distribution are oscillations recognizable as the fine structure and small source oscillations that have been studied recently in Hanford exponential assembly experiments.

The small source treatment and the two-region treatment of exponential assemblies have been prepared for inclusion in the latest Quarterly Report.

Digital Computer Programs for Reactor Analysis

An informal document describing multi-group neutron diffusion code HFN is being processed for reproduction.

As was mentioned last month, convergence difficulties had plagued attempts to calculate the effects of an internally-cooled control rod, using HFN. The convergence rate increased by a factor of seven when the diagonal transfer matrix elements were set to zero. This change does not affect diffusion theory results(1). The corresponding results were satisfactory.

Computational Programming Services

The reactor kinetics code TRIP001 is in operating condition and has produced satisfactory correlation with results previously obtained on the analog computer. A more sophisticated version, TRIP002, is being prepared. TRIP002 will adjust

(1) Lilley, J. R., "An Extension of the Gauss-Seidel Method to Solution of Systems of Homogeneous Equations," on pp. 22-7, HW-68389.

a specified parameter in order to produce the desired behavior of a given variable. Coding of the new version is complete and debugging has begun. TIRP001,2 are specialized versions of the reactor kinetics code HAIREK being prepared at the request of IPD personnel.

Revisions to KERNEL permit the code to select the appropriate set of parameters for calculation of each kernel, from three sets of input parameters, on the basis of initial energy and energy transfer. Changes are completed and the code is apparently debugged.

Instrumentation

Experimental tests were continued to determine the best operational methods for the NPR graphite purity tests. Various types of BF_3 tubes have been tested in an effort to obtain optimum performance. Some difficulties have arisen concerning HAPO fabricated BF_3 tubes with performance degradation noted after only modest neutron flux exposure. Development was started on the necessary preamplifier circuits to be used in the final tests.

A trip was made to GE-APED for consultation concerning the NPR nuclear instrumentation procurement contract. Proposed revisions to contract requirements for instrument performance and a proposed new contract on neutron detectors were reviewed, and detailed recommendations were prepared and forwarded to IPD and CE&UO for consideration.

All experimental development on the Fast and Slow Scan Fuel Failure Monitor was satisfactorily concluded. The final report on this project has been drafted and is now being edited.

The Mark I Process Tube Traverse Mechanism was successfully run through tubes at D, F, and C Areas. While in each case the general shape of the distortion was correctly indicated, the accuracy in indicating the amplitude of the distortion needed improvement. The disagreement between the Mercury Manometer and the Optical Device was as great as one inch. Three improvements in the Mark II Optical Device should reduce possible error and bring much closer agreement. The Mark II has greater sensitivity, it can be read with more clarity, and the contact surfaces will be modified to reduce ambiguity in determining what position in the process tube is being measured. Tests are planned on full length ex-reactor tubes at F Area using the Mark II.

A proposal for the fabrication of a prototype traversing mechanism for use in NPR was submitted to Instrumentation Design, CE&UO. The memo outlined a traversing mechanism which would utilize transducer (LVDT) readout for operating convenience with a direct recording or printout option providing automatic data handling capabilities.

Investigations continued on the possible use of microwave techniques to obtain a sensitive linear displacement transducer for use in in-reactor measurement of creep in metallurgy specimens. A Fortran computer program was written to assist in calculation of resonant cavity design and in investigation of possible excitation modes.

Detailed plans and cost estimates were made for the Appropriation Request IPD is preparing for experimental instrumentation for the PRTR Rupture Test Loop.

Systems Studies

Further analog study of reactor speed-of-control characteristics has been requested by IPD. The 9-node model previously used has been changed to a 6-node model. With the 6-node model, enough analog equipment is available to provide individual reactivity feedback to each region, including metal temperature feedback. The reactor is divided into six horizontal slabs, one on top of another, for investigation of top-to-bottom diffusion characteristics and for simulation of VSR (vertical safety rod) insertion fully or part way into the reactor at various speeds. The analog program is completed and will go on the EASE and GEDA computers in November.

Work on the VSR withdrawal rate simulation, designed to aid in updating bases for standards governing the rate of VSR removal during cold startup, has been temporarily arrested due to the need for immediate work on problems of higher priority. The analog program is nearly complete, and it is expected that the problem will go on the computer before the end of the calendar year.

The NPR secondary loop stability study has been completed. The purpose of this study was to determine the effects on stability of using different types of control when two dump condensers and surge tanks are used in the model rather than single lumped parameter units. The results will be reported when they are tabulated and interpreted.

A reactor instrumentation study was made to determine the effect of time delays introduced by the instrumentation of the reactor outlet temperature as a function of reactivity. All runs based on the "B", "D", and "DR" reactors have been completed and those based on "K" reactor are almost completed. The variable parameters for this study are: "scram" trips set for various percentages of power level and for various outlet temperatures, an instrumentation time delay of 0, 1, and 2 seconds, and several combinations of temperature sensor time constants.

The production test required to authorize installation of rod position readout devices at the 100-KW reactor for dynamic data acquisition was revised to provide for permission to obtain simultaneous temperature, flux, and rod position records. The instrumentation for recording incore flux and rod position is ready for use. Sensitive Visicorder galvanometers will be used to record the flux level, using a bucking current for zero suppression. Bench tests show that the net current through the galvanometers must be balanced within 100 microamperes to get a well-defined trace. Further evaluation and testing will be completed as soon as the chambers are installed in the reactor.

The reactor xenon equation simulation program was changed to a form which provides better signal-to-noise ratios than the previous simulation. The xenon-versus-flux transfer function is to be determined by subjecting the simulation to both sinusoidal and step function inputs. The effects of the metastable xenon isomer over the normal operating range of flux levels and for various assumed values of metastable xenon absorption coefficients will be determined. Tests are now in progress.

SEPARATIONS

Plutonium Critical Mass Experiments

The control rod for the critical assemblies was placed in operation after effecting repairs to the magnet coil. During the tests following reinstallation, it was noted that the safety rod was inoperative; the cause was also due to an open circuit in its magnet coil. It was then necessary to dismantle this portion of the control system, which was highly contaminated with plutonium. A new coil assembly was installed and the unit placed back in operation without spread of contamination. Both units are now correctly performing their intended functions.

During the time repairs were being made to the control and safety system, considerable other maintenance work was done throughout the facility.

Critical experiments were continued with plutonium nitrate solutions in a nominally reflected 14-inch diameter stainless steel sphere.* Items being studied are the effects of nitrate on criticality and the effects of a hydrogenous reflector (paraffin) for reflector thicknesses of one-half and one inch. The results of measurements completed this month with the 14-inch critical assembly vessel are presented below.

Criticality Studies with Plutonium Solutions in 14-inch Diameter Stainless Steel Sphere
(Measured Sphere Volume 23.22 Liters; Wall Thickness, 0.44-inch)

Date	Experiment Number	Pu Concentrations* (g/l)	Acid* Molarity	Reflector Condition	Critical Volume (liters)	Estimated* Critical Mass (Kg/Pu)
10-24-61	1141020	~ 165	~ 3.9	½-inch paraffin	23.0	~ 3.8
10-26-61	1141021	~ 165	~ 3.9	1-inch paraffin	20.5	~ 3.4
10-27-61	1141022	~ 150	~ 5.0	1-inch paraffin	21.8	~ 3.3
10-30-61	1141023	~ 140	~ 6.0	1-inch paraffin	23.0	~ 3.2

* Nominal value only since results of chemical analyses for plutonium solutions were not available at time of this report.

An attempt was made to accurately define delayed critical with the control rod in the second experiment (No. 1141021). With the control rod properly positioned (in this case with only one inch of rod remaining in solution) the flux was observed to rise linearly with time for a period of over ten minutes, at which time the unit was shut down by means of the control rod.

Subsequent experiments are planned in which the 14-inch sphere will be fully reflected with water and also concrete. Forms have now been completed for making the spherical concrete reflector shells and arrangements are being made for pouring the concrete.

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* A nominal reflector is defined in TID-7016 Rev. 1 (Nuclear Safety Guide) as one of water not more than one inch thick, or its nuclear equivalent.

Foil Measurements for Spectral Analysis of Plutonium Solutions

A series of Pu-239 and U-235 foils were irradiated in the PCTR in conjunction with experiments to determine the limiting concentration for which $k_\infty = 1$, of a plutonium nitrate-water solution. The purpose of these irradiations was to determine the spectral index or effective neutron temperature of such a system.(1,2)

The method consists in measuring the fission product activity of Pu-239 and U-235 foils which have been exposed to identical neutron flux. The ratio of the activities, due only to fission by thermal neutron, is defined as the spectral index. The actual neutron temperature is then inferred by comparison with the spectral index of known systems.

The experimental procedure and foil arrangement used are described in Reference 2. The experimental system consisted of a large cylindrical annular buffer tank, two end buffer tanks, and the core tanks containing the dilute $Pu(NO_3)_4$ solution. For the measurements the core tank was inserted into the annular buffer tank and centered between the end buffer tanks. These tanks were all made of 1/8-inch thick stainless steel and were enclosed in jackets of 1/16-inch thick stainless steel. The dimensions (and volumes) of the tanks are shown in the table below.

Tank	Outside Diameter	Inside Diameter	Length	Volume
Annular buffer tank	17-13/16"	6-9/16"	32-15/16"	112 liters
Annular buffer tank with jacket	18"	6-3/8"	33"	-
End buffer tank	6"	-	6-1/8"	2.2 liters
End buffer tank with jacket	6-3/16"	-	6-5/16"	-
Core tank	6"	-	20"	8.3 liters
Core tank with jacket	6-3/16"	-	20-3/16"	-

An additional feature of the core tanks was a stainless steel tube (OD = 0.840-inch, ID = 0.546-inch) traversing the tanks diametrically at their midpoints. The foils were irradiated in this traverse tube--one set at the center of the core tank and one set 5/8-inch in from the outside edge of the tank. An order of magnitude measure for the hardening of the spectrum due to the stainless steel traverse tube is obtained from a comparison of the spectral indices at these two positions.

The results of these measurements are as follows:

Foil Position	Spectral Index
Center	1.520 ± 0.002
Edge	1.536 ± 0.002

(1) Dawson, F. G., Proposed Studies on Thermal Neutron Spectrum, HW-66623, July 6, 1960.

(2) Stinson, W. P., et al., An Investigation of the Effective Neutron Temperature, HW-60778, June 17, 1959.

The uncertainty quoted is due to statistical sources only.

Calculations are being made to determine the actual effect of the stainless steel traverse tube; however, the figures above indicate the actual spectral index in the solution was of the order of 1.50. This indicates an effective neutron temperature of about 390°K whereas the physical temperature of the solution was 298.6°K.

The analyses of the plutonium nitrate solution used in the experiment gave the following results:

Pu	- 11.3 gm/liter
H_2O	- 962.4 "
NO_3	- 11.7 "
HNO_3	- 44.1 "
Fe	- 0.5 "
H/Pu (atom ratio)	- 2275
Specific gravity	- 1.037

Preparations are currently being made for a more extensive series of foil activation measurements with various plutonium solutions and temperatures.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

1. 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. This subject matter was also discussed at the recent Los Alamos Conference on Nuclear Safety Data. In order to obtain definitive answers to such problems, a series of calculations were undertaken 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.

The results of these calculations, which have now been completed, are presented herein. The calculations were carried out for various hydrogen-to-uranium atom ratios in the range zero (dry UO_3) to 43.87; the lowest H/U ratio for which experimental data were obtained is 3.58. In the experiments "dry" UO_3 powder (approximately one weight percent H_2O) was mixed with polyethylene to obtain the desired H/U atomic ratios. The compositions of the mixtures for which the calculations were made are given below.

Material Densities

H/U	Hydrogen	Oxygen	Carbon	Uranium
43.87	0.0568	0.0634	0.3371	0.3058
8.57	0.0321	0.1860	0.1849	0.8830
3.58	0.0179	0.2501	0.0978	1.1809
1.25	0.0069	0.2618	0.0409	1.2980
0.0	0.0	0.2852	0.0	1.4144

The results obtained from this series of calculations are summarized in Table I together with measured values of k_∞ from the PCTR experiments.(1)

Also given in Table I are the values for the Fermi age, migration area, mean life of the neutron, and the mean slowing down time of neutrons for each of the systems as determined by the Monte Carlo calculation.

TABLE I

H/U	PCTR k_∞	k_∞	$\tau(cm^2)$	$M^2(cm^2)$	$\bar{t}o(\mu$ sec)	$\bar{t}s(\mu$ sec)
43.87	0.996 ± .006	1.033 ± .032	89.4	105.9	140.67	2.74
8.57	1.342 ± .020	1.368 ± .034	179.3	192.9	64.57	4.29
3.58	1.310 ± .023	1.269 ± .015	332.8	347.6	42.66	6.01
1.25	-	1.033 ± .021	801.3	816.8	26.51	8.59
0.0	-	0.584 ± .019	721.4	721.4	2.22	2.22

The Fermi age is defined as one-sixth the mean square distance a neutron travels from birth to either an absorption event, which terminates the history, or to the collision that transfers the neutron below indium resonance. The migration area is one-sixth of the mean square distance a neutron travels from birth to absorption. The mean slowing down time is the average lifetime of neutrons from birth to either termination by an absorption event or the collision that transfers the neutron below indium resonance. The mean lifetime is the average lifetime of neutrons from birth to absorption.

It is noted from the above results that the value for k_∞ decreases quite rapidly at low hydrogen-to-uranium ratios. The dry UO_3 salt has a k_∞ that is quite low, $k_\infty = 0.584 \pm 0.019$. This low value is primarily due to the moderating effect of oxygen; neutrons are transferred out of the fast spectrum where there is a good probability of a fission event, into a region of high capture probability for U-238. For this particular case, no neutrons were found below 10 e.v.

To determine the oxygen effect in dry UO_3, a calculation was made for 3.04% enriched uranium metal at a density of 18.9 g/cc. The only moderating effect that neutrons experience is due to inelastic scattering in uranium. Calculations were also made for enrichments of five and six percent. A summary of the results are given in Table II.

TABLE II

MONTE CARLO RESULTS - URANIUM METAL (ρ = 18.9 g/cc)

Enrichment wt. %	k_∞	$\tau(cm^2)$	$\bar{t}$ s(μ sec)
3.04	0.720	55.2	0.188
5.00	0.915	51.5	0.112
6.00	1.014	49.7	0.105

(1) Neeley, V. I., J. A. Berberet, and R. H. Masterson, k_∞ of Three Weight Percent U-235 Enriched UO_3 and $UO_2(NO_3)_2$ Hydrogenous Systems, HW-66882.

The net effect of the oxygen in the dry UO_3 for an enrichment of 3.04 weight percent is therefore $\sim$ - 136 milli k. Interpolating the enriched metal cases, a value of 5.88 weight percent U-235 is the limiting enrichment for uranium metal; i.e., the enrichment at which k_∞ is just unity in the unmoderated system. This result is in agreement with the conclusion drawn by Paxton, obtained by the extrapolation of exponential column data, that the limiting U-235 enrichment for unmoderated uranium metal is between five and six weight percent.(2)

2. Quantity of Cadmium Required to Render Plutonium Solutions "Safe" from Criticality

The amount of cadmium necessary to reduce k_∞ to unity in a hypothetical solution of plutonium and water has been calculated for a wide range of plutonium concentrations. It is of interest to note that the curve representing the Cd/Pu atom ratio (for $k_\infty = 1$) versus Pu concentration has an endpoint for Pu concentrations between 0.4 gm/cc and 0.6 gm/cc. This results because of the displacement of water by the cadmium.

The effect of the cadmium is almost entirely a thermal neutron group effect; the displacement of water by the cadmium at higher concentrations reduces the H/Pu ratio. When the spectrum becomes sufficiently fast, k_∞ can no longer be reduced to unity by the addition of a thermal group poison.

A summary of the results of the calculations is given in Table 1. These data are given graphical representation in Figure 1.

TABLE 1

THE CADMIUM-PLUTONIUM ATOM RATIO REQUIRED TO REDUCE k_∞ TO UNITY IN Pu-H_2O MIXTURES

H/Pu	Pu (gm/cc)	N^{Pu} (10^{24}/cc)	N^{Cd} (10^{24}/cc)	N^{Cd}/N^{Pu}	Thermal Parameters $^{239}\sigma_a$	$^{239}\sigma_f$	$^{Cd}\sigma_a$	$^{H}\sigma_{tr}$
65	0.4	1.008 (-3)	1.78 (-3)	1.77	975.0	627	2200	28.98
131	0.2	5.04 (-4)	3.2 (-4)	.635	1088	691.1	2057	30.17
264	0.1	2.52 (-4)	1.1 (-4)	.437	1113	723.1	2642	35.14
529	0.05	1.26 (-4)	4.2 (-5)	.337	1084	722.5	2866	38.44
872	0.03	7.565 (-5)	1.95 (-5)	.323	1049	713	2947	40.31
1325	0.02	5.04 (-5)	1.17 (-5)	.266	1000	700	2990	41.55
2652	0.01	2.52 (-5)	2.8 (-6)	.111	974.5	688.4	3011	43.13

(2) H. C. Paxton, Critical Masses of Fissionable Metal as Basic Nuclear Safety Data, Report LA-1958, January 1955.

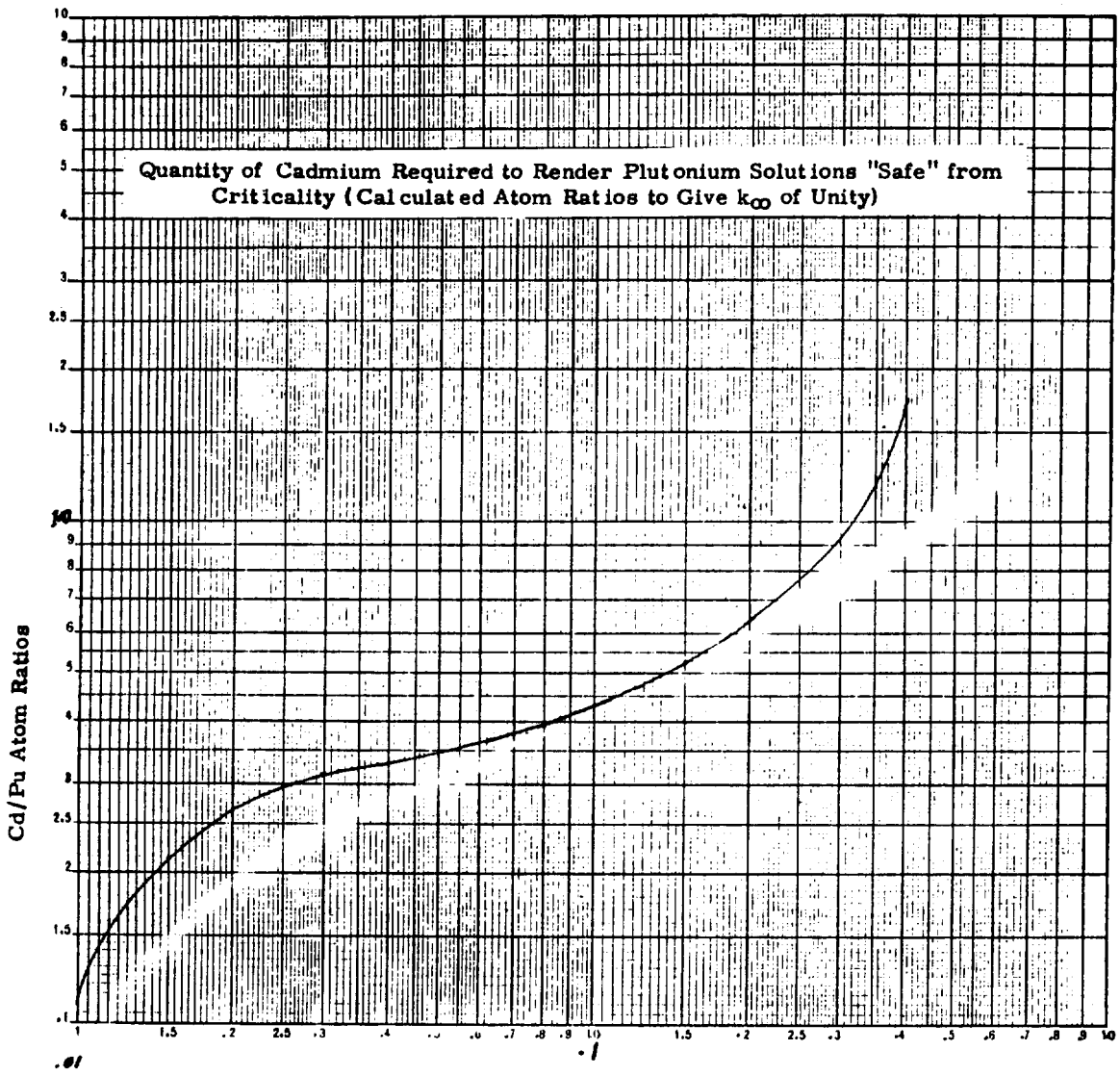

FIGURE 1

3. Calculated Critical Parameters for Plutonium-Carbon Mixtures

The critical radius, critical volume, and critical mass of bare plutonium-carbon spheres was calculated using the 9-Zoom code and library. No Pu-240 was included in these calculations; the C/Pu ratio was varied from zero to 55,586, which includes the C/Pu ratio for the minimum mass of these mixtures. These calculations provide supplementary data on plutonium criticality for inclusion in the Plutonium Handbook.

CALCULATED CRITICAL PARAMETERS FOR PLUTONIUM-CARBON BARE SPHERES

C/Pu (Atom Ratios)	Atoms Pu (10^{24}/cc)	Density of Pu (Kg/l)	Critical Radius (cm)	Critical Volume (l)	Critical Mass (Kg)
0	4.9623 (-2)	19.70	5.14	0.569	11.21
0.1854	4.4661 (-2)	17.17	5.61	0.739	12.69
0.417	3.970 (-2)	15.76	5.97	0.89	14.04
0.715	3.474 (-2)	13.79	6.67	1.24	17.10
1.113	2.977 (-2)	11.82	7.59	1.83	21.63
1.67	2.481 (-2)	9.85	8.82	2.87	28.27
2.5	1.985 (-2)	7.88	10.48	4.82	37.98
3.89	1.4887 (-2)	5.91	13.0	9.20	54.37
6.68	9.925 (-3)	3.94	17.05	20.76	81.79
15.02	4.9623 (-3)	1.97	25.34	68.16	134.27
31.71	2.481 (-3)	9.85 (-1)	34.15	166.8	164.30
54.0	1.4887 (-3)	5.91 (-1)	39.98	267.7	158.21
165.2	4.962 (-4)	1.97 (-1)	48.20	469.1	92.38
332.1	2.481 (-4)	9.85 (-2)	51.80	582.2	57.33
554.5	1.489 (-4)	5.91 (-2)	54.56	680.3	40.21
1667	4.962 (-5)	1.97 (-2)	62.20	1008.0	19.85
3377	2.481 (-5)	9.85 (-3)	66.25	1218.0	11.99
5560	1.489 (-5)	5.91 (-3)	68.75	1361.1	8.04
16,000	4.962 (-6)	1.97 (-3)	78.90	2057.4	4.05
33,400	2.481 (-6)	9.85 (-4)	93.45	3418.4	3.37
55,586	1.489 (-6)	5.91 (-4)	111.60	5822.1	3.44

Interactions of Subcritical Systems

The interactions of subcritical systems among themselves and with their surroundings can be formulated in terms of the leakage, albedo, secondary absorption, etc., of the various components, and the solid angles subtended at each component by the others. In order to gain better insight into the complexities of such a formulation, so that reasonable approximations to it can be made, the interactions of core and reflector in a simple one-dimensional slab reactor with infinite reflector were formulated in the same manner. A one-group model was used so that the calculated quantities are simple analytic expressions. Dependence of these quantities on fuel concentration and slab thickness has been found. A more realistic two-group model is now being treated in the same manner.

Miscellaneous Experiments for Nuclear Safety Specifications

In Situ Neutron Multiplication Measurements with Plutonium Metal

During the week-end of October 7 and 8, further in situ neutron multiplication measurements were made with Pu metal in the 234-5 Building. Production commitments made it desirable to increase the storage limits for current models in Hoods HC-22-SR, 45-SR, and 23-CTR. The objectives of the measurements were to establish the extrapolated critical masses for arrays of castings, and adjacent stacks as defined by credible error situations including compact masses in the breakout hood. Personnel of CPD made the arrangements for the experiments and performed the measurements with instrumentation borrowed from Critical Mass Physics. E. D. Clayton and W. A. Reardon served as technical directors during the two days of the experiments.

The array studies on October 7 involved probably the largest amount of plutonium ever used in a neutron multiplication measurement (the total amount of plutonium used in the experiment was 504 Kg). The extrapolated critical mass for the storage array in Hood 22-SR was of the order 2000 Kg Pu. As a result of these measurements, the desired increased mass limits may now be permitted, and if required, the mass limit in Hood HC-22-SR could be as much as doubled over the current capacity.

Mass Spectrometry

The heavy element mass spectrometer for this program provided isotopic analyses on two uranium samples for Reactor Lattice Physics and on four plutonium samples for Plutonium Fuels Development during the month.

A new source collimator assembly was designed and installed in the mass spectrometer. This assembly was designed to provide a more accurate alignment and rigid mounting of the collimator slits. After installation of the collimator assembly the shapes of the observed ion peak intensities were consistent with the geometric collimation indincating that the installed alignment was satisfactory.

Criticality Hazards Specifications

1. Nuclear Safety in HLO

   A nuclear safety specification (J-2) was prepared for the Plutonium Metallurgy Operation to cover special plutonium casting in Glove Box 47-B. This specification will include a list of pouring crucibles and casting molds approved for plutonium quantities in the 3-7 Kg range.

2. Nuclear Safety in FPD

   Comments were submitted to the Engineering Operation concerning general nuclear safety limits for handling and storing 1.6% U-235 enriched uranium.(1) The safe limits that apply to all fuel rod sizes rather than to just certain sizes for 1.6% U-235 are as follows:

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1) Letter from C. L. Brown to C. H. Shaw, A General Nuclear Safety Basis for 1.6% U-235 Enriched Uranium, October 10, 1961.

Safe Unit Mass: 308 lb of U (maximum)
Safe Slab Height: 6.6-in (maximum)
Safe Mass Per Unit Area: 92 lb/ft^2 (maximum)

In addition, it was pointed out that one single piece of 1.6% uranium, such as one large billet, or one extruded tube, is nuclearly safe regardless of weight or size. After such a uranium piece is cut into two or more pieces, however, a specific criticality control limit, such as given above, must be applied.

3. Evaluation for Nuclear Materials Operation

The nuclear safety of a shipment of about 4 Kg of plutonium as $PuCl_3$ to the Dow Chemical Company was reviewed and approved.(2,3) The material is to be shipped in an approved, water-tight container on an AEC car.

4. Nuclear Safety Discussions with Off Site Visitors

Mr. D. F. Cronin of the National Lead Company of Ohio visited Hanford October 2 and 3. Information was exchanged concerning the nuclear safety of handling, storing and transporting slightly enriched uranium. The fuels preparation plant (313 Building) was visited on October 3, at which time discussions were held with Fuels Preparation Department personnel concerning nuclear safety problems common to both sites in the shipping of I and E fuel elements and uranium billets.

A meeting was attended on October 10 with personnel of the Plutonium Metallurgy Operation, the Radiation Protection Operation, and visitors from the Physical Chemistry section of Harwell (L. Roberts, M. Waldron, and R. Sowden). The information exchanged concerned primarily the criticality alarm system and the evacuation plan currently in use in the 308 Building (Plutonium Fuels Development). The alarm systems used at Hanford and Harwell are quite similar. The spacing and location of alarms at Harwell are based on a minimum burst of 10^{14} fissions.

Instrumentation

Evaluation of CPD tracer lathe data indicated the ranges of the variations of parameters which affect resonant frequencies, and damping. A transfer function was synthesized for use with the analog computer simulations for investigating methods of mechanical damping and electrical compensation. A recommendation was made, also, to provide a hydraulic bias which will cause the amplifier and hydraulic control valve to operate off of the null points. The purpose of the bias is to eliminate the deadband type of non-linearities and the associated meandering or hunting.

A literature search of liquid level measuring techniques was conducted for the Critical Mass Facilities. Applicable methods were described in Systems Research Memorandum 61-41. Recommendations were made on two methods that have the accuracy possibilities of interest at the Critical Mass facilities.

(2) Letter from G. B. Kuklinski to C. L. Brown, $PuCl_3$ Shipment, October 18, 1961.
(3) Letter from P. F. Gast to G. B. Kuklinski, Nuclear Safety of $PuCl_3$ Shipment, October 24, 1961.

In addition to instrument maintenance, the following projects are being worked on at the Critical Mass Laboratory:

1. A transistorized pre-amplifier is being built for use with semiconductor neutron detectors. Three of these detectors will be installed in the critical assembly to measure buckling.

2. Two neutron scintillation detectors are being built for use in a new type of log-n period meter.

3. Design work has been completed on the control rod drive assembly by Nucleonics Instrumentation Operation. A work order has been issued for fabrication of a prototype model. The model will be tested in the 300 Area and, if satisfactory, it will then be installed at the Critical Mass Laboratory.

An additional problem for future work involves the redesign of the aural monitoring system. The present system connects a speaker directly to a neutron monitoring channel. Each pulse from the neutron detector produces a pop in the speaker. Small changes in reactor level are almost indistinguishable. The proposed change would present a large audio frequency change to the speaker for a small change in neutron count rate.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Cross Sections

The 105-DR neutron crystal spectrometer is in the process of being put in operative condition following long awaited repair of the fission counting electronic system. Over-all alignment and calibration of the spectrometer system is in progress. During the month arrangements were made to borrow a prepared Am^{243} sample for resonance fission measurements. Requests were also made for future assignment of Th^{229} and U^{232} samples for fission measurements.

Slow Neutron Scattering Cross Sections

Inelastic Scattering from Water

It has been found necessary to repeat part of the measurements of the inelastic scattering of 0.3 ev neutrons from room temperature water because of erratic performance of the beam monitor counting system during the original measurements. The required measurements are in progress. Two measurements were made of the distribution in energy of neutrons of 0.4 ev initial energy scattered from room temperature water. These preliminary measurements indicated that significant results could be obtained for large neutron energy changes of 0.2 to 0.25 ev ($\beta \sim 8$ to 10).

Quasi-Elastic Scattering

The analysis of the quasi-elastic scattering of 0.15 ev neutrons from water continued during the month. Statistically adequate fits to the observed peak shapes have been made at all scattering angles with the fitting program, GLOCKE, reported previously. Analysis of the uncertainties introduced by subtraction of the uncertain inelastic scattering component is in progress.

Fast Neutron Cross Sections

The efforts to develop a satisfactory liquid scintillator for fast neutron detection reported last month have been continued. An interior surface of the liquid cell with suitable optical reflection properties has not been attained as yet.

The shielding tanks for total cross section measurements have been completed. Design of the beam collimators for the tanks has been completed and fabrication is in progress.

The new Hall-effect gaussmeter to measure the field of the analyzing magnet of the Van de Graaff was received and used during realignment of the accelerator following the maintenance shutdown during the month. Performance of the gaussmeter substantially exceeds that required for alignment, and recommendations for permanent installation were given to Radiological Physics.

Instrumentation

Development of the 1000-Channel Slow-Neutron Time-of-Flight Analyzer continued. A read-write amplifier to be used with the magnetic drum memory was designed and a prototype built and tested. Long term tests will begin shortly. The timing track that was supplied with the drum proved to be poorly written, but was successfully rewritten. Two fiducial tracks were also written, and will be used to help locate the desired drum address.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Lattice Parameters for Low Exposure Pu-Al Fuels

Measurements have been made on clusters of 1.8 w/o Pu-Al fuel in three graphite lattices (6-1/2 inch, 8-3/8 inch, and 10-1/2 inch) to provide data for comparison with theoretical calculations and later measurements on high exposure fuel and mixed Pu-U fuel. Analysis to obtain values of k_∞ and f requires a knowledge of the effective cross sections of the fuel and copper poison for the distorted spectra in the poisoned lattices. The effective cross sections can be obtained from ratios of the relative activities of a copper foil and a Pu-Al foil, irradiated first in the unknown spectrum and then in a thermal spectrum. However, variations in the counting equipment between irradiations have caused the previous attempts to determine the effective cross sections to be unsatisfactory. To overcome this difficulty, sets of simultaneous irradiations have been performed during the past week with the new PCTR thermal column. Pairs of Pu-Al and copper foils were irradiated simultaneously, one pair in the lattice spectrum and one pair in the thermal spectrum. Both pairs were counted on the same equipment during the same time span, to eliminate the counter variations. One set of foils was irradiated in each of the three lattices which have been investigated. The data is being processed using APDAC-I.

Pu-240 Effective Resonance Integral

The detailed operational procedures are being drawn up for experiments to measure the effective resonance integral of Pu-240 relative to the dilute

resonance integral as a function of Pu-240 concentration. The experiment is potentially hazardous, and careful planning and stringent controls are necessary.

Plutonium Fuels Development Operation has partially completed the fabrication of the fuel rods for the experiment.

Plutonium Fuel Temperature Coefficient

The fuel temperature coefficient for plutonium will be measured to establish the fuel part of the temperature coefficient for plutonium lattices.

The heater assembly for the experiments which will attempt to measure the change in k_∞ due to heating the Pu-Al fuel rods has been completed and tested. Some changes were made in the heater to provide a more uniform temperature distribution throughout the 19-rod cluster. Measurements of the core material temperature and the cladding surface temperature have been made as functions of time during a simulated experimental run, using the aluminum dummy rods. These data provide the correlation between cladding temperature and core temperature which will be required to interpret the later measurements, using rods with Pu-Al cores, when only the cladding temperatures can be measured.

The low exposure fuel rods and the 16% Pu^{240} fuel rods have been delivered to Experimental Reactors Operation.

PuO_2-UO_2 Lattice Studies

PCTR experiments are being planned with 19 rod clusters of PuO_2-UO_2 in a graphite lattice. These experiments will extend our present work on PuAl lattices to a more complicated Pu lattice system.

The study which is being conducted to determine both the most desirable lattice spacing for the initial experiment, and the amount of Pu enrichment is nearly completed. Calculations on the thermal flux distribution have been made with the use of the IBM-7090 code IDIOT(1) for various lattice spacings and enrichments. The resonance escape probability for U^{238} has been estimated from the inferred effective resonance integral for a similar 19-rod cluster of natural UO_2.(2) The fast multiplication factor can be obtained rather accurately from calculations or comparisons with other experimental results. Determinations of an effective η^{49}, including both thermal and epithermal absorptions, and the resonance escape probability for Pu^{240} as a function of lattice spacing and enrichment are more difficult, and are still in progress.

Detailed physical specifications for the fuel assemblies are now being prepared. In order to keep costs to a minimum, the final specifications will be no more rigid than is absolutely necessary to obtain the desired physics data.

(1) Richey, C. R., IDIOT - A Lattice Parameter Code for the IBM-709, HW-63411. Jan. 7, 1960.
(2) Lilley, J. R., Correlation of Data on Heavy-Water Moderated Cluster Lattices, HW-60275. May 19, 1959.

A preliminary cost estimate for the job has been prepared by personnel of Plutonium Fuels Development Operation.

PRTR Startup

A formal presentation of the results of the cell traverses which were done with lutetium foils at the startup of the PRTR is being prepared. These results will become part of the formal document which is to describe the PRTR startup experiments.

The Critical Facility of the PRP

Rough drafts of several experiments have been written in preparation for startup of the PRP-CF. These drafts describe the various experiments and are intended to inform management and other interested personnel of plans for the facility. The descriptions will be presented in HW-71214. Detailed procedures will be written later. These experiments will be accomplished with a reactor loading similar to that shown in Figure 1 of HW-67725. The loading is one which has an annulus of clusters of 19 Pu-Al rods surrounding a central core of clusters of 19 UO_2 rods.

Rough drafts of the general description of the tests and of an experiment to study the critical loadings for this reactor and to measure the worth of control and safety rods have been written. In addition, drafts have been prepared of experiments to determine the ratio β/l, the absolute flux per watt and the power calibration, the void, pressure and temperature coefficients, and the effect of H_2O substitution around the fuel. Procedures for adding fuel, raising the moderator, taking period measurements, and physically removing the control rods from the core are described in the drafts. The latter procedure is required because the control rods leave cadmium in the reactor unless the rods are physically removed and some of the experiments will be done in the Critical Facility with all the cadmium removed. Some of these drafts have been circulated to members of the PRP-CF planning group for comments and the rest will be circulated in the near future.

The introduction to the startup document and several descriptions of the design tests have been reviewed.

Modifications to the hazards evaluation document have been recommended. These modifications affect the hazards evaluation for the experiments which are planned for the first six months after startup and in general would allow the facility to be used with the desired flexibility.

The mechanical parts of instruments which will be used for horizontal and vertical flux plots have been designed and construction drawings of the instruments are being prepared.

Neutron Spectrum Studies

Neutron Rethermalization in Water and Graphite

The preparation of an article concerning neutron rethermalization in water and graphite, was temporarily suspended because relatively minor, but fundamentally significant, discrepancies were found in the results of the water

experiments. The discrepancies are ± 4% trends in the differences between the calculated and observed activation traverses in the water experiments (HW-68389, p. 45). Although ± 4% trends would normally be considered small, their effect on the uncertainties in rethermalization cross section has been shown to be as large as ± 75%. Further, the trends could be considered a measure of the inadequacies of the multithermal-group diffusion model. Since verification of the model is the primary objective of this work the discrepancy was investigated and two problems were found. First, and most important, two thermal groups are not sufficient to describe a three-region problem precisely where each region is at a different physical temperature. This is true even though the two ambient regions differ in temperature by only 30°C as compared to the 400°C difference between the hot and ambient regions. Second, experimental uncertainties in physical temperature ratios, which are used in calculating reaction rates, are large enough (± 2%) to produce 1% trends in differences between calculated and observed traverses. No correction can be made for the latter; however, a first order correction can be made in the spectral problem.

The correction has been made to the experiment with the largest trends and has eliminated a major portion of the disagreement. The space-energy distribution of thermal neutrons was calculated with two groups of thermal neutrons but with three thermal group diffusion parameters. This yields the gross rethermalization properties of the system (two thermal groups) while preserving, the first order, the spatial distribution of reaction rates (three-group absorption cross sections).

Pu Burnup in Fast Spectrum Reactors

Preparatory work is continuing to get the fast spectrum Pu burnup studies under way.

In order to obtain a better understanding of the important parameters involved in such a study and to get some insight regarding plutonium values in fast reactors, ANL data and procedures were used to relate breeding ratio and specific power to fuel loading ratio and Pu/U price ratios. On the basis of some rather simple assumptions, a framework has been constructed into which subsequent digital computer results can easily be inserted.

[redacted]

temperature of 130°C, 470°C, and 1000°C. The analyses gave significant differences in the burnup characteristics for the various spectral conditions and indicate that experiments over a range of neutron spectra could provide useful data for checking burnup analyses if sufficient burnup data such as exposure, isotopic composition, reactivity changes, and neutron spectral data are obtained from the experiment.

Code Development

MELEAGER

Revisions in the MELEAGER code include provision to maintain a step-wise constant reactivity by varying SDPV. Changes in slowing down power (SDPV) are accompanied by changes in the non-fuel macroscopic absorption cross section; this follows from the assumption that moderation changes will be accomplished by addition or subtraction of the original moderator rather than change in moderating medium. The change in non-fuel macroscopic cross section (SNF) is controlled by the following equation:

$$SNF = A + B\left(1.0 + C\,\frac{SDPV - SDPV_o}{SDPV_o}\right)$$

where

$SDPV_o$ = original SDPV
SDPV = current value

A = macroscopic cross section associated with the fuel element cladding
B = macroscopic cross section associated with the moderator for the initial SDPV
C = a constant to correct for changes in flux peaking in the moderator, 1.0 = no change in peaking

RBU

The RBU basic library revisions and corrections were completed and a new library is ready to be distributed to Hanford cross section users.

Several critical mass experiments (both uranium and plutonium systems) have been simulated for RBU. The experimental results are to be matched by the program before more complex and time-consuming problems are considered. The diffusion program seems to predict a high reactivity on the NPR-PCTR experiment but the results have not been completely reduced as yet.

The Hanford Critical Mass Laboratory contributed several experiments to be verified, and assistance will be given to future experiments done by the lab from RBU.

G-2 Nuclear Data Tape

In order to increase the usefulness of the ANPD program G-2, a one-dimensional slowing down diffusion calculation, a program to update its 19 level data tape

has been written and debugged. The updating program will be used to add plutonium isotopes to the tape using the RBU basic library as a source of data.

HET

Program HET to calculate the eigenvalue and fluxes for a heterogeneous reactor is being revamped in an attempt to get more accurate answers to PRTR Pu loadings.

It was decided to change from two-group diffusion theory to age-diffusion theory, following more closely the HERESY program of TRG. During the changeover a mistake was found in HET which could possibly account for the 3-4% inaccuracy encountered. Since the changeover was nearly completed, it was decided to continue it and to evaluate the effect of the original error via a comparison of matrix elements. When completed the HET code will be nearly an exact replica of HERESY.

Nondestructive Evaluation of Uniformity of PuO_2 Distribution in UO_2

Methods of fabricating PuO_2-UO_2 fuel rods with 0.5 w/o PuO_2 (140 mg of PuO_2 per lineal inch of 1/2 inch diamter rod) are being developed in PFDO (Plutonium Fuels Development Operation). A nondestructive means of measuring the homogenity of PuO_2 in the rods is required. A preliminary investigation has been made of the sensitivity and techniques of the reactivity coefficient method using the TTR. The results are favorable.

Critical and subcritical methods have been evaluated with respect to sensitivity and time requirements. For the critical method, a sample of U^{235} ($\sim$180 mg) was exposed to the reactor neutron flux in a 1.125-inch-long window of a cadmium tube which was coaxial with the core of the TTR. The window was centered in the reactor. The reactivity coefficients of the sample in window and well up into the cadmium tube were measured and yielded a sensitivity of 0.0063 ¢/mg of U^{235}. Or, in terms of fuel rod evaluation, a 7 mg variation PuO_2 content in one inch of rod can be measured to ± 1.5 mg. This sensitivity and precision meet the tentative requirements of PFDO.

The subcritical method is essentially a differential multiplication measurement which is made at a k_{eff} of 0.95 to < 1. The differential multiplication of the system due to a change in fuel mass is measured in terms of a differential ion current from a neutron sensitive ion chamber. The measured sensitivity was 10^{-12} amperes per 180 mg of U^{235} at a k_{eff} of 0.99. This is equivalent to 0.05×10^{-13} amperes per mg change in PuO_2 per inch of rod. The current level may be within the noise level of the system so preparations are being made to measure the noise level.

The two methods differ significantly in their respective time requirements. Each critical measurement requires a minimum of twenty minutes while the subcritical measurement can be made in one minute. In both cases the time is dependent upon the mean life of fission neutrons. However, in the subcritical measurement the time is proportional to the multiplication which can be varied over a wide range.

The preference for one method over the other is dependent in part upon the extent of the testing desired. PFDO has not, as yet, made a concrete specification of their requirements. This is due to a lack of knowledge of the

sensitivity and time requirements of a satisfactory method of testing. The information which has been obtained in these preliminary investigations will be presented to PFDO for their evaluation.

Instrumentation and Systems Studies

Advice and assistance was rendered to PRTR instrument personnel concerning a new DC amplifier circuit proposed to drive recorders for a power test. A connection circuit diagram was prepared concerning a process room scintillation detector and cabling to the 200-channel analyzer in the PRTR Control Room.

Recommended extensive circuitry changes for the PRTR Fuel Failure Monitor are continuing to be made in the system. It appears that another month will be required to complete these revisions. The system will then be extensively tested to determine if further modifications are needed.

The transistorized, one-microsecond scaler and electronic timer recently developed for the Critical Facility have continued on test this month with no apparent component failure.

The four-transducer, ultrasonic probe assembly for use in measuring the wall thickness of the PRTR process tubes is nearing the point where mockup evaluation testing can begin. Out-of-tolerance dimensions of the commercial transducers has necessitated a trim-and-shim shop process in order to obtain proper transducer contact with the tube walls. Difficulty has also been encountered in obtaining suitable spring material from which to fabricate the leaf springs which hold the transducers against the tube walls. A corrosion-resistant material is required which possesses springing properties approximating those of spring steel.

A recording of PCTR neutron flux was made to test equipment changes made in preparation for the PRTR noise test and to determine the effect on neutron lifetime of a new lattice configuration at PCTR. These data are currently being processed. It has been determined that a new ion chamber design will be required for the PRTR noise test. The minimum critical flux has increased by a factor of approximately one thousand since the earlier tests were made. Noise measurements at this level will require the use of a chamber which will saturate at this flux level for a reasonable value of chamber voltage.

A new mathematical model of the PRTR Gas Balance system is being derived in an attempt to better study the stability characteristics of the system. This model may provide a better understanding of the physical characteristics and answer some future questions arising about this system.

PHOENIX FUEL

ARMF-MTR Experiments with Plutonium Fuel

Two Pu-Al samples have been irradiated in the MTR. These irradiations are part of the experiment to study the reactivity lifetime of Pu-Al fuels as a function of Pu^{240} content. The reactivity of one of the samples (6.2 w/o Pu^{240}) has been measured in the ARMF and the reactivity measurements on the second sample (27.2 w/o Pu^{240}) have begun. A third sample (16.3 w/o Pu^{240}) is currently being irradiated in the MTR. This sample, unlike the other two,

will be subjected to reactivity measurements ~4 hours after shutdown of the MTR. Reactivity measurements will be made at selected times thereafter until it is reloaded into the MTR. In this way the reactivity effects which are caused by the buildup and decay of fission products will be studied. The purpose of the measurements is twofold. First, the measurements furnish a check on calculational techniques. Secondly, they answer the more practical question of what the waiting period should be between discharge from the MTR and measurement in the ARMF to insure a constant reactivity during the measurement.

A letter has been sent to the representative at the MTR site. This letter describes the frequency of measurements for the transient study and the method of cutting and counting Co-Al wires. The wire is 0.040" in diameter and contains 0.1 w/o Co in Al. The wires are mounted near a sample which is being irradiated in the MTR and is used to determine the integrated exposure of the sample.

Use of Phoenix Fuel for Compact Power Reactors

The first phase of an investigation regarding the possible use of Phoenix fuel for compact, water moderated power reactors has been completed. An informal document, HW-71279, "The Use of Phoenix Fuel for Compact Power Reactors," has been issued.

NEUTRON FLUX MONITORS

Investigations of sample experimental Pu-nuclide foil preparation methods continued. It was determined that a colloidal suspension of Pu in a carbon matrix would be the most suitable foil preparation method for use in later irradiation experiments. In addition, a new metal alloy was determined to be better than titanium for the capsule for use in hot graphite.

Further theoretical work showed that a mixture of 10:1 of U^{234} and U^{235} could result in a long life in-core neutron detector with near attainment of secular equilibrium of U^{235} burnout equating to buildup from U^{234}. Calculations showed lifetimes to ± 10% and ± 2% for three years and 16 months, respectively. To reduce the epithermal resonance effects of U^{234}, a 10- to 50-mil shield of U^{236} could be employed. This shield would enhance the detector lifetime by reducing the effective flux in the 1/v region of the detector; however, this would lead to production of a spectral-dependent response which might be detrimental under certain reactor operating conditions.

Continued theoretical and computer studies were made concerning the multi-Pu nulcide detectors of the Phoenix or breeder types.

A number of possible neutron reactions were considered for feasibility in the microwave neutron flux monitor study. Additional improvements also were made in the experimental equipment.

NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

The theory of the proposed multiple-parameter eddy current device for detecting and identifying small individual parameter excursions has been confirmed

by laboratory measurements in which the test specimen was represented by an electric circuit having four inductively-coupled meshes with provision to change the series mesh resistances. Measurements have been made to test the method for identifying simultaneous small parameter changes. These data are now being analyzed.

The method being used to check the proposed principle of operation is a combined experimental and analytical approach in which the desired transformation of the measured eddy current test signal into parameter values is done by calculation. However, the required transformation has been instrumented and this section of the proposed device will be tested next.

Heat Transfer Testing

Operating experience with the new 314 Building fuel element heat transfer testing equipment has shown that several added features are needed. These are a circuit to synchronize the print frequency generator in the model 1003 heat transfer mapping system (described in previous reports) with the infrared chopper frequency, and a motion detector which will cause interruption of the heat source when the scanning lathe is not in motion. Circuits to provide these functions were developed and are now being installed. Gain of the mapping system input amplifier was lowered to improve stability. The result of these changes should be improved heat transfer test sensitivity, reproducibility, and safety.

Calculations indicate that sensitivity of heat transfer testing to core-cladding bonds in Zircaloy-2 clad ceramic fuel elements should be between that for aluminum-clad and that for Zircaloy-2 clad uranium fuel elements. A request for Zircaloy-2 clad UO_2 fuel element samples containing known defects has been sent to Ceramic Fuels Development, HLO.

Zirconium Hydride Detection

An attempt was made to detect differences in ultrasonic attenuation between hydrided and non-hydrided Zircaloy-2 samples. No differences greater than those due to normal testing variations could be detected under the present testing conditions.

Tests indicated that X-ray diffraction analysis is sensitive enough to detect 300 ppm hydrogen in Zircaloy-2.

Samples containing approximately 21, 100, and 500 ppm (by weight) hydrogen were ultrasonically tested by Testing Methods, FPD, by continuously varying the frequency from 25 to 42 megacycles at both room temperature and -196°C, and by varying the frequency between 17 and 22 megaycles at +100°C. The ultrasound was applied in bursts travelling longitudinally along the samples, which were approximately six inches long by two inches wide by one-fourth inch thick, and amplitudes of subsequent reflections were compared to determine the magnitude of absorption. The samples were also tested in this manner at fixed frequencies of 2.25 and 10 megacycles at room temperature.

Any ultrasonic attenuation differences that might have existed between samples were masked by variations due to standard coupling variations and

differences in grain size and other structure factors.

Zircaloy-2 samples containing 49, 300, and 5000 ppm (by weight) hydrogen were submitted to Physical Metallurgy, HLO, for X-ray diffraction analysis with their equipment. A strong indication of gamma phase hydride was obtained from the 300 ppm sample. Interference between a diffraction peak for zirconium and the strongest gamma hydride peak obscured the results in the 5000 ppm sample. Further studies are underway to determine whether X-ray analysis might be applied to nondestructive detection of hydride in Zircaloy-2 reactor tubes and corrosion samples.

Development began on a probe for the simultaneous measurement of Hall coefficient and resistivity by inductive means. If this can be done within a Zircaloy reactor pressure tube, it would be useful for detecting localized hydride concentrations in excess of about 1000 ppm hydrogen by weight. The design of suitable test coil configurations appears promising.

USAEC/AECL COOPERATIVE PROGRAM - Nondestructive Testing of Sheath Tubing

Standards Development

Samples of tubing with electro-machined notches were partially evaluated as described later. Preparation of additional trial standards has been deferred pending results of these tests.

Production Tester Development and Evaluation

Methods are needed for comparing the response of supposedly identical transducers. One possible procedure is described in ASTM Specification E-127-58-T, "Tentative Recommended Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks". In this, the amplitudes of signals reflected from smooth ball bearings are measured as a function of ball diameter. Analysis of the response for various ball sizes and ball positions yields information regarding the ultrasonic beam geometry, energy distribution in the beam, and instrument system linearity. These relationships were experimentally determined for a 0.75-inch-diameter, ten-megacycle, point-focused, lithium sulphate transducer, used with an Immerscope.

Techniques for the direct imaging of ultrasonic beams also would be highly useful for comparing transducers and investigating ultrasonic behavior. Very encouraging results were obtained from preliminary experiments with schlieren imaging. An ultrasonic beam in water was readily observed visually by the schlieren method which detects the slight deviation of light due to pressure changes in the ultrasonic beam. The optics system is being refined to determine applicability of this method for study of ultrasonic beam geometries.

Modifications were made to obtain more accurate positioning of the mechanical manipulator developed to study the ultrasonic response as a function of defect orientation in flat and curved plates, and in short lengths of tubing.

A new reject circuit was developed for the Immerscope instrument. The new circuit is less sensitive to noise and also maintains a rejection level which

is more independent of the rotational speed of the tube being tested. Two transducer holders with built-in tuning coils also were fabricated. These about double the gain and will aid in obtaining maximum sensitivity from the Immerscope.

Ultrasonic responses were determined as a function of the orientation of electro-machined notches of various sizes in both the inner and outer surfaces of tubings. Although the general applicability of these results remains to be fully evaluated, several observations were made for this particular test system and this particular set of artificial discontinuities. With a cylindrical transducer oriented parallel to the tube axis, the response increased almost linearly with increasing length of longitudinal defects until the defect length became comparable to the beam width. The longitudinal defect test was insensitive to a defect which was at an angle of 20 degrees to the tube axis. Likewise, the transverse test sensitivity decreased markedly for defects not oriented at 90 degrees to the tube axis. Varying the angular relationship between the defect and the tube surface had a lesser effect on ultrasonic response.

Fundamental and Theoretical Studies

The literature survey of experimental and theoretical work in ultrasonic testing of thin components is nearing completion.

A versatile laboratory test tank suitable for Lamb wave experimentation has been delivered. The accompanying electronic system has been calibrated and is ready for use. Experiments with this equipment will begin upon delivery of the transducer positioners which are expected in early November. Aluminum and Zircaloy sheath tube samples are on hand.

PHYSICAL RESEARCH - 05 PROGRAM

Mechanism of Graphite Damage

Theoretical studies were carried out in preparation for future experiments.

BIOLOGY AND MEDICINE - 06 PROGRAM

Atmospheric Physics

Analysis of measurements obtained during atmospheric diffusions field trials continued. Summaries of wind direction variability for the 1959 and 1960 Hanford experiments and the first Cape Canaveral series were received from the Air Force. Computations of the wind direction variance at various filter widths were made on the Air Force IBM-650 computer to determine some characteristics of the turbulence spectrum for the eight anemometer heights on the meteorology tower. The basic data were comprised of 20-second visual averages of the wind azimuth trace on the strip chart records for the one-half hour duration of tracer release. Seven filter widths were used, increasing logarithmically to 1280 seconds.

Attempts were made to separate the high frequency components of the spectrum from the meander frequencies and correlate these with stability ratio, wind speed, and plume width. No good correlations were found. It appears now that

additional wind data for periods prior to and following tracer release will have to be analyzed to characterize the more general long-period oscillations causing wind direction trends during the experiments. Also, the 20-second average over which the basic data were first transcribed may have filtered a sufficiently high fraction of the high frequency component of the turbulence to require rereading these records for shorter initial filter widths.

Data summaries for the first series of atmospheric diffusion experiments conducted at Vandenberg Air Force Base, California, were forwarded to the Air Force for further analysis. A total of 52 field trials were included, embracing a wide range of atmospheric stabilities and wind speeds over rough coastal terrain. Several experiments conducted during periods of fog were also included.

Concerning the rain scavenging experiments, collection of droplets during natural rains continued. The purpose of these samples is to obtain the raindrop spectrum during the various periods in the history of the rainfall. The tedious microscope work of sizing drops and zinc sulfide tracer particles collected in the drops during the scavenging experiment conducted in August is nearing completion.

In work on atmospheric tracer technology, three additional Rankin Counters, recently equipped with Americium sources, were calibrated against the counter containing a Plutonium source that has shown sustained dependable performance. The calibration curves are tabled below, where M represents the mass of zinc sulfide in grams and C represents the counters per minute on the Rankin Counter.

Counter Number	Calibration Curve	Source
3	Log M = 0.9521 log C - 9.07924	Pu
4	Log M = 0.9539 log C - 8.9709	Am
6	Log M = 0.9575 log C - 9.0818	Am
7	Log M = 0.9642 log C - 9.2540	Am

Dosimetry

The whole body counter was calibrated for measurements of potassium. No change was found from the calibration of two years ago. This indicates excellent stability of the counting system. At the same time the scanning counter and the shadow shield counter were calibrated for potassium. It was found that the spread in results expected for different size people in the scanning counter is about two and one-half times that found in the present whole body counter. This is disappointing and is not entirely consistent with previous data. The shadow shield counter was found to be about thirty percent less sensitive, but the spread in results expected for different size people is less, than the present whole body counter.

Most of the annual maintenance for the positive ion accelerator was completed. A new accelerator tube was installed in hopes it might reduce sparking and energy instability. No reduction resulted. The accelerator operated satisfactorily during the rest of the month.

Careful tests were made of some recently purchased aluminum wall BF_3 counters. They were found to have good resolution and the effect of gamma radiation was

quite small. However, the counting rates were observed to change with time and the counters were judged unacceptable.

Analysis of some inverse square measurements with a precision long counter indicated the need for more accurate counter deadtime corrections.

The calorimetric measurement of the half life of Sb-124 is continuing. Present results indicate a half life 0.5% longer than estimated last month. This may indicate the presence of a short half life contaminant.

A fifty gram plutonium source was put in the calorimeter. Initial measurements of the power output indicated values about ten percent higher than expected from the amounts of Pu-239, Pu-240 and Pu-241 present. A few hundredths percent of Pu-238 could account for this excess power.

Calculations continued on corrections to be applied to ionization chamber measurements within contaminated tissues.

Radiation Instruments

A second consecutive month of satisfactory operation was obtained on the experimental prototype coincident-count alpha air monitor. Good test data are being obtained, and the only difficulties have been with the recorder strip-chart drives. Experiments and calculations now indicate the system will satisfactorily and reliably alarm in about one hour for a continuous Pu^{239} alpha air concentration of 2×10^{-11} μc/cc (10 MPC), even with abnormally high radon-thoron concentrations.

Fabrication continued on more experimental (two of each type) prototype pocket dosimeters which use modified pencil ionization chamber detectors and transistorized circuitry. One unit gives an audible alarm after accumulation of a preselected dose and the second unit registers one digit on an incorporated miniature register for each 10 mr of dose accumulated.

The experimental prototype background suppression beta-gamma combined hand and shoe counter, clothing monitor, and background recording system operated successfully for the second consecutive month at 105-D. It will now be moved to Purex for further demonstration. Complete Hanford drawings for the circuitry and detector probes are being prepared for use in obtaining 12 instruments for use at NPR.

Complete electromechanical drawings were prepared of inexpensive probes for use in alpha-only, beta-gamma only, and combined alpha-beta-gamma hand and shoe counters. The probes incorporate thin wall aluminum shells (housings) of effective area sizes of $4\frac{1}{2} \times 7\frac{1}{2}$ inches and $4\frac{1}{2} \times 12$ inches for the hand and shoe coverage, respectively. Only the internal air light-pipe is needed for the alpha-only and beta-gamma only counters; however, for the combined alpha-beta-gamma counter, the thin wall housing is poured full of a special clear plastic which is then slowly hardened at 145°F. This method completely eliminates the expensive machining previously used for the original Lucite light pipes. For a six-probe, combined alpha-beta-gamma instrument, the poured plastic method can reduce the gross instrument cost by $800 to $1000.

Modification and development effort continued concerning the Atmospheric Physics Radiotelemetry System. A new schematic drawing was prepared for the data station chassis. A new slip ring assembly was designed, fabricated, and installed for use with the generator-to-tower power transmission circuit. In addition, agreement was obtained for the purchase of 12 new wind-driven battery charger generators of a satisfactory type. A new battery charger regulator was designed to prevent the generator shorting relay from destroying itself by continuous cycling. Drawings were prepared for fabrication of the item for all generators in the field. An explanation and orientation class was held with CPD maintenance personnel concerning the radiotelemetry system in an effort to improve maintenance. One data station was relocated at the 100-F Area to provide better 110 VAC line power quality and to permit the obtaining of better meteorological data.

Experiments continued concerning circuitry and probe development for the prototype scintillation transistorized combined alpha, beta, gamma hand and shoe counter. NE-102 terphenyl-in-polyvinyltoluene sheets 0.010 inch thick were installed in the hand and shoe probes in place of the 0.065-inch sheets used for beta detection. This essentially eliminated the background counting that was affecting the alpha channel sensitivity; the excellent beta-detection abilities were retained. In a series of counting experiments with the alpha-detecting ZnS on the 0.010-inch-thick NE-102, the alpha-channel background count averaged 1.35 per 15-second count period, while a standard 500 d/m Pu^{239} source, distributed over a 4-by-8-inch area produced an average of 22.5 counts per 15-second period. This is an excellent signal-to-background ratio of nearly 17:1. The rest of the modification effort should now proceed quite rapidly. New transistor circuits, with discriminators, were used to drive scalers for alpha-channel readout.

Experiments were started to use tunnel diodes for low-level pulse integral discriminators, wherein the tunnel diodes are directly driven by the anode of a phototube. The discrimination level is adjustable.

Discussions were held with Biology personnel concerning later development work on a radionuclide monitor for hogs; moving them into the Biology Total Body Monitor is considered risky because of the activity levels involved. In addition, some discussion concerned a special beta scintillation counter for low-background detection work.

A new transistorized miniature alpha monitor instrument using a 0.75-inch-diameter silicon surface barrier diode detector was completed and is being tested.

A pulse-triggered semiconductor tone-generator circuit was developed and an invention report was submitted. The unit drives a miniature weatherproof "howler" unit using four transistors. Temperature tests from -10°F to +150°F were satisfactory. The circuit will first be used in two prototype portable transistorized GM instruments which are now being modified.

Circuitry development was completed for a new type of transistorized scintillation portable alpha "poppy" instrument to replace the obsolete vacuum tube model. One experimental unit will use standard headphone indication and the second will employ the pulse-triggered tone-generator circuit.

Alternate proposals and cost estimates for a date acquisition system were developed for the Atmospheric Physics Operation. Sixteen channels of information are to be recorded for about two hours, with a frequency response of at least one cps. The data are to be processed by the IBM-7090 computer.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Program

Isotopic analyses were provided for program samples according to goal schedules during the month. In addition, twenty analyses were made on eight special uranium standard samples prepared by the National Bureau of Standards and previously mass analyzed at KAPL. Four operating days were lost due to equipment failure. These and other operating difficulties were due at least in part to the failure of the laboratory air conditioner which has been out of service for over three weeks. Repair of the air conditioning unit has not been completed as yet, presumably because of delay incurred awaiting replacement parts.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely except for a two-day maintenance outage. There were no unscheduled shutdowns.

The properties of tube-in-tube fuel in a 14½-inch graphite lattice were investigated. k_∞ wet and dry, f, p, and ϵ measurements were completed.

A series of foil normalization irradiations was completed using plutonium-aluminum cluster fuel elements in 10½, 8-3/8, and 6½-inch graphite lattices.

A temporary graphite column roughly 3' x 3' x 3' was built on the top of the PCTR. This represents a great improvement in fission foil counting. Previously it had been necessary to irradiate normalizing foils in the TTR thermal column simultaneously with the PCTR core irradiation. One series of gold foil irradiations was made to determine whether a cadmium shutter is needed between the PCTR and the thermal column. The data are being analyzed. When the results are available a permanent column will be designed and built.

The face speed control was modified to extend the minimum closing speed range (½ inch/minute) from 3 inches to 4 inches. This provides an increased margin of safety, should the reactor reach criticality while the face is closing. An improved switch mechanism minimized the increase in the total time required for a complete face open-face closed cycle. The original design required that the face open to 4 inches at slow speed in order to close for 3 inches at slow speed. The improved arrangement has only a 0.2 inch overlap.

An improved, more accurate coarse face position indicator was installed.

The PCTR Hazards Report is being revised to reflect our current philosophy of operation and safety. A calculation was made of the pressure rise which would occur in the PCTR reactor room during an excursion if the reactor were not shut down until the Pb-UO_2 driver elements were vaporized. This would cause about 1.3×10^{18} fissions in the Pb-UO_2. In such an event, the reactor room pressure would increase to about one and one-third atmospheres if all the

gases were contained in the reactor room. The reactor room seals will not withstand this high a pressure, and a seal rupture would undoubtedly occur.

It can be concluded that about one-fourth of the fission products corresponding to 1.3×10^{18} fissions would be released almost immediately from the reactor room.

Operation of the TTR continued during the month with no unscheduled shutdowns. An extended series of reactivity measurements was made to investigate the feasibility of using the TTR to measure the uniformity of PuO_2 distribution in PuO_2 PRTR fuel elements. A practical but somewhat time-consuming method appears to be available. Some preliminary work was done in exploring a subcritical reactor method. It is potentially faster but requires instrumentation improvements to give comparable sensitivity.

One set of fission foils was irradiated in the TTR thermal column simultaneously with the irradiation of fission foils in the PCTR core.

The TTR facilities and one qualified reactor operator were made available one evening per week to the University of Washington Graduate Center for a Nuclear Engineering Course.

CUSTOMER WORK

Weather Forecasting and Meteorological Service

Consultation service was rendered on meteorological and climatological aspects of NPR and FRPP safeguards analyses. Meteorological services, viz., weather forecasts, observations, and climatological services were provided to plant operations and management personnel on a routine basis.

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	83.2
24-Hour General	62	90.8
Special	150	84.7

October was a little cooler and windier, and a lot drier, than normal. Precipitation totaled 0.07 inch--just 10 percent of normal.

The Russian 50-megaton test registered as a vertical mark on the barograph trace near 0645 PST, October 30. This was the first time that a nuclear blast anywhere has produced such an effect.

Instrumentation and Systems Studies

The experimental line and battery-operated Radiation Field Analyzer Instrument, designed for Biology for HAPO field use and for Project Chariot in Alaska, was completed along with all additional probes desired, and the complete package was demonstrated and delivered to Biology personnel. All tests were satisfactory. A complete, detailed operation and instruction manual was prepared.

Fabrication of the detectors and electronic circuitry for the Automatic Conveyor-Type Laundry Monitor for alpha, beta, and gamma monitoring was accelerated. The mechanical loading, unloading, and contaminated drop portions of the system were extensively tested, and a new automatic loading mechanism is being fabricated. All circuit and detector tests to date have been satisfactory.

One of the two experimental prototype "palm size" alpha monitor instruments, using solid state surface barrier diode detectors and transistorized circuitry including an aural annunciator, was delivered to Finished Products Chemical Technology, CPD. It performed satisfactorily.

Advice and assistance were provided to Radiological Development, HLO, concerning incorporation of transistorized air monitor circuitry developed here into a commercial air monitor that has a good moving filter tape head.

A reinvestigation was started regarding packing density measurements of UO_2-packed fuel tubes for Ceramic Fuels Development, HLO. A new proposal and cost estimate is being prepared to include shielding, source, detector, all electronics and recording equipment, and a complete, automatic mechanical fuel rod conveyor system.

Fabrication continues in the 328 Shop on a special line-operated transistor circuit to be used with air-proportional alpha-detecting probes.

Calibration of micro-displacement readout systems to be used by Physical Metallurgy Operation for in-reactor creep measurements has continued during October. A transducer (0.030-inch range) of the type installed in the third generation creep capsule has been incorporated into the reference system and calibration is about 50% completed. The data taken during the calibration of the three-range (second generation) transducers are still undergoing statistical analysis by Operations Research and Synthesis. A fully automated computer program is being set up to produce the required analysis with a single computer operation and thereby eliminate the tedious manual operations used for previous data.

The completed prototype model of the Panellit-Heise gage readout device has been tested by Office Procedures Operation in the 700 Area and in trial operation in the 105-DR Building. After initial inspection by reactor operation personnel, several small modifications were made: a disposal pipe was installed to dispose of the tape punchings, and a zero index mark was placed on the remote-gage readout-box Panellit simulators.

A work order was obtained from Fuels Preparation Department for assistance in testing and determining proper procedures for operating the autoclave vessels. Preliminary tests showed that several modifications should be made to auxiliary control equipment before a decision on the procedures and controller adjustments for the various autoclaving operations could be made. Recommendations for detailed modifications to the auxiliary equipment are in preparation.

A "C" column simulation study has been initiated by the Chemical Development Operation of HLO. It will consist of an attempt to develop a satisfactory

mathematical model of a pulse column used in chemical separations. Three possible mathematical models have been derived, and the analog computer study will be designed to determine the chemical constants necessary to give the best fit of each of the models to given experimental data. The results of the analog work will be used to determine which, if any, of the models will most nearly describe the operation of a pulse column. Tentative analog circuits for the models were designed this month.

A "data acquisition task force" was organized at the request of the Contract and Accounting Operation in an attempt to standardize the form in which automatically-recorded data are sent to Electronic Data Processing Operation. G. E. Driver is the Instrument Research and Development representative. In two meetings on October 5 and 26, the group reached agreement on the coding and format to be required of perforated paper tape to be transmitted to 713 Building for data processing.

Development and testing were completed on a paper tape readout for a device which measures the dimensions of NPR fuel elements. The instrument is being fabricated. The coding and format of the perforated tape are in accord with the above-mentioned requirements.

Optics

During the period October 1 to October 29, 408 manhours of shop work were performed. This included:

1. Fabrication of quartz plugs for dilatometer equipment in the 234-5 Building.
2. Fabrication of the Mark II traverse mechanism.
3. Repair of two borescope sections for Irradiation Testing Operation.
4. Lapping one quartz crystal for high frequency ultrasonic work for Testing Methods, FPD.
5. Repair of one borescope and one microscope for Reactor Plant Engineering, IPD.
6. Fabrication of TV lens covers for IPD.
7. Assembly of an underwater viewer for the PRCF.
8. Repair and modification of one borescope head for Structural Materials Development, HLO.
9. Repair of one camera iris diaphragm for Radiometallurgy.

Physical Testing

Testing continued at a high level. A total of 11,335 tests were made on 6,974 items, totaling 139,379 feet in length. Tubular products continue to represent the greater part of this footage.

Test work included: autoclaving; borescoping; dimensional measurements (micrometric); eddy current; failure analysis; magnetic particle; mechanical tests (flattening, hardness, and impact); metallography penetrant (fluorescent OD and ID); radiography (autoradiography, gamma-ray, and X-ray); stress analysis; surface treatment (alkaline cleaning, pickling for autoclaving, steam detergent cleaning, ultrasonic cleaning, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements). Work was done for 27 organizational components representing most of the operating departments

and service organizations at HAPO. Advice was given on 69 different occasions on general testing theory and applications.

Work proceeded routinely towards finishing the testing of the remaining NPR pressure tubes. Principal effort is now centered on conditioning and testing of ID surfaces. Satisfactory operation of the Vacu-Blast station now permits work on many of the tubes previously on a hold basis. A photoelectric detector was developed and installed for monitoring the Vacu-Blast process for uniformity. Use of this system precludes the need for an extra borescope examination.

Four PRTR spare pressure tubes are ready for the straightening operation which will make them available for reactor installation. The eleven tubes pickled and autoclaved, of which the four are a part, have demonstrated satisfactory oxide film formation with the existing NPR facilities for processing. Further PRTR pressure tube testing and treatment will be integrated with the remaining NPR tube work.

Pickling of the PRTR Rupture Loop tubes cannot be accomplished in the same manner as pickling the PRTR process tubes because of the reducing section in the tube. The abrupt diameter change would trap gas during pickling and promote staining. To alleviate the trapping of gas, the tube will be turned end-for-end so the gas will dispel from the large section. Adapter equipment to process in this manner has been fabricated.

Field radiography utilizing X-ray and gamma-ray equipment was conducted at the following sites: 309 (PRTR), 100-N, 277-W Shops, and the 1706-KER Building. A considerable number of fluorescent penetrant tests were made including examination of broach nozzles, Tru-Arc retaining rings, pump impellers, expansion joints, and new front face pigtails for the reactors. Magnetic particle examinations were conducted on inlet thimble components. Stress measurements were taken on the rear face of 105-C reactor.

In the 300 Area testing labs, the receipt of fuel element sheath tubing has not kept up to schedule; as a consequence, tubing output averaged only about 50 tubes per week. A considerable ultrasonic testing backlog is being accumulated, as planned, to allow the primary tube tests to be completed first.

The Physical Measurements Operation 40-kilowatt plasma-arc-jet heat source in the 314 Building was successfully used in 265 tests to determine heat transfer properties of canned fuel elements. Experiments were conducted with different nozzles, distances, amperages, and techniques for masking the elements with tempera paint.

An ultrasonic thickness measurement program was started on unfired pressure vessels in the 309 Building, and on the sand separators in the 382 Building. Radiographic work on the non-isothermal loop construction passed the 60% completion mark. Radiographic examination assistance was provided on short notice over a two-week period to help prepare capsules for in-pile testing.

Extensive work was done on an emergency basis on NPR primary loop piping at the request of IPD. Two phases were involved, representing two different fabrication procedures. The work included both field testing at the HUICO

shop at Pasco and laboratory work in the 300 Area. Testing in the field included: continuous X-ray examination at 20 degrees on both sides of the weld; complete ultrasonic examination, including shear-wave testing in the longitudinal (two sides) and transverse (two directions) directions, and longitudinal wave testing; and fluorescent penetrant testing of all available weld-end preparations. Testing in the laboratory included: X-ray examination at angles ranging from 0 to 40 degrees in 5-degree steps, utilizing 250 KV, 300 KV, and 1 Mev radiation; ultrasonic testing utilizing shear and longitudinal wave examination; fluorescent penetrant testing; and sectioning and macro-etching. Additional development work was done in the following areas: adapting the ultrasonic test for this application; preliminary tests utilizing slit radiography to provide a production method; and trial exposures on the 234-5 Building One-Mev X-ray generator. Radiography did not successfully resolve the inherent discontinuities in the pipe welds. Correlation tests on the ultrasonic testing are not yet completed, but considerable difficulty is anticipated because of minor laminations occurring in the base metal adjacent to the welds. Sectioning work and macro-etching did disclose small inter-granular cracks in the weld metal from samples of both fabrication methods.

The reactor Parker fitting test was successfully applied under actual reactor conditions. Two fittings on the 105-DR rear face were tested. No rejectable signals were observed. Further testing is to be coordinated with future reactor outages.

ANALOG COMPUTER FACILITY OPERATION

Studies

The major analog computer problems considered during October include:

1. Reactor Instrumentation
2. NPR Secondary Loop
3. Reactor Xenon Effects

Equipment Operation

The GEDA was 68% and the EASE 88% operational during the month. The computer operations were as follows:

GEDA	EASE	
106	104	Hours up
40	44	Hours unscheduled downtime
22	20	Hours scheduled downtime
0	0	Hours idle
168	168	Hours total

Maintenance

The computer maintenance has suffered somewhat in October because of work needed on auxiliary equipment such as recorders.

It appears part of the maintenance problem may be solved if one instrument man were to work swing shift every other week. He would then have eight hours to do needed computer maintenance work that cannot be done while the computers are operating. The necessary shift agreements are being negotiated by FPD Instrument Crafts Operation.

INSTRUMENT EVALUATION

Evaluation tests of the Ni-Cd rechargeable batteries for portable instruments started showing failure effects after about 50 repeated charge-discharge cycles, the equivalent of from one to two years of usefulness in typical portable instruments.

The experimental gamma background-suppressed beta-gamma hand and shoe counter (scintillation and transistorized) completed two months of successful testing demonstration in 105-D, and it is now being moved to Purex for further demonstrations.

Acceptance tests were nearly completed on 100 zero-to-600 r gamma pencil-type self-indicating dosimeters. The accuracies were disappointing; more than 25 pencils had reading errors of -20 to -30%.

Complete schematic and written specifications were completed at the request of Radiation Protection Operation concerning the scheduled purchase of 30 portable transistorized BF_3 tube neutron instruments. The instruments will employ a special miniature BF_3 tube designed by Radiological Development, RPO, and permit use of a much smaller double moderator, as originally conceived by Radiological Physics, to obtain fast neutron dose-rate information.

Advice and assistance was provided to the Portable Instrument Repair Shop personnel regarding adjustment and calibration of the portable battery-operated transistorized scintillation gamma-energy analyzers developed by Nucleonic Instrumentation. A new, simplified adjustment and test procedure was prepared.

Discussions were held with CPD personnel concerning various types of developmental, line-operated area and building scintillation gamma-dose-rate monitors and various types of developmental pocket alarming and registering dosimeters and commercial pocket rate-indicating devices.

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Manager
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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Reactor Effluent Radioisotope Studies

Studies are continuing with the aim of devising altered reactor water treatment processes to reduce the concentrations of radioisotopes discharged in the reactor effluent water. Recent studies indicate colloidal iron in process water may play a part in the film formation and salt adsorption processes which lead to prolonged retention (and enhanced activation) of certain parent materials in the reactor. Tests were made to determine the effect of colloidal iron on removal of As-76 by the high alum water treatment process. A negatively charged iron colloid containing As-76 as the arsenate ion was prepared and added to river water which was then treated with 20 ppm aluminum nitrate in a laboratory scale water treatment plant at pH's of 7 and 6.75. In both cases a control run was made in which As-76 as arsenate ion was added to the same total concentration but no colloidal iron was added. At pH 7, greater than 94 percent of the As-76 was removed from both feeds. At pH 6.75, however, only 77 percent of the As-76 was removed from the colloidal iron bearing feed while 96 percent removal was obtained on the control. Thus, it is apparent that the presence of colloidal iron can have a significant effect on the removal of arsenic by the high alum treatment. Further study is planned to determine to what extent such colloidal phenomena influence the results obtained in plant water treatment.

One possibility for reducing the formation of P-32 and As-76 in reactors is to periodically inject agents into the process water which will either alter the character of the films to reduce adsorption of precursors of As-76 and P-32 or will be so strongly adsorbed themselves as to inhibit adsorption of precursors of As-76 and P-32. A number of candidate film poisoning agents have been tested in laboratory experiments. To date, sodium silicate has proven the most effective agent for this purpose. In the first 30 minutes after addition of sodium silicate, adsorption of arsenate is reduced to about one-seventh of that found in a control experiment. In tests of the effect one day after addition of the poisoning agent, octadecylamine acetate appears to be the most promising with preliminary tests indicating reduction of arsenate adsorption by a factor of about ten. Pending further laboratory tests, it is planned to test this approach in reactor tube tests.

Reduction of Reactor Effluent Contamination

Laboratory experiments were continued to characterize the soil adsorption of radionuclides from reactor wastes. A marked reduction in the adsorption of neptunium at 90 C was found for 10^{-5} M solutions in tap water compared to solutions prepared with distilled water. The 50 percent breakthrough capacity was reduced from 75 to 22 column volumes when tap water was used, representing an adsorption capacity decrease from 0.045 to 0.018 millimoles/100 g of soil.

A soil column removed about 30 percent of the added P-32 rather steadily for 250 column volumes throughput. The relatively constant removal is in contrast to the breakthrough curves normally obtained in adsorption columns. In other experiments at least 50 percent of the P-32 in a tap-water solution was associated with a precipitate which could be separated by centrifugation for one hour at 1600 g. The P-32 in a distilled-water solution was also partly colloidal as indicated by its inability to penetrate a dialyzing membrane. From these results it is concluded that at least part of the removal of P-32 by soil can be attributed to filtration of a dispersed precipitate in passage of the solution through the soil.

Effluent Monitoring

Operation of the As-76 monitor on the 107-F retention basin inlet stream was continuous during the month except for minor shutdowns. A two-day shutdown was necessary to correct a deficiency in the original scaler circuit. Two additional malfunctions were noted during the month's operation; unreliable "reset-to zero" operation and a component failure in the 1000's scaling section of the scaler. Both malfunctions were corrected.

Ground Water Temperature Studies

The thermistor probe, which is sensitive to relatively small changes in temperature, is now used routinely to obtain periodic measurements of temperatures in 100 Area monitoring wells. Temperature data to be collected for a period of one year will be used to prepare isothermal maps of the ground water under the 100 Areas. Such maps in combination with operating information should have practical application in evaluating the effects of effluent disposal and local ground-water conditions on water characteristics of reactor coolant intakes.

SEPARATION PROCESSES

Diluent Evaluation

The results of a series of "use tests" on Penn 2251, a petroleum kerosene produced by Penn-Drake Refining Company, indicate that it is similar in behavior to other low-naphthene kerosenes previously tested. When severely degraded (24 hours, 8 M HNO_3 - 0.05 M $NaNO_2$, 80 C) it extracts less fission product activity and has lower scrub E_a^o's than Shell E2342, a kerosene derived from a high-naphthene crude. In a similar experiment, contacting the diluent-30 percent TBP mixtures with 8 M HNO_3 for 24 hours at 90 C resulted in an increase in density from 0.7694 to 0.9125 for Soltrol 170 and an increase of viscosity from 2.5 to 26 centipoise. Respective values for the 2251 oil were 0.7680 to 0.8768 and 1.6 to 4.3.

Other use tests indicate that the buildup of "do bads," factors which contribute to extraction and retention of fission products, during chemical degradation with HNO_3 - $NaNO_2$ solutions is initially more rapid in Soltrol 170 than in Shell E2342. This trend is reversed as the severity of degradation is increased. After mild degradation (2 hours, 8 M HNO_3 - 0.05 M $NaNO_2$, 60 C) Soltrol 170 extracts and retains more fission product activity than Shell E2342. After more severe degradation (24 hours, 8 M HNO_3 - 0.05 M $NaNO_2$, 80 C) the reverse is true. This behavior is difficult to translate into Purex plant solvent behavior since it is not known if changes in solvent behavior are due to mild degradation of large quantities of [illegible] or severe degradation of a fraction of it.

Redox Anion Exchange Test

An anion exchange run was made to study decontamination of Redox IIBP solution. The solution was made up to a typical anion exchange feed and processed through a loading, scrubbing and elution cycle similar to that used in the Purex process. Preliminary results gave a ruthenium DF of greater than 450 and a product of acceptable purity. Some difficulty with gassing was encountered during the loading cycle, believed due to reaction of residual hexone with the 7 M nitric acid feed. This difficulty would presumably not arise in a plant application since the hexone would be routinely stripped from the aqueous stream before acidification.

Disposal to Ground

The results of previously conducted soil column tests showed that existing Redox plant cribs, with two exceptions, have estimated remaining lives for radioisotope removal in excess of ten years. The exceptions are the 216-SL-1 and 2 (Redox laboratory and 300 Area wastes) cribs which have an estimated useful life of 3 to 6 years. Soil column evaluation of the organic decant waste discharged to the Redox 276-S crib is in progress.

Incinerator Off-Gases

Samples of incinerator particulates trapped in the scrubber were examined microscopically and the particulate material found to be almost entirely less than 1 μ mean diameter. The data suggest that the upstream cyclones are efficient for the larger particles.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Ion Exchange Extraction of Technetium and Cesium from Purex Waste Supernatant

A second A-cell ion exchange run with as-received Purex waste tank 103-A supernatant was completed during this month. Significant differences from the first run (reported last month) included (1) use of a lower flow rate, about 3.2 ml/min, cm^2 vs. 6.1 ml/min, cm^2; (2) use of a 0.25 M HNO_3 wash following loading and prior to elution; and (3) use of a second column, filled with the cation exchange resin, Duolite C-3, for removal of cesium. Technetium recovery on the Amberlite IRA-401 anion column was even better than in the first run. Over 110 column volumes of feed were pumped through the column without appreciable breakthrough, compared to 50 percent breakthrough at 90 column volumes in the first run. This improvement is presumably due to use of a lower flow rate and correspondingly greater residence time. Following loading, the column was washed with two column volumes of water and six column volumes of 0.25 M nitric acid (to improve fission product decontamination) and then eluted with 8 M nitric acid. The absorbed technetium, amounting to about 5 grams, was recovered in only twelve liters (2.5 column volumes) at an average concentration of 0.42 g Tc/l. Decontamination factors from cerium, cesium, and zirconium-niobium were 190, 21,000 and 280, respectively (compared to ruthenium and zirconium-niobium decontamination factors of 57 and 67 in the first run).

The capacity of the Duolite C-3 column for cesium was low. Although very nearly complete removal of cesium was obtained from the first few column volumes, fifty percent breakthrough was reached after passing only 18 column volumes of feed (equivalent to 12 volumes of waste tank supernatant prior to jet dilution).

Following loading, the column was washed with 4.5 volumes of 0.25 M HNO_3 and an equal volume of water. This treatment removed 84 percent of the sodium from the column while removing only four percent of the cesium. Ninety percent of the cesium was then eluted in 13 column volumes of 1 M HNO_3. If this product were then neutralized with caustic for loading onto Decalso, the sodium-to-cesium ratio would be reduced by a factor of about four as compared to the original waste supernatant (from a value of 13,000 to 2,400). This reduction in sodium content would result in an increase in Decalso cesium capacity to 2.2 grams per liter, or 290 curies per liter, compared with about 70 curies per liter for direct loading. Supporting laboratory work, not yet tested with full-level waste, indicates that addition of 0.25 M caustic will increase the cesium loading of Duolite C-3 by a factor of about 2.5 and that no further increase in capacity occurs as the sodium hydroxide concentration is increased to 3 M. This increased capacity would result in a sodium-to-cesium mole ratio of ~900 in the neutralized eluate and imply a subsequent Decalso loading of 4.5 grams per liter, or 600 curies of cesium-137 per liter, an improvement factor of 8.5.

Considerable difficulty was encountered in removing the used Duolite C-3 resin from the column. Further cesium runs have been postponed until after the promethium flowsheet tests are completed.

Promethium Recovery

A second peroxyacetate run, similar to that reported last month, was completed at Purex and the promethium product shipped to the hot cells. Although the run appeared successful, based on Purex analytical data, the received solution was found to contain only 314 curies of promethium per gallon (1/5 the expected concentration) associated with 1400 curies of cerium per gallon. Because of the high cerium-to-promethium ratio, all of the material is being reprocessed by batch-wise peroxyacetate precipitation in B-cell prior to use as feed in the A-cell columns. Processing is being done in 100 liter batches with phase separation by double decantation (since a suitable centrifuge or filter is not available). Cerium decontamination factors have ranged from 10 to 100 and promethium recoveries from 65 to 80 percent, depending on pH. Sufficient promethium (about 40 kilocuries) for one A-cell run should be obtained. Additional feed (for B-cell up-grading) will be obtained from Purex as rare earth oxalate solution, a by-product of current strontium processing.

In-Cell Promethium Analysis

The processing of promethium in B-cell, and in the plant, has been severely hampered by the difficulty in obtaining timely and reliable analyses. An in-cell gamma spectrometer method has now been developed which should markedly improve analytical control in B-cell. Advantage is taken of the presence of substantial amounts of gamma-emitting promethium-148 in short-cooled plant material. Some samples can be scanned directly. Others require a preliminary cerium separation. However, this is easily accomplished by adding a potassium iodate-potassium bromate solution to the sample and filtering directly into a gamma-spectrometer sample vial. No volume measurements are required, and the sample can be counted as soon as the 14 minute praseodymium-144 decays.

Precipitation and Stability of Strontium-90 Peroxide

The use of strontium peroxide as a filterable intermediate in the packaging of fission-product strontium has been the subject of engineering study and appears quite promising. However, there has been uncertainty as to whether the compound would be adequately stable to self-radiation. A hot-cell experiment, using some of the purified strontium-90 retained from the final A-cell strontium purification run, was accordingly performed. It was found that strontium peroxide precipitation is not critically limited by peroxide stability in a radiation field, that the precipitate formed in a radiation field is easily filterable, and that washes do not remove significant amounts of the strontium.

Cerium Precipitation for Shipping Cask Loading

A series of experiments were performed to establish optimum conditions, within the limitations imposed by existing plant equipment, for precipitating cerium (as the sodium double sulfate) for loading into the cerium filter cask for shipment to Oak Ridge. The vapor pressure limitations imposed by jet transfer result in lower temperatures than desired and lead to relatively high solubility of the double sulfate, which has a retrograde solubility. Two procedures were established; one with tartrate complexing during the precipitation step and one without. With either, loss of cerium at 40 C is about 16 percent. An additional 10 percemt is lost on slurrying and filtering into the cask.

Ce-144 Shipment Hazard Evaluation

Data were obtained relative to particle size and solubility of precipitated sodium-cerium sulfate, the salt intended as carrier for shipping large quantities of Ce-144. The work was performed to assist in a hazards evaluation. The salt, precipitated according to the anticipated flow sheet, consists of crystallites about 2.5 μ square in section and 10 μ long. The crystallites exhibit appreciable strength and break up into smaller fragments only with considerable force. The solubility of the salt was determined to be 3 g per liter at 20 C.

WASTE TREATMENT

Batch Calcination

Studies continued to determine the effects of a draft tube insert on boil-up rates and on operation during the concentration of a simulated waste solution.

A draft tube 2-ft. high and 4-7/8-in. in diameter was placed within a 6-in. diameter by 3-ft. high pot. The cross sectional area inside the draft tube was 1.8 times that outside the tube. Water was boiled in the pot with the energy provided by induction heating. At three different power levels of the induction heater, the insertion of the draft tube increased the boil-off rate by an average of only 5 percent over that measured without the draft tube.

A run also was made in a 24-in. high annular pot constructed from 4- and 8-in. pipe and containing a 7-in. diameter draft tube. The chemical composition of the simulated solution was the same as that previously used in the same pot. An air sparge was found to be necessary in the previous run to control solution foaming during the boil-down step. With the draft tube, no air sparge was required because foaming was not a serious problem and the boil-off rate was increased by approximately 15 percent.

Testing of various liquid level sensing devices was the object of a run in the pilo plant batch calcination facility. The devices tested in an 8-in. diameter by 5-1/2 ft. high pot were: (1) an air purged dip tube with a steam bleed into the air supply to the dip tube, (2) an alumina jacketed capacitance probe, (3) a 1/16-in. diameter, stainless steel sheathed, chromel-alumel thermocouple heated by an alternating current. The thermocouple was inserted from the top and bent in a "U" so that the tip pointed upwards. A similar device with the thermocouple tip pointing downward was tried previously, but became heavily coated with solids and all sensitivity was lost.

During the boil-down of a simulated, low acid waste solution, only the air purged dip tube with the steam bleed gave satisfactory liquid level detection. In previous pilot plant runs without a steam bleed, the dip tube became plugged. The steam bleed proved to be effective in eliminating this pluggage problem. Both the heated thermocouple and the capacitance probe became heavily coated with solids. The heated thermocouple gradually lost sensitivity as the solids continued to build up and eventually was unable to detect the solution level. Although the capacitance probe could detect changes in the solution level even when heavily coated with solids, the sensitivity was reduced by an order of magnitude.

Purex Waste Tank Sludge Sampling

Specifications for a core driller for sampling sludge in underground storage tanks have been developed in a series of tests drilling synthetic materials. A commercial core drill drive is proposed, with 1-3/8 in. OD tubing drill rod running in a close-fitting casing. The casing is spring-centered in an 8-inch pipe guide tube. Relatively high speeds (100 200 rev/min), feeds, and bit flushing flow rates are also recommended. Final details of the core bit itself are awaiting additional vendor tests.

In-Tank Solidification

In laboratory scale boil-down tests of synthetic Purex tank farm supernates with externally applied heat (no carbonation), rapid application of heat (one degree per minute rise) developed foam at approximately 130 C and the foaming doubled the apparent volume of the solution at 140 C. Crystals were observed throughout the solution at 120 C and were grown above the liquid edge from that point on. The boil-down was continued until the volume of the solution was decreased to 20 percent of the original. Complete solidification occurred on cooling. The product was granular and, once broken, remained as a free-flowing solid.

Simmering (temperature rise of 0.1 C/min) developed no foam. Crystals were found in the solution at 85 C. At 93 C the volume had been reduced to 2/3 of the original quantity and 80 percent solidification occurred on overnight cooling. The solids partially re-dissolved on resumption of heating and at 116 C, corresponding to a reduction to 44.5 percent in volume, solidification was about 90 percent. On cooling, the mass resembled a well consolidated filter presscake (moist, but completely solid).

Other laboratory studies were started to determine the characteristics of solids which would result from in-tank concentration and solidification of low-activity level waste solutions. These studies were with simulated old Purex plant coating removal waste. When the simulated waste was concentrated while being sparged with air only, the boiling temperature reached 150 C at a condensate to original volume ratio, V_c/V_o, of 0.79. Condensate pH was 8.1. The residue was still a mobile slurry

which solidified completely on cooling to 70 C. The solids were hygroscopic. When the waste was sparged with a 50 volume percent CO_2 in air mixture during concentration the V_c/V_o ratio was 0.81 at a boiling temperature of 150 C. The residue solidified completely at a temperature slightly below the boiling point. The hygroscopic character of these solids is being determined and thermobalance studies are in progress to determine their behavior on heating.

Hot Semiworks Operation

Strontium-90 recovery activities in the Hot Semiworks were concluded October 14, with the transfer of the facility to the Chemical Processing Department. Preliminary material balances for the program indicate a recovery of over 800,000 curies of strontium-90 with over 700,000 curies of specification product. The cerium content of the difference material is above specification and will have to be reworked when the necessary tankages become free. Summary reports detailing operations are in preparation.

The last run in the campaign was a research and development run designed deliberately to test and to demonstrate the technical feasibility of broadening the process bases to recover strontium, cerium and a cerium-free rare earth concentrate, i.e., promethium. The run was considered successful, although facility limitations and equipment difficulties resulted in cerium and promethium recoveries of only 60 and 30 percent, respectively; on the other hand, 80 percent recovery of strontium was achieved. Both the cerium and promethium by-product materials were deliberately discarded in the absence of adequate storage facilities.

Bulk Fission Product Packaging

Fission product canister capacities for Sr-90, Ce-144 and Pm-147 were re-evaluated to reflect expected plant flowsheet product purities. With a 4-1/2 inch OD canister, 24-in. high, and a maximum of 200 watts radiolytic heat generation, canister loadings of 30, 26 and 55 kilocuries of Sr-90, Ce-144 and Pm-147, respectively, can be obtained with a maximum surface temperature of 325 F in air at 100 F. In the case of Pm-147, dilution with other tri-valent rare earths results in physical filling of the canister prior to reaching the heat dissipation limit of 200 watts, i.e., a 55 kilocurie Pm-147 canister will dissipate approximately 90 watts.

In other bulk packaging development studies, design of the canister loading station was completed and fabrication started. Conceptual drawings of a canister capping station have been completed and are being reviewed.

Remote welded closures are being studied for both fission product and waste packaging, and in this area detailing of the remote inert gas-shielded, tungsten-arc welding equipment is 70 percent complete. The canister gasketed closure design has been revised to accommodate a Belleville spring type metallic gasket.

EQUIPMENT AND MATERIALS

Hydraulic Equipment

Life test of a Hastelloy C canned motor submerged pump using water at 50 C as a test fluid has continued uneventfully for the past month. A total of 2700 hours of operation has been completed to date and the test continues.

Ultrasonic Welding of Titanium to 304-L Stainless Steel

In attempts to use ultrasonic techniques to weld titanium to 304-L stainless steel, a brittle phase was formed, with consequent poor mechanical properties of the weld, when the two metals were joined directly. Welds with satisfactory mechanical properties were produced when a 0.5 mil interleaf of nickel between the two metals was used. However, in nitric acid the nickel corrodes rapidly.

Corrosion of 1020 Steel by Oxalic Acid

During short term (16 hours) exposure of 1020 steel coupons to five weight percent oxalic acid at 25 and 75 C, corrosion rates of three and six mils/month, respectively, were observed. The solutions were not aerated during the exposure. Prior literature indicates oxidizing conditions may accelerate corrosion in this system.

Corrosion of Titanium in Purex 1WW

Further tests on the corrosion of titanium in Purex 1WW solution were made to define the effects of varying the solution composition, particularly fluoride composition. Tests made this month also included heat transfer conditions. Titanium corrosion rates less than 0.1 mil/month were obtained under all conditions tested.

Role of Cr(VI) in Corrosion of 304-L Stainless Steel

Tests made with synthetic Purex 1WW and H4 solutions indicate the corrosion rates for 304-L stainless steel in concentrators handling these solutions can be reduced by factors of from two to six if most of the chromium present is kept in the reduced (III) state. The most promising means of accomplishing this so far found involves a reduction of chromium with hydroxylamine before the solution enters the concentrator and a bleed of NO_2 or a nitrite to the concentrator.

PROCESS CONTROL DEVELOPMENT

Measurement of pH in Process Solution

Considerable difficulty has been experienced with failure of pH electrodes in high activity solutions. It has previously been shown in laboratory tests that breakage of electrodes, presumably due to hydrogen peroxide buildup, occurs after irradiation to 5×10^8 R, corresponding to about 30 days in the E-3 neutralized waste tank at Purex. A new electrode fitted with a pressure relief valve was irradiated to 10^9 R without breakage. Efforts now are underway to utilize an inorganic sealing material to achieve improved resistance to radiation change.

Plutonium Summation System

Instrumentation for determining total plutonium flow in a process stream has been developed and was previously tested in the Redox plant. This system in effect mechanically multiplies plutonium concentration times flow rate and integrates the product over a given period of time. After initial operation in the final column product stream, the system has been relocated to another product line further downstream and recalibrated Improved sensitivity of the plutonium concentration monitor was achieved by increasin the volume of the holdup tank where neutrons are counted. The flowmeter output was adjusted to compensate for non-linear response at low flow. Based on the satisfactory operation of the system, no further development effort in the laboratories is anticipated.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Separation of Plutonium from Uranium in Molten Chloride Systems - Previous work in NaCl-KCl melts demonstrated the feasibility of electrodepositing UO_2 relatively free of plutonium and of codepositing PuO_2 with UO_2, depending on the conditions of the electrodeposition. Establishment of a method for the recovery of plutonium free from uranium would increase the flexibility of the Salt Cycle Process by allowing the uranium and plutonium to be recovered either separately or together.

In addition to separation of plutonium from uranium, separation is desired from the rare earths (other than cerium) which constitute the dominant nuclear poisons among the fission products. In the electrodeposition work in NaCl-KCl melts, decontamination factors for rare earths of only 6 to 8 were achieved by jointly depositing PuO_2 and UO_2. While adequate in terms of a single recycle, these low decontamination factors would forbid the prolonged re-use of the same salt melt and would compel frequent fission product waste processing.

Since the possibility of achieving economies via requiring waste processing only at infrequent intervals compared with processing of valued constituents is one of the incentives for work on this pyrochemical approach, means are being sought to effect cleaner separation of plutonium from rare earths.

At the temperature (750 C) customarily employed for electrodeposition in NaCl-KCl melts, plutonium(III) is the predominant oxidation state in solution. To improve the probability of obtaining good separation of plutonium from the trivalent rare earths, more recent work has been done at lower temperatures where plutonium can be obtained in solution as plutonium(IV) by the oxidation of plutonium(III) with chlorine.

The melt system chosen for the initial studies is the LiCl-KCl system. This system allows operation at considerably lower temperatures than does the NaCl-KCl system and also allows operation at high temperatures without the volatility problems encountered in the $PbCl_2$-KCl system. Another advantage of LiCl-KCl melts over $PbCl_2$-KCl melts as far as precipitation processes are concerned is the lower density of the LiCl-KCl system.

Separation of uranium from plutonium in the LiCl-KCl system was demonstrated by the same technique employed in the NaCl-KCl system, that is, by electrodepositing UO_2 at 750 C from a dry melt under a chlorine atmosphere. The deposited UO_2 was separated from plutonium by a factor of about 130 and from promethium by a factor of about 250.

Separation of plutonium from uranium was attempted by sparging a plutonium(IV) chloride-bearing melt (LiCl-KCl containing 10 w/o U and 0.1 w/o Pu) with dry oxygen to precipitate PuO_2. Only ten percent of the plutonium was precipitated by a one hour oxygen sparge at 550 C, however. One reason for the small amount of plutonium precipitated may be that the equilibrium $PuCl_3 + 1/2\ Cl_2 = PuCl_4$ may be forced to the less reactive plutonium(III) when the chlorine is removed from the melt by the oxygen sparge. An attempt to increase the amount of plutonium precipitated by

adding two volume percent chlorine to the oxygen sparge was unsuccessful. Another possible explanation for the small amount of plutonium precipitated is that the reaction of plutonium(IV) chloride with oxygen may simply be slow. In this connection, the reaction of uranium(IV) chloride with air (to form uranyl chloride) in LiCl-KCl at 600 C was found to have a half-time of about two hours.

Another method under investigation for precipitating PuO_2 from molten chloride salt solutions is the addition of a metal oxide to the melt to metathesize plutonium(IV)-chloride to PuO_2. To achieve separation of plutonium from uranium it is necessary, of course, to choose a metal oxide having a thermodynamic stability (in a chloride system) intermediate between plutonium(IV) and uranium(VI) oxides. The change in free energy associated with the conversion of uranyl chloride in molten salt solution to uranium(VI) oxide is apparently only a small positive value, thus severely limiting the number of metal oxides which will precipitate plutonium(IV) oxide but not uranium(VI) oxide. According to available free energy data, separation of plutonium from uranium by this technique should also give separation from the trivalent rare earths.

Scouting experiments along these lines were conducted employing uranium(IV) as a stand-in for plutonium(IV). Addition of MgO or SnO_2 to LiCl-KCl melts containing uranium(IV) chloride at 550 C resulted in rapid and complete precipitation of UO_2. When the MgO or SnO_2 was added during a chlorine sparge, the UO_2 was rapidly redissolved by conversion to uranyl chloride. When melts containing precipitated UO_2 and excess MgO or SnO_2 were HCl sparged, the UO_2 did not dissolve until the MgO or SnO_2 had dissolved. It was concluded from these experiments that addition of MgO or SnO_2 to plutonium(IV)-bearing melts would precipitate PuO_2, that separation of plutonium(IV) from uranium(IV) would be achieved if the addition were made during a chlorine sparge, and that no substantial amount of precipitated PuO_2 would be redissolved by the chlorine sparge as long as MgO or SnO_2 is present.

Addition of MgO to a LiCl-KCl melt containing 0.1 w/o Pu and 10 w/o U during a chlorine sparge at 550 C resulted in the precipitation of about 80 percent of the plutonium. About five percent of the uranium was also precipitated, however, giving a uranium DF of only about 15.

A similar experiment employing SnO_2 as the precipitant was performed, but no analytical data are yet available. Qualitative observations indicate that neither plutonium(IV nor uranium(VI) oxide was precipitated as extensively as in the MgO experiment, however.

Mechanism of Reduction of UO_2Cl_2 to UO_2 - The latest modification of the chronopotentiometer has allowed better definition of the curves. Analysis of the more refined data indicates that the electroreduction of uranyl chloride to UO_2 does not proceed via a direct two electron transfer. The data indicate that a soluble uranium(V) species exists as an intermediate in the reduction of uranyl chloride to UO_2.

The curves consist of two portions; the first having the appearance of a reduction to a soluble product and the second a reduction to an insoluble product. Determination of "n" values (number of electrons) for the two portions of the curves is made difficult by their poor separation, and by the fact that the second portion is not a smooth curve. For a two-step reduction with a one electron change in each step, the transition time of the second step should be three times as great as that of the first step. The best defined curves approximate this relationship.

Studies of $PbCl_2$-KCl Systems - Large (up to 4 gram) UO_2 crystals prepared by electrodeposition under a chlorine atmosphere have been found to have O/U ratios of 2.002 and to contain 50 ppm Pb and 200 ppm K. The importance of breaking up the deposit into individual pieces before washing to remove lead contamination was again emphasized by the fact that washed agglomerates of UO_2 crystals from the same deposit contained 1000 ppm Pb.

The prime requisite for the growth of large UO_2 crystals still appears to be the maintenance of a dry, oxygen-free system. By maintaining a chlorine or HCl atmosphere in the cell during electrolysis, large crystals are obtained but the crystal faces are etched to the extent that the surface luster is lost. Large (up to 4 gram), lustrous-faced crystals were obtained in a recent deposition run under a helium atmosphere with 4 w/o U(IV) in the melt to assure dry, oxygen-free conditions. The uranium(IV) was introduced into the melt, which contained about 20 w/o U(VI), by dissolution of UO_2 with HCl.

The densities of various $PbCl_2$-KCl-UO_2Cl_2 melt compositions have been determined. Values were obtained at several temperatures with potassium-to-lead ratios of 1:1 to 3:1 in the absence of uranium and, with a potassium-to-lead ratio of 2.5:1, at uranium concentrations up to about 25 w/o.

Rates of Dissolution of UO_2 by Chlorine - Rates of dissolution of large, single pieces of UO_2 have been determined under various conditions. These data are more consistent than those obtained in earlier work employing UO_2 powder, where apparent inconsistencies were probably due to variations in surface area and in the degree to which the powder was mixed with the melt during dissolution.

On short-term (ten minute) exposure to chlorine-sparged melts, UO_2 was found to dissolve at a rate of about 0.25 mg U/(cm^2 UO_2 surface area)(min) in each of the following cases: NaCl-KCl at 700 C, $MgCl_2$-1.5 KCl at 600 C, and $PbCl_2$-2.5 KCl at 600 or 700 C. At 600 C, dissolution rates in $PbCl_2$-0.9 KCl and $PbCl_2$-1.5 KCl were about 75 and 90 percent, respectively, as high as in $PbCl_2$-2.5 KCl. Addition of 0.5 m/o TlCl increased the dissolution rate a factor of about 17 in $MgCl_2$-1.5 KCl at 600 C and a factor of about 35 in NaCl-KCl at 700 C, $PbCl_2$-0.9, 1.5, or 2.5 KCl at 600 C, and in $PbCl_2$-2.5 KCl at 700 C. Addition of 0.25 m/o TlCl to NaCl-KCl at 700 C resulted in a 14-fold increase in the dissolution rate. Addition of 0.5 m/o $FeCl_3$ or $CuCl_2$ resulted in about 24-fold and 27-fold increases in the dissolution rate in either NaCl-KCl or $PbCl_2$-2.5 KCl at 700 C.

On long term (up to three hours) exposure of UO_2 to chlorine-sparged NaCl-KCl at 700 C, the rate at which the UO_2 dissolved was found to increase with time. Experiments showed that this phenomenon was not due to an increase in the solubility of chlorine in the melt as the uranyl chloride concentration increased, to an increase in the number of active sites as the UO_2 "aged" in the melt, or to an increase in the UO_2 surface area as dissolution progressed. Instead, all available evidence points to the fact that uranyl chloride catalyzes the dissolution of UO_2. In the concentration range studied (up to 3 w/o UO_2Cl_2), the dissolution rate was found to be proportional to the one-half power of the uranyl chloride concentration. With 0.5 m/o UO_2Cl_2 (2.5 w/o) in the melt, the rate of UO_2 dissolution was a factor of about four greater than with no uranyl chloride in the melt.

Molten Salt Spectrophotometry - In the development of spectrophotometric methods for molten salt systems, isobestic points have been observed in the spectra of various uranium compounds as a function of temperature. A paper entitled, "Fused Salt Spectrophotometry III: Isobestic Points Generated by Variation in Temperature," has been written which gives considerable insight into the phenomenon. It is shown (1) that only one species contributes to the absorbance at a given isobestic point, (2) that the only manner in which the isobestic point can be generated is for the absorptivity of the species at the isobestic point to be linearly dependent on temperature (at least to an approximation suggested by experimental accuracy) and be of the form $\epsilon(\lambda) = \ell(\lambda)[1+h(\lambda)t]$, and (3) that correcting the medium for density change as a function of temperature, shifts but does not destroy the isobestic points.

Materials of Construction - In search of a suitable material for engineering scale application of the molten salt electrolytic process, a Pfaudler Company Nucerite Vessel was tested for thermal shock tolerance. After three cycles from 750 C to room temperature containing a $PbCl_2$ KCl mix, the lining was found to have spalled off the bottom. Later, spalling from the sides was noted.

A second and third vessel were also tested by holding at 650 C for one week. The salt in one vessel was sparged continuously with chlorine; the other was left static. The coating of both vessels spalled at the molten salt gas interface.

Reprocessing PRTR Spike Elements

Dissolution rates of PRTR Pu-Al alloy spike fuel in HNO_3-NH_4F-$Hg(NO_3)_2$ solutions were measured. In the presence of 0.03 to 0.06 M NH_4F, the Pu-Al alloy will activate in 6-7 M HNO_3 - 0.002 M $Hg(NO_3)_2$ solutions. Without fluoride, the concentration of mercury must be increased to ca. 0.025 M before activation will occur. The dissolution rate (33 mg/min.,sq.cm.) in 6 M HNO_3 - 0.002 M $Hg(NO_3)_2$ - 0.03 to 0.06 M NH_4F) is about half that without the fluoride and with 0.025 to 0.05 M $Hg(NO_3)_2$ to induce activation. The fluoride-containing system shows promise as a means of obtaining reduced dissolution rates (desired for processing the spike fuels in the Redox plant). A survey of activation characteristics and dissolution rates as a function of nitric acid and aluminum nitrate concentration is underway to define a possible flowsheet for use in the Redox plant.

RADIOACTIVE RESIDUE FIXATION

Sorption Studies

Work reported in June showed that the same amount of Cs-137 was removed by clinoptilolite from 1WW waste regardless of dilution provided that the flow rate of the undiluted waste remained the same. The greatest waste dilution used was 1 to 20. Dilutions of 1:30 and 1:40 have now been used, with the flow of undiluted waste the same as that previously reported. Even at these large dilutions there was no change in the quantity of cesium removed from the waste.

Kinetic Studies of Ion Exchange Materials

A kinetic study in the particle diffusion region of sodium exchange by cesium was previously reported for erionite and clinoptilolite. The shallow bed technique was used to study the loading rates of several other cation exchange materials including Decalso, Linde 4A, phillipsite, vermiculite and a sulfonated polystyrene resin.

The loading rate curves obtained for these materials were analyzed by use of Reichenberg's equation for evaluation of specific reaction rates. Diffusion coefficients at two temperatures were also determined from which Arrhenius activation energies were calculated.

The zeolite loading rates are similar to those of the organic resins, and all gave rate constants of the order 0.01 to 0.05 sec^{-1} over the temperature range 30 C to 50 C. Activation energies are low, ranging from 1.1 kcal/mole for phillipsite to 6.5 kcal/mole for Decalso.

Condensate Wastes

Equilibrium experiments were performed with clinoptilolite, a sulfonated polystyrene resin (Amberlite IR-120), a sulfonated phenol base resin (Duolite C-3), and an aluminosilicate gel (Decalso) in dilute calcium ion systems containing trace cesium or strontium. Based on the observed K_d values, trace strontium in a 20 ppm calcium solution would reach 50 percent breakthrough on Decalso, clinoptilolite, IR-120 and C-3 after 15,000, 5,300, 2,500 and 1,400 bed volumes, respectively. Trace cesium in 20 ppm calcium solution would reach 50 percent breakthrough only after greater than 50,000 bed volumes for both clinoptilolite and Decalso. However, less than 1,000 bed volumes would be expected to reach 50 percent breakthrough for IR-120 and C-3. Although Decalso appears to have a selectivity advantage, its long-term use is limited to solutions of near neutral pH.

Micro Pilot Plant Run 19 is in progress to evaluate the performance of a 0.25 liter column of Amberlite IR-120 followed in series by a 0.25 liter column of clinoptilolite, both in the hydrogen form. About 5000 liters of Purex Tank Farm condensate were treated to date. Preliminary analytical results indicate that Sr-90 and Cs-137 concentrations in the effluent have not exceeded their respective MPC_w.

Laboratory experiments indicate that the addition of 5 ppm sodium hydroxide to the steam stripper feed will increase and maintain a high enough pH so that the steam stripper bottoms may have a residual concentration of less than 0.5 ppm ammonia compared to the presently attainable 2 to 6 ppm value. Because sodium ion does not interfere as greatly with cesium adsorption on clinoptilolite and Decalso as does ammonium ion, the addition of small amounts of caustic may increase significantly the capacity for cesium removal from Purex Tank Farm condensate.

Organic Incineration

Burning of degraded radioactive organic from chemical processing operations may be a good alternate to ground disposal. In order to determine the feasibility of the direct combustion of non-radioactive 30 volume percent tri-n-butyl phosphate in hydrocarbon diluent, a test was performed by the Thermal Research and Engineering Corporation at our request. The waste was introduced with a steam atomizing type nozzle into a model LV-3 Vortex burner. The combustion was started from a cold condition using a gas pilot for ignition, and the operation did not require auxiliary fuel or burner preheating. The waste material appeared to burn completely, generating the expected white phosphorous pentoxide smoke. No visible deposit was observed in the combustion chamber.

Ruthenium Tetroxide Studies

Measurements of the capacity of silica gel for ruthenium tetroxide absorption showed a strong, inverse temperature effect, from 7.2 mg Ru/g silica gel at room temperature to 1.8 mg/g at 55 C and 1.2 mg/g at 84 C. Pre-treatment of the silica gel with an absorbed reducing agent, formaldehyde, increased the room temperature capacity to 64 mg/Ru/g. Experiments at higher temperatures are in progress.

Off-Gas Particulate Studies and Treatment

Electron microscope studies have shown that the off-gas from the spray calciner, which has passed through the primary filters and scrubber, consists of very small particles, in the 0.01 - 0.1 micron size range.

The use of conventional wet scrubbers offers little hope of removing particles in this size range. Thus, an efficient bubble scrubber, such as a Peabody scrubber, was found to give essentially no removal. A new model of the electrostatic bubble scrubber gave decontamination factors of 10 to 15 and resulted in effluent dust loadings of about 20 $\mu g/ft^3$. It is believed that the efficiency of the electrostatic bubble scrubber can be even further improved. An invention report has been prepared describing the device.

BIOLOGY AND MEDICINE - 06 PROGRAM

Geology and Hydrology

Two recently completed wells, one near 100-N Area and the other southeast of Hanford encountered basalt at depths which were, respectively, 86 feet shallower and 66 feet deeper than predicted. These significant deviations are indicative of the probable variability of the basalt surface under much of the project. In the case of the well near 100-N Area, interpretation of recent airborne magnetometer data disclosed a probable east-west trending anticlinal ridge previously undetected and of unknown height. Completion of the well and confirmation of the anticline validate the magnetometer surveys and encourage complete interpretation of the magnetic data. The well southeast of Hanford is about atop the continuation of the Gable Mountain anticlinal ridge; hence, the ridge is lower than estimated. The effect of this on the movement of ground-water from both sides of Gable Mountain into the Columbia River near Hanford is under study.

The computational problem associated with the proposed method for measuring permeability in-place has been examined and a suitable solution found. A linearized flow approximation is used initially to get a fair estimate of permeability in the region. The estimate is then improved by successive steps to yield the correct permeability distribution. Such a procedure by-passes the numerical differentiation difficulties found earlier in conventional finite difference solutions of these particular partial differential equations.

The well-packer was used in well 699-69-45 in an attempt to determine the vertical variation in potential. The packer test indicated that there was leakage of water between the well casing and the formation at the 110-125 foot depth. The existence of such lack of contact between formation and casing in many other wells may require pressure grouting or other similar operations to obtain the necessary potential measurement through use of the well-packer.

Use of the well-packer to determine permeability requires that a geometry factor be obtained for use in the mathematical treatment of the particular flow system under study. The geometry factor for an 8-in. well with a packed-off section five feet long was found to be 14.54 feet through use of the steady state computer program.

Field Apparatus Development and Application

Further testing of the in-well vertical flowmeter was carried out in three wells. Operation was satisfactory down to the maximum depth checked, 70 feet below groundwater surface. Evidence of vertical water movement was noted in all three wells. A subject report of this development is in preparation.

Particulates from Heated Irradiated Uranium

Particulates released from heated irradiated uranium were sized with a 5-stage impactor. A great predominance of the uranium and fission products was associated with particles with less than 1 micron mass median diameter.

Analytical Methods for Environmental Materials

Two procedures were developed for determining I-131 in milk at low concentrations to fulfill the new requirements established by the Federal Radiation Council. One procedure is based on the ion exchange of 20 liters of milk. At a flow rate of 100 ml/min and at the 1 μμc/liter level, the radiochemical yield is 90 ± 10 percent. The analysis can be completed in four hours. Tests at increased flow rates are in progress to decrease the time necessary for analysis. In the second procedure, direct gamma counting on 12 liters of milk between two 9-in. diameter by 4-in. high sodium iodide detectors allows measurement of concentrations of I-131 as low as 3 μμc/liter.

W. H. Reas

Manager
Chemical Research and Development

WH Reas:cf

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

Dr. D. Dennis Mahlum from the University of Wisconsin joined the Metabolism Operation during October as a Biological Scientist.

Dr. V. H. Smith returned in September to the Metabolism Operation, following a two-year leave of absence at the University of Minnesota.

H. L. Corson retired following eight years' service in the Biology Operation assigned to the Experimental Animal Farm.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 02 PROGRAM

Effect of Reactor Effluent on Aquatic Organisms

The experiment to test the effect of crowding on the incidence of columnaris infection continues to suggest that this disease is density dependent. Trout being held in Columbia River water with different numbers represented in each trough show that the greater the number in a trough the greater the incidence of columnaris. After three months of tests, troughs with initial numbers of 900, 450, 150 and 50 trout show 11.3, 10.0, 1.3 and 0 per cent mortalities, respectively.

Field samples of scrap fish and salmon have shown negligible infection with C. columnaris. Columnaris organisms have been isolated only from gills. Indications are that gill lesions on salmon that are called columnaris infection by field workers are not columnaris at all, since only once have organisms been isolated from these lesions. A strain of columnaris with intermediate virulence was cultured in media containing 0.5 mc H^3/ml for nine days. Virulence tests showed no differences compared to control cultures indicating that irradiation does not affect virulence.

Salmon Survey

The first survey for 1961 of chinook salmon spawning in the vicinity of HAPO was made on November 6. Four-hundred and ninety-one salmon nests were observed in the Columbia River from Richland to Midway. The greatest number of nests were near 100-H and along the island near Midway, which is upstream from all reactors. No nests were seen downstream from Hanford.

The number of nests observed is probably lower than actual due to poor light conditions, water turbidity, and lateness of season.

Rapid fluctuations in river level from manipulation of flow by the upstream dams was apparent. About six nests had been exposed to the air due to fluctuation in river level.

(This information, due to be reported in the November report, is reported early because of delay in obtaining airplane service to conduct the survey.)

Waterfowl

Heads of more than 1,000 waterfowl harvested by local sportsmen were analyzed in cooperation with the Radiological Protection and Evaluation Operation. Arrangements were made with the U.S. Fish and Wildlife Service to obtain heads of waterfowl from Oregon, California, Idaho and Montana to expand this investigatic

BIOLOGY AND MEDICINE - 06 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Strontium

The serial study of the distribution and retention of Sr^{90}-Y^{90} in trout after a single oral dose of 15 μc showed that the concentration of the isotope in the blood rose sharply at 3 to 12 hours to about 0.2 μc/ml and declined after 12 to 24 hours. At the fourth day the concentration in the blood was about 0.001 μc/ml. In general the increase and decline of the concentration in the liver, spleen, and kidney followed the pattern expressed in the blood. The bone showed a rapid rise for 24 hours to about 0.16 μc/g after which a much slower continued increase was observed. At the eighth day the concentration in the bone was 0.24 μc/g.

Studies to determine normal characteristics of rainbow trout blood have been initiated. To date, calcium and chloride concentrations have been found to be 5.24 ± a standard deviation of 0.06 meq/l and 140.1 ± 2.0 meq/l.

A new feeding level of 3.1 mc Sr^{90}/day was initiated in three swine. It is anticipated that these animals will expire within two or three months. With the initiation of this group we now have six feeding levels - 1, 5, 25, 125, 625 and 3,100 μc Sr^{90}/day - and a control group. From this wide range of dose levels a rather complete picture should be obtained of the clinico-pathologic effects of Sr^{90} ingestion, from minimal long-term effects at the low levels to acute changes and early death at the higher levels.

No gross changes have yet appeared in the group started on 625 μc Sr^{90}/day 70 days ago, although circulating blood examined 60 days after initiation of feeding showed a suggestion of depression of the leukocyte components. Both animals at this feeding level are pregnant and will farrow in January if gestation is normal.

Eight additional animals were injected or fed Sr^{90} or Sr^{85} for use in calibrating the whole-body monitor. These animals were monitored immediately after administration of the isotope when it was given intravenously and will be counted six times before sacrifice. Frequent monitoring as the Sr^{90} relocates within the body and analysis of the spectrum of energies detected by the crystal should result in a better understanding of Bremsstrahlung production and its attenuation within the body of the large animal. These swine were also given Ca^{45} and their skeletons will be analyzed at sacrifice to provide data relative to the retention and discrimination of strontium relative to calcium as a function of age.

A preliminary analysis of whole-body data revealed that in month-old swine Ca^{47} retention 11 days after intravenous injection was about 90 per cent as compared to 30 to 40 per cent for four-year-old animals. (Analysis of oral feeding data for Sr^{90} and Ca^{45} and intravenously administered Sr^{85} in swine of various ages is incomplete).

Iodine

Three Palouse gilts and three young ewes were fed 5 μc of I^{131} daily for one and one-half months and sacrificed for radioanalysis in order to obtain data to compare with earlier data on equilibrium concentrations of I^{131} in tissues, organs and excretions obtained in adult ewes on a similar radioiodine regimen but using different radioanalysis methods. The data obtained on young ewes compared quite favorably with the results observed earlier in adult ewes except for bile and whole blood which was higher in the young ewes by a factor of three to four. The thyroids of the young ewes had higher concentrations, as was predictable with lower age and undamaged thyroid glands. Almost all of the samples in the swine exhibited concentrations that were slightly less to less than one-tenth of similar tissues or excretions in sheep.

Thyroid sections of adult ewes maintained for up to four years following the feeding of 45 μc of I^{131} daily for twelve months and 135 μc daily were reviewed and some thyroid adenomas were found. The adenomas were minute or moderate in size. The thyroid glands showed severe fibrosis and the follicles were reduced in size.

Plutonium

Further studies with the chelating agent triethylenetetramine hexaacetic acid (TTHA), indicate a consistent but slight superiority over DTPA by removing plutonium from rats. The most promising results were those obtained with oral administration where TTHA, in a dose of 6 mM/kg, left in the animals only 8 per cent of a previously injected dose of plutonium. DTPA administered under the same conditions left 13 per cent. These results were obtained with prompt treatment and at near toxic dose levels. Further studies will be required in order to completely evaluate the potentialities of oral TTHA.

Further studies have been made employing an equal molar ratio of plutonium and DTPA. This material, when injected into rats, is mostly excreted but that which remains is deposited almost entirely in the liver. In one experiment 25 per cent of the injected dose was deposited in liver. This accounted for 90 per cent of the total plutonium retained one day after injection. Autoradiographic studies indicate that the plutonium in the liver is in the form of much larger aggregates than the plutonium in the solution injected.

Radioactive Particles

One-hundred-twenty days after exposure of rats to a Ce^{144}-Pr^{144} oxide aerosol (Mass Median Diameter = 0.6 μ) about 81 per cent of the body burden was recovered from lungs, 10 per cent from liver, 6 per cent from bone and 1 per cent from kidneys. The body burden at 120 days after exposure

accounted for 25 per cent of the total amount deposited. Seventy per cent was excreted in feces and 5 per cent in urine. The whole-body retention half-time was about 58 days for the first month after exposure and the lung retention half-time was about 37 days. A more extended study is planned using dogs.

Complete physical examinations are being completed on 25 dogs exposed to $Pu^{239}O_2$ aerosols about two years ago. Only 3 dogs show respiratory symptoms. Examination of colony dogs prior to selection for experiments indicate an unusually high incidence of abnormal formula. One dog has bilateral cataracts. Five puppies were welped and others are expected.

In one dog exposed to $Pu^{239}O_2$ last May, a gradual increase in scattered opacities in the lung field was seen radiographically. An increasing respiratory rate and a very low blood lymphocyte level confirm the development of lung lesions.

Three dogs given plutonium nitrate intravenously were sacrificed after 30 days for comparison with three dogs previously given plutonium nitrate by inhalation. In the later dogs the daily rates of excretion in urine and feces at about 30 days after exposure were 0.02 per cent and 0.2 per cent, respectively, of the body burden. The blood contained 0.0005 per cent per ml of the body burden.

Radiation Effects on Insects

Data were obtained on the reproductive cycle of the insect (Tribolium confusum) which is used for radiation effects experiments. Males are fecund at the first day of adult life; however, females are not until the sixth day.

Radiation Effects in the Regenerating Liver

Results of studies on dry weight, protein, sodium and potassium levels in the various sub-cellular fractions of the regenerating rat liver are now available for unirradiated animals. Results from the irradiated animals should be available within another month. The total picture is a complex one which can only be hinted at in this report. The dry weight/wet weight ratio decreases by 20 per cent as early as three hours after partial hepatectomy. Protein and potassium levels show a similar drop which may be explained as simple dilution. However, sodium levels do not decrease suggesting a possible influx of sodium into the tissues. At times periods subsequent to one day dry weight protein, sodium and potassium levels are increased above controls to various degrees. Significant differences in these effects are noted in certain of the sub-cellular fractions studied (nuclear fraction, mitochondrial fraction, microsomal fraction and soluble fraction), although no startling effects are noted. These data should be of considerable fundamental interest and constitute a basis for comparing effects of radiation and other environmental variables on a relatively synchronized cellular system.

Radiation Effects on Cells

The rate of decrease in mitotic activity after 400 r of X rays can be altered by pre- or post-treatment with sodium fluoride.

It has now been established that yeast cells must be grown in D_2O before a modification of radiation sensitivity is observed. It was also shown that not only is the slope of the survival curve of D_2O cells changed, but also the shape of the curve. Ordinarily the yeast used in these studies gives an exponential X-ray survival curve. However, when grown on D_2O the survival curve is sigmoidal with an extrapolation number of 1.15. This cannot be accounted for on the basis of a change in ploidy.

The previously reported effects of D_2O on phosphate uptake are in part pH dependent. Inhibition is seen at all pH levels with 99 per cent D_2O. With 50 per cent D_2O inhibition is evident only at pH levels around 9.0. Studies with cells grown for four months on D_2O media showed that both phosphate and potassium uptake is inhibited indicating that yeast cells do not become physiologically adapted to a D_2O environment.

Plant Ecology

Field plots harvested for radioassay of fallout materials in Alaska and Hanford were compared as to annual harvest yield. Harvest yields were greater per unit area in Alaska than at Hanford and produced at a rate 4 times that of Hanford. Results were compared with other kinds of short growing season ecosystems in Wyoming and Nevada.

Project Chariot

Samples of terrestrial invertebrates collected from the tundra at Cape Thompson, Alaska, last summer were sorted for community and population analyses. Samples of plants and animals were analyzed for fallout radionuclides.

HA Kornberg

Manager
BIOLOGY OPERATION

HA Kornberg:es

C. Lectures

a. Papers Presented at Meetings

L. A. George, "Biological Warfare," October 24, 1961, Richland Section, American Chemical Society Meeting.

b. Seminars (Off-Site)

None

c. Seminars (Biology)

R. C. Thompson - "A Report on the Gordon Conference on Bones and Teeth", October 3, 1961.
H. A. Kornberg - "Hanford Biology Program", October 3, 1961.

V. H. Smith - "The Oxygen Effect in Radiation Biology", October 17, 1961.

J. J. Davis - "Environmental Factors on the Accumulation of Fallout", October 17, 1961.

d. Miscellaneous

A. C. Case, October 13, 1961 - "Counting and Analysis", Health Physics Certification Examination Refresher Course.
R. C. Thompson, October 27 - "Internal Dosimetry", Health Physics Certification Examination Refresher Course.
R. H. Schiffman, October 19, "Biological effects of ionizing radiations," Carmichael Junior High School, Richland.
N. L. Dockum, October 25, "Physical and Chemical Methods for Localization of Radioisotopes in Animal Tissue," Physics and Chemistry Club, Kennewick High School.
J. J. Davis, October 27, "Some Effects of Environmental Factors upon Accumulation of World-wide Fallout in Natural Populations," Finance Group, 300 Area

J. J. Davis, October 27 - same title as above - Northwest Vector Group, Desert Inn, Richland.

D. Publications

a. HW Documents

None

b. Open Literature

None

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - OCTOBER, 1961

ORGANIZATION AND PERSONNEL

There were no changes in organization or personnel during the month.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Model

Most of the data for the forthcoming report have been checked and updated. Some investment figures are still questionable and will need refinement

Considerable warp data from NPR fuel elements were analyzed as requested. A number of hypotheses concerning warp magnitudes and direction were suggested, and were tested using these data.

An analysis was completed on test data from a test optimizing canning conditions for eight-inch I and E fuel elements. The estimated response surfaces were graphically depicted by the use of contour lines.

Consultation with the information study team continued during the month.

Consultation and instruction continued on methods of constructing, solving, and studying linear programming models of the fuels fabrication forecasting and scheduling processes.

Irradition Processing Department

Reactor Optimization Studies

A proposal to simulate reactor operations using a computer was submitted to IPD for comment and approval. This was prompted by a request to study ways and means of reducing overtime within the Department. Additional benefits to be gained from this study were pointed out.

Preliminary work was done in controlling work rates for work performed during reactor outages. First attention will be directed toward controlling charge-discharge and tube replacement rates. It is anticipated that cumulative sum charts will be employed.

Process Tube Leaks

Meeting have been held with individuals concerned with all phases of the reactor tube leak problem. A tentative program of activities to be carried on by Operation Research and Synthesis Operation personnel in support of these studies has been drawn up. This will be discussed with appropriate parties during the first part of November, and work will commence shortly thereafter.

General

Attention is being given the possibility of using a variation of cumulative sum charts on the rupture control charts in place of present methods. Simulations are being performed at the present time in order to select an appropriate mask design.

A discussion was given of the meanings and implications involved in failure rate predictions for high speed scanning systems.

Frequency distribution of the Weibull and exponential types were fitted to data on the percentage of delay times during reactor outages.

Sample size determinations were made in a problem concerned with the number of poison balls which must be tested to permit making certain tolerance statements.

Numerical assistance was given in computing probabilities of detecting cracks in welded primary piping for the NPR Project.

Chemical Processing Department

Z-Plant Information Study

Full time training and system consultation was terminated October 5, 1961. Computer capacity estimates for alternate usage in the inspection operation were provided at a meeting with R. E. Tomlinson, Manager, Research and Engineering Operation, CPD; H. Tellier and J. D. Orton, EDPO; and the sales representatives from the General Electric Company's Computer and Industry Control Departments. Consideration for permanent installation of the GE-311 computer in this area may be given depending upon the evaluation of the operational requirements and funds currently available.

The ease of system modification to accommodate the process changes experienced in the fabrication area of the Z-Plant was successfully demonstrated. The on-line computer system has been modified to accommodate process changes several times during operational periods, even in cases where no prior notification was involved. This is a commendation not only for the system, but for those personnel who have accepted the responsibility for operating, re-programming and debugging the system during the on-line demonstration period.

Machining Development

Work is continuing on means of producing magnetic tapes capable of automatically positioning and timing the Gorton lathe during a complete machining operation.

General

Assistance was given in processing data to demonstrate conformance to specifications for parts produced during the third quarter.

A review is being made of measurement requirements (frequency of sampling) relative to plutonium purity in the final product. This is being looked at both from the point of view of demonstrating conformance to specifications, and of maintaining adequate control of the process.

The completion of the generalized linear regression program provided an opportunity to make a more comprehensive analysis of the data obtained in the process tests directed toward greater dimensional stability. This program is now being used for analysis of the available data on purity of the plutonium at the button stage of the process.

A discussion with appropriate personnel indicated the use of a simple range and average control chart would be beneficial for the control of nitric acid concentration in the continuous Redox recycle stream.

An elaborate real-time information system study does not appear justified in this area. However, a survey to evaluate further this tentative decision will be performed in the near future.

Work continued on a motor pool problem for the Facilities Engineering Operation. Aspects of efficient use of present available vehicles as well as the feasibility of combining office facilities are under consideration.

Relations Operation

General

A blood count study was requested on data from approximately 500 employees who had radiation exposures in excess of one rad in 1960 and data from about 500 other employees tested in 1960 prior to their employment at HAPO. The request concerned the significance of differences in average blood counts for the two populations.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Pulse Column Test Facility

The organic inlet stream rotometer was calibrated from experimental data using a calibration function of the form previously found to fit the aqueous inlet stream rotometer data. Work continued on the calibration of the absorptiometer. One centimeter and five centimeter test cells are being calibrated for aqueous uranium solutions. The zero shift is being estimated to transform the aqueous calibration into the corresponding organic one. The mid-column photometer calibration was finished and is being programmed into the master IBM data reduction system.

Reactor Effluent Studies

Further consultation was carried out with regard to the reactor effluent problem.

General

The analysis of data from the test designed to evaluate the effects of using chronic acid in the autoclave as a corrosion inhibitor was completed.

Available uranium burnup data from fuel elements irradiated in the K loops were analyzed. Estimates were found of certain error components. In addition, an over-all estimate of the heat of fission and its associated standard deviation were found.

Assistance was given in the interpretation of some buckling data resulting from a critical mass study.

A solution has been obtained to a mathematical model devised to study the steady-state fluid flow of material from a multicompartment well in the earth. The problem is one phase of an experiment designed to obtain on-site measurements of the permeability of particular subsurface strata.

A mathematical model for the diffusion of hydrogen in a zirconium-clad uranium core fuel element has been constructed, and a formal solution obtained. Because of the complicated functional and algebraic structure of the solution, further study is needed before quantitative results can be obtained.

A brief report summarizing data from tests made on a suggested calibration curve for dose-film density relationships has been completed.

4000 Program

Swelling Studies

Further calculations are underway on pore size distribution data to obtain the relative void fraction and relative void density per cell as a function of burn-up, axial position, annealing temperature and annealing time. Another analysis was started in an attempt to unfold the empirical pore size distributions as they appear on micrographs in order to estimate the true distribution in the uranium matrix.

Nondestructive Testing

A series of meetings with representatives of Instrument Research and Development Operation resulted in an agreement to conduct an experiment designed to test the sensitivity and selectivity of an electronic nondestructive fuel element testing instrument. The design was carefully selected so that a complete mathematical solution based on standard circuit analysis theory can be obtained, compared with actual instrument data, and subjected to statistical analysis. Instrument data is in the process of being taken, and the formal mathematical solution is nearing completion.

5000 Program

Radiochemical Analysis

Work continued on the debugging of the computer program for the quantitative reduction of a set of time dependent multichannel energy spectra.

6000 Program

Environmental Studies

A linear regression was fitted to river water data collected by the Environmental Studies and Evaluation Section of Radiation Protection Operation. A letter conveying this information was sent to the interested person.

Other

Atmospheric Diffusion Studies

All the Operation Green Glow sample data were transformed from IBM cards to magnetic tape and the fitting of tentative models to selected diffusion experiment data has begun.

General

Work continued on the debugging of an IBM program to do the routine analysis of the data from reference system calibration studies.

METHODS DEVELOPMENT

Mathematical

Further work was done on the algebra of four-state devices, and an invited paper was presented at a Northwest Regional Meeting of the Society for Industrial and Applied Mathematics entitled, "A Reliability Algebra for Four-State Safety Devices". Graphs were plotted showing time-dependent probabilities of different states under several different conditions of input and output logic within the context of the above-mentioned algebra.

Numerical

Further debugging was done on NELLY, the nonlinear least squares routine discussed in Los Alamos Document LA-2367. Three of the four possible cases which arise in the course of the iterative fitting process have been successfully debugged and the fourth is almost complete. The summary output at the conclusion of a problem has been modified to include sufficient information so that the user will know in all cases exactly what the routine has been able to do with his data - whether the least squares estimation problem has been successfully completed, or if not, exactly why NELLY failed.

An interruptive package has been programmed so that all BIMD statistical routines can be used directly on the IBM 7090 without any revision from their Western Data Processing form.

Carl A. Bennett

Manager
Operations Research and Synthesis

CA Bennett:dgl

[redacted]

PROGRAMMING OPERATION

OCTOBER, 1961

I. REACTOR DEVELOPMENT - 04 PROGRAM

A. PLUTONIUM RECYCLE PROGRAM

1. Cross Section Evaluation

An effective neutron temperature must be supplied to the Westcott spectrum employed in the MELEAGER code to develop effective cross sections used. Such a temperature is supplied from other computational or experimental sources for a given isotopic makeup of the fuel; however, as burn-up proceeds, the isotopic composition changes which alters the spectrum and shifts the most probable neutron energy (i.e., the "effective neutron temperature"). In computations to date, the effective neutron temperature used in each calculation is chosen to correspond to the mid-range value of anticipated isotopic compositions. A study has been under way to develop a simple method of automatically supplying a neutron temperature computation within the MELEAGER code. The current "standard" for this phase of the study is General Atomics Spectrum Code.

It was found that many of the Spectrum runs yielded inaccurate neutron temperatures due to the spacing of the energy points. This is because the maximum of the flux curve is found by the code with a parabolic fit to the maximum three points; however, if these three points are widely separated, a parabola is a poor fit to the true flux curve. A correction was attempted by means of a series of runs with the energy points highly concentrated about the anticipated maxima. However, since there was no basis for selecting these points, it was found that there were still some discrepancies in the neutron temperatures as calculated.

For the Maxwellian portion of the flux, the flux can be represented by:

$$\phi(E) = \frac{cE}{E_o^2} e^{-\frac{E}{E_o}} \qquad (1)$$

Where:

(a) E is the neutron energy in electron volts (ev).

(b) ϕ (E) is the instantaneous differential flux at energy E which is

$$\lim_{\Delta E \longrightarrow 0} \left(\frac{d\phi}{dE}\right)(\Delta E)$$

or the limiting value (continuous) of the neutron flux, ϕ, in energy level between E and E + Δ E as Δ E $\longrightarrow$ 0. The neutron flux, ϕ, is the number of $\frac{\text{neutrons}}{\text{cm}^3}$ of a specified energy multiplied by the corresponding velocity.

(c) $E_o = kT_n$, where T_n is the effective neutron temperature in °K, and

(d) k is Boltzmann's Constant, (8.616×10^{-5} °K/ev).

(e) c is a normalization constant.

Rearranging equation (1), it is seen that:

$$\ln \frac{\phi\,(E)}{E} = -\frac{E}{E_o} + \ln \frac{c}{E_o^2} \qquad (2)$$

The next approach, then, was to plot ln $[\phi\,(E)/E]$ versus E and examine the slope, which should be - $1/E_o$, from which T_n could be ascertained. This method proved satisfactory, but somewhat laborious for studies of large scope.

Investigation was then begun to determine the feasibility of using a computer code to do this work. It was decided that a Maxwellian should be fitted to the flux points as such, rather than the linearized fit as mentioned above, in order to avoid excessively weighting the low energy points. For this purpose, the Scientific Production Library (SPL) program Generalized Least Squares Code was used. The input format to this code is different from the output of the Spectrum codes. Therefore, two short subroutines to convert the Spectrum flux output to Generalized Least Squares Code input were written. To date, the subroutine for the Generalized Least Squares Code has been compiled, and several cases have been run which are completely satisfactory.

2. PRTR

To fully exploit the versatility of the PRTR, a new basis for determining the required plutonium content in PRTR spike enriched fuels has been recommended. This new standard would allow adjustment of the plutonium concentration in a spike until a specified nuclear reactivity is achieved, rather than the current specification of a given fissile plutonium concentration. For various isotopic plutonium compositions, the latter specification does insure a constant initial heat generation in specific spike fuels provided the differences in fission cross sections of Pu-239 and Pu-241 are negligible. The MARK I PRTR plutonium-aluminum spikes covered by such a specification currently yield satisfactory reactivity and heat contributions using low exposure plutonium (LX Pu) which served as the specification basis (LX Pu is $\sim$5.3 percent Pu-240 and the balance essentially Pu-239). While PRTR critical test data show such spikes to provide adequate enrichment for reactor operation, these data also show that reducing the spike reactivity may be detrimental to the program.

The anticipated program involving high exposure plutonium (HX Pu) will not provide fully satisfactory reactivity with the current specification. This stems from the supplying of neutrons to absorption in the fertile plutonium isotope, Pu-240, whose concentration is much greater in HX Pu than in LX Pu. Ignoring Pu-242 and the variations in the Pu-239 and Pu-241 fission cross sections, plutonium used in spikes having constant initial heat generation will contribute reactivity in inverse ratio to Pu-240 isotopic content. The maintenance of constant initial reactivity (using the current LX Pu spike reactivity value as "standard") requires higher HX Pu spike plutonium concentrations than does the maintenance of constant initial heat generation rates. Typical calculated values for the existing standard[1] and the recommended standard are compared below. Notes on program effects and deviations from existing operating standards are included.

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(1) Bradley, J. G., "Pu-Al Mark I PRTR Spike Materials Standards", September 27, 1960, HW-66871.

PLUTONIUM REQUIREMENT FOR PRTR MARK I PU-AL SPIKES

Nominal Wt. % Pu-240	Present Standard(a)				Recommended Standard(b)			
	Total	Fissile	$\eta \times f$	Heat kw	Total	Fissile	$\eta \times f$	Heat kw
5.3	260	246	1.550	920	260	246	1.550	920
16.5	295	246	1.494	920	378	315	1.550	1160
20.2	309	246	1.476	920	430	342	1.550	1260
23.1	322	246	1.464	920	480	366	1.550	1350

Notes

General: Nineteen rod cluster assemblies have an 88-inch long active length with about 5170 cm^3 volume. "PRTR Engineering Data"(2) are used for cell geometry and flux ratio relationships in reactivity calculation. Heat generation rates are initial values for $\phi = 5 \times 10^{13}$ cm^{-2}, sec^{-1}, with T = 130 C and $\gamma = 0.08$.

(a) Constant initial fissile concentration. No operating standard(3) maximum values are exceeded.

(b) Constant initial reactivity contribution. Operating standard(3) maximum values exceeded include:

1. 330 g plutonium per spike assembly.
2. 14 kg plutonium per PRTR spike loading within the 42 maximum spikes per PRTR total core loading allowed.
3. 1200 kw, maximum, per fuel channel.

In order to permit flexibility of operation; along with the more appropriate reactivity to be attained under the recommended standard, suggested revisions to operating standards follow. (Revision of our present license (Final Safeguards Analysis) will be required.)

1. Change 330 g plutonium per spike to 400 g fissionable plutonium isotopic content per spike.
2. Change 14 kg plutonium per PRTR spike loading to 16.8 kg fissionable plutonium per PRTR spike loading.
3. Change 1200 kw per fuel channel to 1500 kw per fuel channel.

(2) "PRTR Engineering Data" by J. C. Fox, November 18, 1959.

(3) "PRTR Final Safeguards Analysis" by REDO Staff, October 1, 1959, (Table V, Page 128), HW-61236.

3. Zoned Spectrum Reactor

As a result of renewed AEC interest, computations are being made of the reactivity limited lifetime of plutonium fuels in an HLO reactor concept having different amounts of moderator in various zones to allow absorption of excess neutrons in fertile fuel rather than in control systems. In this sense, such reactors are similar to the Edlund Spectral Shift Reactor under study by the Babcock and Wilcox Company, wherein the H_2O is introduced in D_2O to adjust the moderating power. Preliminary estimates based on calculations with the MELEAGER code indicate that this technique may improve the reactivity limited fuel lifetime by from 50 to 100 percent over conventional batch cycle techniques. This theoretical gain is essentially the same as that achieved by the continuous or "graded" cycles in which the "freshest" fuel is put in appropriate proximity of the highest irradiated fuel and thereby the excess reactivity of the new fuel prolongs the exposure of the highest irradiated fuel. Both of these methods involve physical shifting of the fuel to attain the same theoretical reactivity lifetime value. The newer zoned spectrum method may have many overriding practical advantages involved with uniformity of power generation in a reactor and batching of fuel through processing plants. As a consequence of such factors, the appropriate codes are being altered so as to permit investigation of the relative economics of these approaches.

The following preliminary results are for a reactor resembling the APWR as described in TID-8502 except, of course, for the changes in amounts of light water moderator in separate zones in the reactor. An exact solution of the problem is probably beyond the present MELEAGER code due to problems associated with flux peaking in the moderator and to interaction between zones. However, the following numbers do appear valid to the extent that substantial increases in fuel exposure can be attained using the zoned moderator concept.

ATTAINABLE REACTIVITY LIMITED FUEL LIFETIMES FOR A 3% U-235 ENRICHED FUEL - PHYSICS CONSTANTS APPROXIMATING THE APWR STUDY

($\triangle$ k = 1.145 - 1.045 = 100 mk)

	No. of Zones	Fuel Exposure MWD/T
A - Ideal case, no account taken of increased absorption cross section as moderator is added, no flux peaking.	3	23,500
	4	~26,000
B - Absorption cross section increased as moderator (light water) increased. No flux peaking.	3	~19,000
C - Absorption cross section increased as moderator (light water) increased. Thermal flux in moderator assumed twice that in fuel.	3	~16,000

The batch discharged fuel exposure calculated for the APWR (base case with no zoning) is about 13,500 MWD/T and ~ 27,000 MWD/T graded. The delta k for the batch discharged base case is 1.212 - 1.045 = 167 mk, but this can probably be reduced to about a 100 mk if one employs burnable poisons.

It appears that the penalty for flux weighting used in case (C) above is too extreme, and that the true situation for light water is more nearly like (B) above. Also if moderators with lower absorption cross sections than light water are employed, the calculated exposures should lie between cases (A) and (B) above.

A set of calculations are also available with identical parameters to those previously shown except that the fuel is composed of uranium-238 and two atom percent plutonium-239.

ATTAINABLE REACTIVITY LIMITED FUEL LIFETIMES TWO ATOM PERCENT PLUTONIUM ENRICHED URANIUM-238

		No. of Zones	Fuel Exposure MWD/T
A -	Same as 3% U-235 case shown above.	3	12,900
		4	15,250
		5	16,850
B -		3	12,400
		4	~13,300
C -		2	9,000
		3	~11,500

The batch discharged base plutonium case (no zoning) is calculated to give an exposure of 7500 MWD/T.

Calculations made with an increased number of zones show a slight increase in attainable exposure. For cases where delta k was allowed to drop only by 35 mk (1.080 - 1.045) before a change was made in moderator ratio, the three percent U-235 case gave an exposure of 27,025 MWD/T while the two percent plutonium case had an exposure of 18,350, both numbers corresponding to the conditions of (A) in the tables above.

4. Salt Cycle Reprocessing Economics

Work continued on the computer program to evaluate economic merits of the Salt Cycle reprocessing for Plutonium Recycle fuels. Considerable difficulty was experienced in getting the base flowsheet (Conventional Solvent Extraction) program to operate properly and a major revision of program logic was necessary. At month's end this portion of the program appeared to be working satisfactorily.

B. SPECIFIC FUEL CYCLE ANALYSIS

Preparations were made for writing and issuing a series of five formal reports on the fuel cycle analysis work done on a crash basis at the Division of Reactor Development request, and informally reported during August and September, 1961. Additional computations in behalf of these reports are being held to the planned iteration of the successive plutonium recycle steps employing the CHAIN MELEAGER code.

Fuel element fabrication cost calculated using a model fuel fabrication plant have been made with the FEFJ portion of the RIGOROUS ECONOMIC code. Due to the restrictions which the code places on the plant operation, agreement with hand calculations of only ten percent was reached. Most of the difficulty stems from the fact that zirconium makes up two-thirds of the total cost. The code was designed assuming the cost for jacketing materials would be less than this compared with labor and machining costs; thus, the code does not handle zirconium scrap or parallel line of manufacturing processes without special innovations. Code revisions are being recommended.

The preparation of the set of uranium price schedules requested by the Division of Reactor Development was begun. This request necessitated some changes to the uranium cascade computer code and these modifications are currently being made. The computations are scheduled to be finished by November 22. Price schedules will be calculated for all combinations of 25 values for the cost of the feed material and 29 values for the cost of separative

duty. These values are determined by varying the cost of feed from 50 to 170 percent of the present cost ($23.50 per kilogram) and varying the cost of separative duty from 30 to 170 percent of the present cost ($37.29 per kilogram) in five percent increments. These amount to roughly three times the number of schedules prepared for the Division of Reactor Development in April (725 as compared to 256). In addition, each schedule will have about twice as many enrichments computed for it.

Improvement in the precision of the computation codes and of communication with the codes is continually being made. Currently an extended effort is being made to bring the codes to a practical balance of technical excellence and practical usability. Many alterations are under way and a selected few follow as a matter of general interest.

The QUICK economics code has over the past year, had many additions to the main program. Every time one is made, it requires costly assembly of the entire main program on the computer. To avoid this, the main program is being split into many smaller units which are relatively inexpensive to assemble. The CHAIN MELEAGER code was revised to handle thorium fuels as well as any variation in U-238 or thorium density desired.

Modifications to the PROTEUS code were completed, but work on the accuracy check is still in progress. (PROTEUS expands upon basic fuel burnup data developed by the more costly MELEAGER code.) The modifications include:

1. A merge routine that will allow "fill-in" MELEAGER runs to replace and/or to supplement previously calculated data.

2. An error checking routine that will calculate the error in the polynomial curve fits of the most important concentration in each case. The program will print out a warning message if the average error, based on the maximum concentration, exceeds three percent.

3. A device whereby certain selected cases can be calculated from a data tape reel which may contain 20 to 50 cases. This will allow cases with error messages to be recalculated without redoing the entire set of cases.

An investigation into the effect of the number of data points supplied PROTEUS on the accuracy of the polynomial fits was initiated. The procedure is to calculate a case using every data point supplied, every other point, every third point, etc. In all of these, the first ten points were always used, however. Work to date indicates that about 25 points are the optimum number.

For example, the U-235 concentration calculation error for a specific case is shown for different numbers of time steps used:

Percent of Data Points Used	Number of Time Steps Skipped For Each Step Used	Total Number of Time Steps Available	Number of Time Steps Used	Percent Error Based On Initial U-235 Concentration
100	0	46	46	10.2
61	1	46	28	0.2
47	2	46	22	1.5
41	3	46	19	3.5

II. OTHER ACTIVITIES

1. Mercury Isotopes

The first rough draft of the mercury-204 report is completed. Of the computations completed to round out the study, the following one is of special interest.

Computations show that the reactivity change upon mercury-204 boil out in a representative lattice using rigid fuel elements will be in the range of .008 to .014 delta K.

A cylindrical fuel element was assumed with the following dimensions.

Region	Composition	Outside Radius of Region, cm
1	Mercury-204	0.636
2	Stainless Steel	0.700
3	UO_2-U-235 Enriched	1.500
4	Stainless Steel	1.563
5	Graphite	(Varies with SDPV)*

$$* \text{ SDPV} = \xi \Sigma_s \frac{\text{Moderator Volume}}{\text{Fuel Volume}}$$

ξ = Logarithmic Energy Decrement

Σ_s = Thermal Scattering Cross Section of the Moderator

For an SDPV = 1, the following results were obtained.

U-235 Enrichment = 6 Percent

Density of Mercury-204 in Coolant Channel %		K_∞	
100	(No Boiling)	1.11350	
88.8		1.11448	
77.7		1.11546	
66.5	(One-third Voids)	1.11643	
55.3		1.11739	
44.1		1.11836	
33.0	(Two-third Voids)	1.11931	
21.78		1.12026	
10.61		1.12121	
0.00	(Dry Tube)	1.122	(Extrapolated)

It will be noted that the reactivity increases as mercury-204 boils out. This constitutes the major problem (aside from mercury-204 cost) in application of boiling mercury cooling in thermal reactors. Several innovations to eliminate this characteristic are treated in the document of which the following are representative.

A negative reactivity coefficient can be obtained by the placement of an extremely small rod (0.1 cm radius) of high thermal neutron absorption cross section in the center of the coolant region of the above element.

Example - Case B-121

SDPV = 2

UO_2 Fuel - Four Percent U-235 Enriched

Density of Mercury-204 in Coolant Channel %		K_∞
100	(No boiling)	1.25562
90		1.25503
50	(50 Percent Voids)	1.25183
30		1.24950
10	(90 Percent Voids)	1.24559

Analysis also showed that at certain SDPV's a slurry fuel can have a negative reactivity coefficient for a decrease in spatial density of the slurry region. The analysis appears sound.

2. Radioactive Heat Sources

The final report, HW-71319, "Availability and Applications for Thorium-230 (Ionium) from the Uranium Ore Milling Industry in the United States," was completed and distributed. In this document the following significant details were developed:

a. The availability of thorium-230 has been extended even further by the results of additional laboratory analyses of uranium ore mill feeds.

b. The St. Louis airport residues are shown to be rich sources of valuable elements such as nickel, cobalt, and particularly selenium as well as thorium-230 (200 + kg).

c. Under certain and reasonable conditions, neutrons for various target irradiations should be available from low enrichment power reactors at about $4,000 per gram. This indicates that the neutron cost for the manufacture of special radioisotopes such as Pa-231 should be about $17 per gram of such isotopes, a cost substantially below other costs involved in the preparation of such materials.

d. Protactinium may be most economically produced in power reactors such as Indian Point, Elk River, and Dresden concurrently with the exposure of thorium containing a few percent of thorium-230. Such a procedure could result in uranium-232 production at one-half the cost which had been assumed in earlier studies.

e. Based on economics, uranium-232 (and thorium-228) via such methods continue to appear highly favorable materials for application as radioisotopic power producers and could logically compete with alternate materials such as strontium-90, plutonium-238, cesium-137, promethium-147, and curium-242.

f. If it is assumed that thorium containing two percent thorium-230 can be obtained for $20 per gram of thorium-230 for use as a target for special radioisotope preparation (protactinium-231), five percent material may be worth about $27 per gram but material 0.7 percent and less is of only marginal value.

3. Hazards Analyses

Activities this month continued on the evaluation of radiological consequences of various types of accidents associated with the NPR and the shipment of radioactive materials, particularly cerium-144 and plutonium. Draft report number 3 of the Federal Radiation Council, "Background Material for the Development of Radiation Standards for Uranium Mining," was reviewed and comments provided to interested persons. Comments were provided to the AEC Fallout Studies Branch on suggestions for topics of discussion at a forthcoming conference on radioiodine.

for Manager,
Programming

WK Woods:EAE:jm

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF OCTOBER 1961

A. ORGANIZATION AND PERSONNEL

Lawrence B. Priest was transferred from Internal Dosimetry to Reactor and Fuels Research and Development Operation on October 2. Adella B. Rouse transferred to Technical Administration Operation from External Dosimetry on October 16. Maurine M. Murphy was transferred from External Dosimetry to Chemical Research and Development Operation on October 27. Transfers within the Radiation Protection Operation included: Phil C. Friend transferring from Radiation Monitoring to Radiological Development and Calibrations on October 16; W. Mickey O'Bryan transferring from Environmental Studies and Evaluation to Radiation Monitoring on October 16; and Charles A. McCoy transferring from Radiation Monitoring to Environmental Studies and Evaluation on October 16. The work force now totals 132.

B. ACTIVITIES

Occupational Exposure Experience

There was one case of plutonium deposition confirmed by bioassay analyses during the month. The total number of plutonium deposition cases that have occurred at Hanford is 272, of which 197 are currently employed.

Regular processing and evaluation of the film badge dosimeters for a reactor maintenance employee and a 100 Area construction laborer indicated whole body doses of 1.4 r and 2.1 r, respectively, which exceeded the operational control limit of 1 rem in a four-week period. A review of the activities of the maintenance employee showed work assignments in four reactor areas during the period that the exposure occurred. Analysis of the work performed, with regard to the exposures received by fellow employees on the same assignments, did not provide a satisfactory explanation for the exposure. Similarly, analysis of the work activities of the construction worker also failed to describe the conditions of exposure. No relationship between the two exposures was apparent although both individuals worked in the 100 K Area on corresponding dates during this period. Previous accumulated dose for the calendar year for the construction employee was nominal. The accumulated penetrating dose for the calendar year for the maintenance employee, including the incident described, is 3.4 r.

A review of unplanned whole body radiation exposures in excess of the local control limit of 1 r in four weeks indicated that six incidents involving eight individuals who received doses in excess of 1 r have occurred in 1961. Five of these exposures were detected through routine processing and evaluation of their film badge dosimeters. This frequency is higher than previous years.

Regular processing and evaluation of the finger ring film dosimeters worn by an HLO technician while working at the 231 Building indicated a hand dose

of about 8 rems. Investigation did not provide a specific reason for the unusual exposure although his work assignments for the period had involved the handling of unusual quantities of material.

Minor injuries incurred by two CPD employees were examined for plutonium contamination in the Whole Body Counter. Detectable plutonium contamination was observed in one instance. A process operator at the 234-5 Building suffered a minor finger laceration while machining plutonium metal. Initial examination revealed 4×10^{-3} μc of plutonium which was reduced to 2×10^{-3} μc by medical excision. Bioassay sampling was scheduled.

Radiation monitoring was supplied for Physical Testing Operation during radiography work at HUICO Facilities, Big Pasco. The work involved use of X-ray equipment at an off-site work location, with non-HAPO employees in the general area. The work was completed without incident.

Failure to return irradiated samples to their storage cave during the course of off-shift work in the 326 Building caused dose rates to 100 mr/hour to exist in adjoining rooms over a week end period. The maximum dose to personnel was 60 mr received by a casual overtime office worker in the room directly overhead.

Monitoring activities at PRTR were largely associated with scheduled shutdown work involving maintenance, leak checking, and fuel and tube inspection. Average dose rates during fuel and tube inspection were 50 mr/hour with radiation beams up to 38 r/hour. Noble gas daughters activity reached a maximum of 1.1×10^{-5} μc/cc in B cell during an operating period. Metallic foreign objects removed from C cell sump and a jumper had corrected surface dose rates of 32 rads/hour and 60 rads/hour, respectively. Tritium concentrations in heavy water systems at the PRTR were 253 μc/ml in the moderator, 38 μc/ml in the primary coolant, and 205 μc/ml in the reflector system. The maximum bioassay sample in PRTR employees showed 7.2 μc T/l corresponding to a whole body dose of 50 mrem in the following 28 days.

Burial ground no. 6, the proposed site for the Fuel Recycle Pilot Plant (FRPP), was opened by digging trenches through the burial ground to determine the depth of the burial ground and level of contamination contained. Scrap metal contaminated to a few mr/hour was uncovered. The depth of the burial ground appears to be about eight feet. These studies indicate that it would be reasonable to move burial ground no. 6 again and construct the FRPP in this general area. Other discussions relating to the FRPP desigr have centered around shielding calculations and the radioactive material inventories upon which they are based. A number of work locations in the FRPP require further analysis to determine that the shielding provided will meet the design criteria set forth in the Hanford document HW-68954, Rev. 1, "Radiological Design Criteria for the Fuel Recycle Pilot Plant".

A modest program to measure any trends in the uptake of cesium-137 in humans was initiated at the request of the Division of Biology and Medicine. Five persons will be examined in the Whole Body Counter on a weekly basis for an indefinite period of time.

Environmental Experience

A release of particulate radioactive material from an open diversion box (151-A) near the Purex facility contaminated ground and building surfaces in the exclusion area. Standard procedures were used to fix the ground contamination. Particulate contamination of several vehicles in and near the area was readily removed. Environmental surveys detected contamination from the incident in a narrow strip southeast of Purex to the Columbia River at a point a few miles north of the 300 Area. No contamination was detected beyond the plant perimeter. The thermally hot and highly contaminated condition of this diversion box results in a high likelihood of spread of particulates each time the box is opened.

Analytical results from air filters and rain, and gamma dose rates three feet above the ground were reported to AEC-HOO on a daily to weekly frequency. Maximum amounts observed in the Tri-City area during the month were: 16 $\mu\mu c/m^3$ of air, 16 $\mu\mu c$/ml rain water, and 550 $\mu\mu c$ I^{131}/l of milk.

Approximately 100 contacts with fishermen were made by personnel of the State Game Department during the month. With the advent of hunting season, a survey of the duck and goose bag of local hunters was initiated by the Game Department. A special form was supplied to game protectors for this survey.

A total of 85 fish comprising ten species, predominantly whitefish, suckers, chiselmouth, and squawfish was obtained from routine sampling locations at Priest Rapids, Hanford, Richland, and Burbank. Ninety-eight tissue samples from these fish were prepared and submitted for radiochemical analysis. Forty-seven ducks comprising seven species, predominantly mallards, mergansers, and coots were taken from three sampling locations within the Hanford reservation. Eighty-five tissue samples from these ducks were prepared and submitted for radiochemical analysis. A total of 671 duck heads and 51 goose heads was received for analysis from Southeastern Washington hunters during the month.

No routine background aerial survey flights were made during the month.

Forty-three routine and eight special produce samples were obtained for radiochemical analysis. Routine samples consisted of milk and pasture grass from the Ringold, Riverview, and Benton City areas; ten sets of bovine thyroids; and three samples of Willapa Bay oysters. Special samples consisted of two samples of commercial ground beef and six samples of commercial milk.

Sharp increases in the iodine-131 concentrations in milk and pasture grass were detected during the month. Commercial milk samples produced in Western Washington and purchased locally indicated iodine-131 concentrations as high as 840 $\mu\mu c$/l. Iodine-131 concentrations in milk produced by locally pastured cows reached 550 $\mu\mu c$/l. These increases are apparently attributable to weapons debris from atmospheric testing, and are similar to measurements found in other areas receiving fallout of weapons debris.

The second official Memorandum by the Federal Radiation Council (FRC) for radiation protection guidance of Federal agencies was published in September

and received early in October. The principal effect on Hanford will be an orderly reduction in the amount of iodine-131 released to the atmosphere. Plans were made for improvement of iodine-131 measurement techniques and for reduction of the local control limit. The present limit restricts release of iodine-131 to the atmosphere to 10 curies per week. Preliminary steps were taken to reduce this control limit to 2 curies per week averaged over a year's period.

Studies and Improvements

Progress was made on the completion of several emergency procedures including the Columbia River Emergency Plan, the Emergency Plan for a Critical Radiation Event, and the Emergency Procedures for the Region 8 Off-site Monitoring Team. The procedures for routine checking and replacement of the dose rate meters and self-reading dosimeters in emergency monitoring kits were completed. Five emergency kits were distributed to field locations with instructions to Radiation Monitoring personnel.

Two high-level dose rate meters, a supply of high-level self-reading dosimeters and charging equipment were installed in the 703 Emergency Relocation Center. Other supplies added to the 703 ERC included two copies of architectural drawings of process facilities at Hanford and additional road maps for Washington and Northern Oregon. Road maps identical to those in the 703 ERC were issued to the Environmental Monitoring Operation for use in radio-equipped vehicles.

Investigation of the dispersion of effluent from PRTR into the Columbia River continued with the use of dye. The test carried out on October 24, confirmed observations of the previous test made during August that the effluent follows the Plant side of the river in a relatively narrow plume to the northern part of Richland. Analysis of samples indicate, however, that assumed dilution factors used in calculations for the radionuclide concentration in the effluent which should trigger full containment of PRTR were very conservative.

The control limits for release of strontium-90 to the atmosphere from the Hot Semiworks are being reviewed in view of the plans for operation of this facility.

Initial fission product inventories were computed for the Redox and Purex plants to be used in the hazard analysis work for the Chemical Processing Department. The inventory to be used for the hazard analysis of NPR was also computed.

Preliminary arrangements were made with Chemical Effluents Technology and Facilities Engineering for a joint comprehensive study of liquid waste handling facilities and practices in the 300 Area.

Debugging of the automatic densitometer continued throughout the month. Improvements were made in the detector head to provide closer tolerance in film positioning. The lead tape perforations for payroll identification were enlarged to provide improved payroll reading ability of the automatic densitometer.

Calibration of the glass fluorod dosimeter contained in the new personnel film dosimeter was studied for doses up to 10,000 rads. Energy dependence data

was obtained for 16, 78, and 100 Kev X-rays. Response of the fluorods was effectively flattened by the 0.02 inch tantalum tube shield. The dose due to gamma photons with energies greater than 100 Kev can be obtained directly from the tantalum shielded fluorod and the calibration curve. An estimate of dose due to gamma photons with energies less than 100 Kev can be obtained by observing the difference between the responses from the tantalum shielded fluorod and the unshielded fluorod.

A mechanized system for X-ray coding special non-routine personnel dosimeters was designed and fabricated.

The response of the moderator foil criticality dosimeter was calculated for several energy spectra. In each case, the dosimeter response was found to be ±15% of the actual assumed dose. Neutron spectra from Godiva II, PuF_4, U^{235} fission, PoB, RaBe, and PoBe were considered in the calculations. The average neutron energy for these various spectra ranged from 1 Mev for the Godiva II spectra to about 4.5 Mev for the PoBe neutron spectra.

A precision current generator with an absolute accuracy of 0.02% was obtained and used in further studies of the silicon diode neutron dosimeters. The 0.075 inch and 0.065 inch silicon diodes were exposed to monoenergetic neutrons at energies varying from 0.459 Mev to 17 Mev. Forward resistance changes for a given neutron dose within this energy range were observed to be essentially equal. The response of the dosimeter to the monoenergetic neutron dose was generally lower than that observed using neutron sources with wide energy spectra. This would seem to indicate that the silicon diode dosimeters have increased sensitivity to neutrons of lesser energies. Further studies of the response at lower energies will be required to fully describe the performance characteristics. A study of the annealing of neutron damage to a set of five silicon diode dosimeters indicated a decrease of 0.3% during a two-week period. This nominal decrease indicates that annealing of neutron damage will not be a problem in the practical field use of these dosimeters.

The performance of a new model BF_3 neutron survey meter was investigated with a semi-spherical moderator and a small 0.250 x 1.25 inch BF_3 tube. The general shape of the dosimeter moderator is that of a 9 inch sphere weighing approximately 12 pounds when fabricated of polyethylene. The angular dependence of the assembly was demonstrated to be within ±6%. The dosimeter to fluxmeter ratios observed with this moderator and the BF_3 tube are in good agreement with values established by Dr. DePangher in his original work with the larger double moderator system. A factor of 50 reduction in sensitivity was obtained with this instrument. Full scale readings of 4, 40, and 400 mrem/hour for slow neutrons and 120, 1200 and 12,000 mrem/hour for fast neutrons were attained. The operating voltages of the small BF_3 tubes have been adjusted so that the larger, currently used BF_3 tubes may be used for increased sensitivity as required.

The use of closed circuit television equipment with conventional microscopes for reading neutron tracks in NTA film was investigated. A television camera and a 600 lines per inch monitor were obtained on a loan basis for investigating the feasibility of this system. Favorable results were obtained in track counting for both proton recoil tracks and alpha tracks.

C. VISITS AND VISITORS

The following visitors met with various members of the Radiation Protection Staff during the month:

Mr. Koenig)
Mr. Davidson) - General Services Administration, Seattle Regional Office
Mr. Logan)

O. J. DuTemple - Executive Secretary, American Nuclear Society, Chicago

D. Harward - U. S. Public Health Service, San Francisco

Dr. A. C. Anderson)
Dr. M. Goldman) - University of California
Dr. R. H. Della Rosa)
Dr. G. N. Taylor - University of Utah

F. E. Kruesi) - Savannah River, Aiken, South Carolina
W. M. Olliff)

W. F. Marlow - AEC, Fallout Studies Branch, Division of Biology and Medicine, Washington, D. C.

Kazuhiko Imai - Brookhaven National Laboratory, Meteorological Division

Members of the Radiation Protection Operation visiting off-site during the month included:

H. V. Larson - Lawrence Radiation Laboratory, University of California, to attend an information exchange on neutron monitoring.

R. F. Foster - IAEA, Vienna, Austria, to participate on the IAEA Panel on Radioactive Waste Disposal to Fresh Waters.
- Windscale and Calder Works, England, for discussions on environmental monitoring studies.
- Pacific Northwest Pollution Control Association, Tacoma, to attend meetings and chairman a session on Industrial Wastes.

F. L. Rising - University of Washington, Seattle, to make radiation measurements.

F. Swanberg - Argonne National Laboratory, to attend 7th Annual Meeting of Bioassay and Analytical Chemistry.

A. R. Keene - Oak Ridge National Laboratory, to attend Annual Information Meeting of Health Physics Division.
- Oak Ridge, Tennessee, to attend meeting of Board of Directors of Health Physics Society.

D. RELATIONS

Ten suggestions were submitted by the personnel of the Radiation Protection Operation during the month; thus, the total submitted in 1961 stands at forty-four. Two suggestions were adopted and one was rejected. Twelve suggestions submitted by RPO personnel are pending evaluation.

There were three medical treatment injuries during the month for a frequency of 1.41. No security violations occurred during the month of October.

Leo F. Kocher was licensed as a professional engineer in Mechanical Engineering in the State of Washington on October 2.

The first of three seminars on the "Consequences of Release of Radioactive Materials to the Atmosphere" was presented by E. C. Watson.

G. E. Backman presented a talk to the Kiwanis Club of Dayton, Washington, on the "Hanford Radiation Protection Program".

A. J. Stevens attended a meeting of the Kennewick City Council regarding Civil Defense matters to answer questions regarding fallout.

A two-hour lecture on basic principles of radiation terminology and measurement was presented to thirty-five members of the National Guard at Walla Walla by D. N. Brady.

Radiation protection orientation included lectures to Biology Research personnel, 300 Area Electricians, personnel at PCTR and PRTR, and Physical Metallurgy Operation personnel.

A "safety monitor" program was established for the five Radiation Monitoring offices in the 300 Area. Safety and housekeeping inspections were made in the 3705 Building, as well as the buildings assigned to the Radiation Monitoring Operation. Safety meetings were held throughout the Operation and one safety suggestion award was presented.

E. SIGNIFICANT REPORTS

HW-68082 - "Radiological Background Studies of the Plutonium Recycle Test Reactor Site, August-October, 1960", by L. D. Williams.

HW-69368 - "A Compilation of Basic Data Relating to the Columbia River, Sections 0 through 6.2", edited by R. F. Foster.

HW-71133 - "Film Capabilities for High Level Dose Evaluation", by R. H. Wilson and H. V. Larson.

HW-71203 - "Evaluation of Radiological Conditions in the Vicinity of Hanford, July-September, 1961", by Environmental Studies and Evaluation Staff.

HW-71329 - "Analysis of Radiological Data for the Month of September, 1961", by R. F. Foster.

HW-71555 - "Monthly Report - October, 1961, Radiation Monitoring Operation", by A. J. Stevens.

"High Level Radiation Dose Evaluation Methods and Procedures", by R. H. Wilson.

PERSONNEL DOSIMETRY AND RADIOLOGICAL RECORDS

External Exposures Above Permissible Limits

	Oct.	1961 to Date
Whole Body Penetrating	0	0
Whole Body Skin	0	1
Extremity	0	0

Hanford Pocket Dosimeters

Dosimeters Processed	2,970	39,720
Paired Results - 100-280 mr	14	406
Paired Results - Over 280 mr	0	20
Lost Results	0	0

Hanford Beta-Gamma Film Badge Dosimeters

Film Processed	10,364	102,463
Results - 100-300 mrads	1,015	9,522
Results - 300-500 mrads	139	1,293
Results - Over 500 mrads	23	237
Lost Results	26	307
Average Dose Per Film Packet - mrad (ow)	9.82	8.48
- mr (s)	22.39	22.69

Hanford Neutron Film Badge Dosimeters

Slow Neutron

Film Processed	2,397	14,763
Results - 50 -100 mrem	1	1
Results - 100-300 mrem	0	0
Results - Over 300 mrem	0	0
Lost Results	13	76

Fast Neutron

Film Processed	781	3,788
Results - 50-100 mrem	3	371
Results - 100-300 mrem	6	124
Results - Over 300 mrem	0	0
Lost Results	13	76

Hand Checks

Checks Taken - Alpha	29,744	330,474
- Beta-gamma	21,928	480,180

Skin Contamination

Plutonium	31	305
Fission Products	40	466
Uranium	0	46
Tritium	0	20

Whole Body Counter	Male	Female	Oct.	1961 to Date
GE Employees				
Routine	54	1	55	564
Special	2	0	2	59
Terminal	11	4	15	97
Non-employees	2	0	2	70
Pre-employment	0	0	0	38
	69	5	74	828

Bioassay

Confirmed Plutonium Deposition Cases	1	9*
Plutonium - Samples Assayed	267	5,044
- Results Above 2.2 x 10^{-8} µcPu/Sample	2	125
Fission Products - Samples Assayed	179	5,580
- Results Above 3.1 x 10^{-5} µc FP/Sample	0	14
Uranium - Samples Assayed	100	2,365
Biological - Samples Assayed	0	196

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples	Following Period of No. Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples
Fuels Preparation	18.2	3.3	37	4.4	1.9	23
Fuels Preparation**	0	0	0	0	0	0
Hanford Laboratories	5.3	2.3	19	18.6	3.2	21
Hanford Laboratories**	0	0	0	0	0	0
Chemical Processing	0	0	0	0	0	0
Chemical Processing**	0	0	0	0	0	0
Special Incidents	0	0	0	0	0	0
Random	0	0	0	0	0	0

Tritium Samples	Maximum	Average	Count	Oct. Total
Urine Samples				
Routine	5.1 µc/l	2.29 µc/l	54	
Samples Above 5.0 µc/l	13.0 µc/l	5.8 µc/l	20	
				74
D_2O Samples				
Moderator	732.5 µc/ml	294.1 µc/ml	10	
Primary	63.94 µc/ml	39.69 µc/ml	12	
Reflector	254.3 µc/ml	182.62 µc/ml	10	
				32
Water Samples	187.52 µc/ml	29.99 µc/ml	169	169

* The total number of plutonium deposition cases which have occurred at Hanford is now 272, of which 197 are currently employed.

** Samples taken prior to and after a specific job during work week.

Calibrations

	Number of Units Calibrated Oct.	1961 to Date
Portable Instruments		
CP Meter	940	9,173
Juno	248	2,470
GM	527	5,272
Other	179	1,667
Audits	103	1,037
	1,997	19,619
Personnel Meters		
Badge Film	1,620	13,809
Pencils	0	7,174
Other	329	3,450
	1,949	24,433
Miscellaneous Special Services	1,317	8,787
Total Number of Calibrations	5,263	52,839

Manager,
RADIATION PROTECTION

AR Keene:ljw

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - OCTOBER, 1961

GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 3.32 for the month and 2.92 for the year-to-date.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 21,872 hours. This includes 17,738 hours performed in the Technical Shops, 3,519 hours assigned to Minor Construction, 93 hours assigned to other project shops and 522 hours assigned to off-site vendors. Total shop backlog is 20,605 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 4.8 per cent (894 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	4,247	19.43%
Irradiation Processing Department	1,798	8.22%
Chemical Processing Department	635	2.90%
Hanford Laboratories Operation	15,178	69.39%
Construction Engineering & Utilities Operation	14	.06%

Requests for emergency service increased slightly requiring a 4.8% overtime ratio compared to a 3.7% ratio for the previous period.

At the close of the reporting period, there were four open requisitions for Machinists. Qualified candidates have been interviewed and are in process.

There were seven medical treatment injuries which is within the forecasted parameters established for this Operation.

CONSTRUCTION OPERATION

There were 62 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $152,230. Ninety new orders, 4 supplements and adjustments for underruns amounted to $100,736. Expenditures during the month on HLO work were $94,326. Total J. A. Jones backlog at month's end was $158,640.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	61	$ 149,496	1	$ 2,734
Issued during the month (Inc.Sup.& Adj.)	94	94,036		6,700
J.A. Jones Expenditures during month (Inc. C.O. Costs)		86,346		7,980
Balance at month's end	83	157,186	1	1,454
Orders closed during month	68	42,100	-	--

Current Maintenance Work Orders - 9 Face Value - $15,562.

Work on clearing of exceptions on Project CGH-834 - 189-D Building are nearing completion. The high pressure compressor 4th stage check valve and two instrument air cylinder valves were received and installed. All known punch list work except a safety valve on the downstream side of the 5,000 psi filter have been completed.

Two acceptance tests remain to be performed and the bleed heat exchanger alteration will have to be done. The heat exchanger vendor representative is here to give a decision on how to prevent baffle leakage.

FACILITIES ENGINEERING OPERATION

Project Activity

At month's end Facilities Engineering Operation was representing the Company on 15 projects having total authorized funds in the amount of $2,892,600. The total estimated cost of these projects is $7,787,000. Expenditures on these projects through September 30, 1961 were $623,000.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end 15

Number of new projects authorized in October 1
CAH-922 - Burst Test Facility for Irradiated Zr Tubes

Projects completed in October 1
CAH-901 - Structural Materials Irradiated Test Equipment - ETR

New project proposals submitted to AEC in October 1
CAH-932 - 300 Area Retention Waste Expansion System (Resubmitted)

New projects awaiting AEC approval: 3
CGH-918 - Second Whole Body Counter Facility
CAH-917 - Field Service Center
CAH-932 - 300 Area Retention Waste Expansion System

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	
"Split-Half" Machine for Critical Mass Studies	Design is essentially complete.
10KW Tube Dryer - 314 Building	Installation is 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 and all systems including criticality annunciator will be centrally monitored.
Monorail Trolley - 326 Building	New insulated electrical conductors being installed on trolley as a safety precaution will be completed during November.
Power Transfer Switch - 306 Building	A new switch is being installed for transferring electrical loads during emergency power periods.
Rezoning of "B" System - 325 Building	Work of adding five separately controlled zones will be completed during November.
Room Air Conditioner - Room 21-A 326 Building	Equipment is on order. Duct work will start during November.
Room Air Conditioner - Room 10A & 12A, 326 Building	Work is planned to start next month.
200KW Motor Generator Set - 306 Building	Installation is essentially complete.

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 some overtime required.

The equivalent of 163 design drawings were completed this month as compared to 152 last month.

Major design and drafting work in progress during the month includes the following:

1. Ultrasonic Development Tank - 13 drawings required - work completed.
2. Fission Product Packaging Equipment - 22 drawings issued for comment. About 50 additional drawings are required.
3. Shim Rod Drive Mechanism - PRTR - 10 drawings required - 50% complete.
4. Optical Measurement Device - In-Reactor - 5 drawings completed.
5. Graphite Creep Capsule - work cancelled.
6. Control Rod Drive Modification - 5 drawings completed.
7. Tensile Test Holder and Capsule - 4 drawings required - 75% complete.

In addition to the above, a considerable number of minor design jobs of one to two sheet magnitude are being produced.

Plant Maintenance Operation

Costs for September were $164,151. Year-to-date costs are 98.3% of forecasted expenditures.

Analysis of Costs

Maintenance costs ran slightly behind predictions for the first quarter, while utilities were slightly ahead. The total expenditures were $7,000 under forecast. For the month of September, maintenance was $10,000 higher than forecast, while utilities were $4,000 higher. The total cost for the month was almost $20,000 above forecast. Considering that at the end of the quarter the balance was $7,000, the rate of expenditure must be curtailed. During the midyear budget review, it was determined that the water consumption at 309 Building was about $40,000 more than forecast.

Analysis of Improvement Maintenance

Item	
Relocation and Alterations	$ 14,464
Repainting	4,212
Heat & Vent Modifications	4,215
Crane	10
Piping Modifications	205
Electrical Modifications	1,006
TOTAL	$ 24,112

Siginificant Activities

1. Painting

   a) The interior of 3745 Building was completed.
   b) The interior of 3730 Building graphite hot shop was started.
   c) The exterior trim of 231-Z Building was completed.

2. Tiling

   The floors of 3746 Building was completed.

3. Significant Space Modifications

   a) 326-306 - The renovation of Rooms 10A and 12A is essentially complete.
   b) 234-5/231-Z - The removal of laboratory apparatus from 234-5 Building is essentially complete. The reinstallation in 231-Z Building is progressing.
   c) TC-1. The AEC has halted J. A. Jones' work on this relocation, but no official explanation has been received.
   d) Partition changes were made in the south end of 3702 Building to improve efficiency.

Waste Disposal and Decontamination Service

Quantities of Waste Removed

	September	August
Concrete barrels	24	16
Loadluggers-hot waste	3	4
Milk pails	25	42
Gattling gun	1	0
Crib waste	190,000 gal.	340,000 gal.

The crib waste handling report is to be issued by mid-November.

The high level waste handling and decontamination work in 325 Building have been studied, and plans are underway to renovate work area and procedures for increased safety and efficiency.

Plant Engineering and Miscellaneous

Approximately 22,500 square feet of prints were reproduced during the month.

The total estimated value of the eleven requisitions issued during the month was $126,000. This procurement is primarily for approved HL projects.

The work of moving TC-1 Building near TC-2 and TC-3 for use as a permanent storage building has been temporarily delayed pending firm cost estimates.

An investigation is in progress to determine a way to improve compressed air service in 209-E Building. It appears that procurement and installation of a new separate compressor will be required.

A design is in progress to provide a constant proportional sampler system for the 307 influent line.

A cursory investigation was made with Radiation Monitoring personnel relative to a proportional sampler for the 309 cooling water effluent.

Plans are made for a water proof protective floor coating to be applied to the floor surface of the air-conditioning unit in 328 Building.

A Work Review has been written and submitted for approval to disassemble the hydrogen sintering furnace in the 325 Building, and remove it to excess storage.

Electrical panel load studies have been completed in the 325 Building and readings started in the 328 Building. In the near future, some distribution panels in the 325 and 328 Buildings will have to be replaced to provide more circuits.

Fire alarm and civil defense signal standardization was completed in the 314 Building this month. Added alarms, in addition to original requirements, were installed in the 325 and 306 Buildings because there were areas where alarms could not be heard. Fire alarm bells were installed in the 328 Building.

Considerable study has been made to determine the alarm systems installed in the 308 and 309 Buildings. Further work will be necessary to standardize these buildings, since the alarms do not conform to plant criteria.

Analysis was made of the automatic fire sprinkler system at the Critical Mass Laboratory because of unwarranted tripping. Emergency compressed air will be required which will also require expansion of the motor control center to accommodate the compressor.

The vendor of the 314 crane has been asked to supply information for mounting a bridge brake. The drive motor does not have a shaft extension as was supposed by the vendor, and additional information has been requested as to prices and materials to apply the brake correctly.

The supplier of a humidity measuring recorder in the 144-F Building has been requested to supply recommendations for dual use of individual recording points as proposed by operating people.

A study and alternate proposals for increasing the 3760 Building lobby lighting level has been written in draft form and submitted to the building custodian for his recommendations.

Manager
Laboratory Auxiliaries

JL Boyd:jw

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ. NO.	TITLE	FUNDING
CAH-822	Pressurized Gas Cooled Facility	4141 Operating

AUTHORIZED FUNDS				COST & COMM. TO 10-15-61	$ 880,057
$1,120,000	DESIGN $ 40,000	AEC $ 0		ESTIMATED TOTAL COST	$ 1,120,000
	CONST. $1,080,000	GE $ 1,120,000			

STARTING DATES		DATE AUTHORIZED	2-3-61	EST'D. COMPL. DATES	DESIGN 4-29-60
	DESIGN 8-19-59				
	CONST. 10-17-60	DIR. COMP. DATE	9-30-61		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

Arrangements are being made to return the NaK heater to the vendor for removal of NaK. Selection of an alternate heat transfer medium has not been finalized.

PROJ. NO.	TITLE	FUNDING
CAH-842	Critical Reactivity Measuring Facility	58-e-15

AUTHORIZED FUNDS				COST & COMM. TO 10-15-61	$ 176,177 (GE)
$ 360,000	DESIGN $ 45,000	AEC $ 148,000		ESTIMATED TOTAL COST	$ 400,000
	CONST. $ 315,000	GE $ 212,000			

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	DESIGN 2-1-61
	DESIGN 11-17-59				
	CONST. 10-3-60	DIR. COMP. DATE	8-15-61		CONST. 12-30-61

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	90
PF			
CPFF *	57	100	83
FP	43	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

The revised project proposal requesting additional funds and an extension of the scheduled completion date has not yet been acted upon by the AEC. A new schedule will be submitted when it is approved.

*Includes equipment to be installed by CPFF.

1231468

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CGH-857	Physcial & Mechanical Properties Testing Cell - 327 Bldg.	0290

AUTHORIZED FUNDS				
$ 460,000	DESIGN $ 57,000 / CONST. $ 403,000	AEC $ / GE $ 460,000	COST & COMM. TO 10-15-61	$ 45,288
			ESTIMATED TOTAL COST	$ 460,000

STARTING DATES				EST'D. COMPL. DATES	
DESIGN	11-2-59	DATE AUTHORIZED	9-22-61	DESIGN	3-15-61
CONST.	5-15-62	DIR. COMP. DATE	12-15-62	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.

The customer has requested re-design of a portion of the cell to incorporate additional viewing windows and manipulator ports as well as relocation of the access door to provide an improved cell arrangement from an operating consideration.

Procurement is initiated and will continue, coincidental with the design changes.

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 10-15-61	$ 327,499
			ESTIMATED TOTAL COST	$ 400,000

STARTING DATES				EST'D. COMPL. DATES	
DESIGN	11-1-59	DATE AUTHORIZED	10-1-59	DESIGN	2-15-61
CONST.	5-15-61	DIR. COMP. DATE	2-28-62	CONST.	2-28-62

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		140
PLANT FORCES		
ARCHITECT - ENGINEER		35
DESIGN ENGINEERING OPERATION		716
GE FIELD ENGINEERING		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	18	13
PF			
CPFF	100	18	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 is planned to start October 30, 1961 on the next stage, which will continue to project completion.

A meeting was held 10-24-61 with Construction, Operations, and Project representatives. The sequence for the next few weeks will be:

1. Installation of cask cart track support.
2. Installation of electrical switchgear.
3. Floor penetrations for service piping and conduit.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535 ☐

DATE 10-30-61

PROJ. NO.	TITLE	FUNDING
CAH-866	Shielded Analytical Laboratory - 325-B Building	61-e-1

AUTHORIZED FUNDS				
$700,000	DESIGN $ 60,000	AEC $ 546,500	COST & COMM. TO 10-15-61	$ 29,836 (GE)
	CONST. $ 640,000	GE $ 153,000	ESTIMATED TOTAL COST	$ 700,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 9-5-59	DATE AUTHORIZED 5-31-60		DESIGN 11-14-60	
CONST. 6-28-61	DIR. COMP. DATE 6-30-62		CONST. 6-30-62	

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	15	784
COST PLUS FIXED FEE		
PLANT FORCES	0	3
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		1

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	20	15
PF	3	1	1
CPFF	2	0	0
FP	95	21	15

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.

First floor concrete slab and wainscoat walls were poured on 10-24-61. 325 Building shut-down on 10-21-64 and tie-in made to 6" water main.

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 10-15-61	$ 506,189 (GE)
	CONST. $1,370,000	GE $ 730,000	ESTIMATED TOTAL COST	$ 1,500,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 8-1-60	DATE AUTHORIZED		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	5	600
COST PLUS FIXED FEE	15	1020
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	43	39
PF	2	0	0
CPFF	57	50	46
FP (1)	10	100	100
(2)	31	15	8

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Company
(2) Lewis Hopkings Construction Company

1231470

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-h-1

AUTHORIZED FUNDS					
$ 420,000	DESIGN $ 44,000	AEC $ 400,000	COST & COMM. TO 9-30-61	$ 395,743
	CONST. $ 376,000	GE $ 20,000	ESTIMATED TOTAL COST	$ 420,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN	8-8-60	DATE AUTHORIZED 9-2-60	DESIGN	3-31-61		WT'D.	SCHED.	ACTUAL
CONST.	7-10-61	DIR. COMP. DATE 3-31-62	CONST.	6-15-62	DESIGN	100	NS	100
					TITLE I			
					GE-TIT. II	17	NS	100
					AE-TIT. II	83	NS	100
					CONST.	100	53*	33
					PF	1	30	30
					CPFF			
					FP	99	53*	33

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	10	875
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides additional space for biological research supporting services, and involves an addition to the 108-F Building.

*Teller Schedule (This schedule Being Revised)

All structural steel has been erected. Second floor forms are complete and third floor forms well underway. Floors cannot be poured until concrete block wall is laid. Concrete block has not been delivered. We have been advised verbally by the Contractor that the local block supplier have not met their own specifications. A meeting will be held with all interested parties to resolve this, also the problem of acquiring an acceptable assembly drawing of heating and air conditioning equipment.

Allied Engineering has reported 100% completion of design of radiation handling equipment and check prints are being prepared. Major fabrication is scheduled to begin on December 3, 1961.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535 II

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CAH-896	Stress Ruptures Test Facility	60-1

AUTHORIZED FUNDS				
$ 90,000	DESIGN $ 7,500 / CONST. $ 82,500	AEC $ 78,500 / GE $ 11,500	COST & COMM. TO 10-15-61 / ESTIMATED TOTAL COST	$ 11,467 (GE) / $ 90,000

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 7-29-60 / CONST. 3-20-61		3-6-61 / DIR. COMP. DATE 10-15-61		DESIGN 12-1-60 / CONST. 12-15-61

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	2	600
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	100	93
PF	2	100	100
CPFF			
FP	98	100	93

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

Installation of equipment has been completed and functional testing has begun. Five of the six cells having installed equipment can be accepted if the testing is successful. However, the sixth cell will be an exception until the sixth accumulator is received and installed.

PROJ. NO.	TITLE	FUNDING
CAH-901	Structural Material Irradiation Test Equipment - ETR	0290

AUTHORIZED FUNDS				
$ 125,000	DESIGN $ 12,000 / CONST. $ 113,000	AEC $ / GE $ 125,000	COST & COMM. TO 10-15-61 / ESTIMATED TOTAL COST	$ 121,731 / $ 125,000

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 9-15-60 / CONST. 6-26-61		9-2-60 / DIR. COMP. DATE 10-15-61		DESIGN 3-31-61 / CONST 10-15-61

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		1,000
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	100	100
PF	100	100	100
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.

The project was completed 10-15-61. No further reporting is necessary.

1231472

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CGH-902	Uranium Scrap Burning Facility	61-j

AUTHORIZED FUNDS				COST & COMM. TO 10-15-61	$ 5,752 (GE)
$ 36,000	DESIGN $ 5,000	AEC $ 27,500		ESTIMATED TOTAL COST	$ 36,000
	CONST. $ 31,000	GE $ 7,500			

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 5-15-61		12-15-60		DESIGN 7-28-61
	CONST. 9-12-61	DIR. COMP. DATE	12-31-61		CONST. 12-31-61

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		148
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		through 10-22-61

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT.II			
AE-TIT.II			
CONST.	100	67	43
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.

Sub-contractor for building proceeding considerably slower than planned.

Scheduled completion of construction is based on AEC's construction schedule.

PROJ. NO.	TITLE	FUNDING
CAH-914	Rattlesnake Springs Radioecology Facility	61-j

AUTHORIZED FUNDS				COST & COMM. TO 10-15-61	$ 16,119 (GE)
$ 90,000	DESIGN $ 3,400*	AEC $ 71,700		ESTIMATED TOTAL COST	$ 90,000
	CONST. $ 86,600	GE $ 18,300			

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 3-1-61		12-22-60		DESIGN 6-15-61
	CONST. 7-10-61	DIR. COMP. DATE	10-31-61		CONST. 12-1-61

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	7	507
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	93	92.4
PF			
CPFF	7	NS	20
FP	93	100	98

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. Initial acceptance of the contractor portion of the work with listed exceptions was done 10-19-61. The contractor, AEC, and customer representatives were present. Installation of GE procured instrumentation is underway.

1231473

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ. NO.	TITLE	FUNDING
CAH-916	Fuels Recycle Pilot Plant	Funds Avail. to Comm.

AUTHORIZED FUNDS				
$ 385,000	DESIGN $ 385,000	AEC $	COST & COMM'L TO 10-15-61	$ 89,422
	CONST. $ -0-	GE $ 385,000	ESTIMATED TOTAL COST	$ 5,000,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN 3-1-61*	DATE AUTHORIZED 2-17-61		DESIGN 3-1-62			WT'D.	SCHED.	ACTUAL
CONST. 5-1-62	DIR. COMP. DATE		CONST. 7-1-64		DESIGN	100	NS	18
					TITLE I	11	100	100
					GE-TIT. II	89	7	8
					AE-TIT. II			
					CONSTR.	100	NS	
					PF			
					CPFF			
					FP			

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

Directive AEC-187 mod. 2 dated October 27, 1961 authorized HOO-AEC total design funds in the amount of $385,000.

Some exploratory excavations were made in a burial ground that is located on the building site (east of the 308 building) to determine the extent of the radioactivity contaminated earth.

Three drawings have been issued for comment.

The ventilation exhaust system studies resulted in substantial savings with improved system features.

A study comparing refrigerative type cooling system with an evaporative type cooling system for the administrative area is about one-half complete.

*A design schedule was submitted to AEC for approval on 10-10-61.

1231474

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CAH-917	Field Service Center - Atmospheric Physics	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 154,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 12-15-61*		DESIGN 4-15-62*	
	CONST. 6-1-62*	DIR. COMP. DATE	CONST 2-15-63*	

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities necessary to conduct atmospheric physics research and development programs.

*Based on AEC authorization by 11-15-61.

The General Electric Company is preparing an answer to the Commission letter requesting information concerning alternates to the proposed project.

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		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 12-1-61*		DESIGN 4-1-62*	
	CONST. 8-1-62*	DIR. COMP. DATE	CONST. 6-1-63*	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

Project Proposal Revision was submitted to the Commission on July 5, 1961. The Review Board deferred it indefinitely on July 13. It has been indicated that correspondence will be submitted by the Commission suggesting other lines of approach to strengthen the justification for this project.

No correspondence was received by 10-24-61.

*Based on Commission approval by 11-15-61.

1231475

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CAH-919	Air Conditioning - 314 Building	61-j

AUTHORIZED FUNDS				COST & COMM. TO 10-15-61	$ 3,923 (GE)
$ 35,000	DESIGN $ 4,850	AEC $ 30,150		ESTIMATED TOTAL COST	$ 35,000
	CONST. $ 30,150	GE $ 4,850			

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN 5-2-61	DATE AUTHORIZED 4-18-61		DESIGN 7-5-61			WT'D.	SCHED.	ACTUAL
CONST. 6-15-61	DIR. COMP. DATE 9-15-61		CONST. 11-30-61		DESIGN	100	NS	100
					TITLE I			
					GE-TIT. II			
					AE-TIT. II		NS	100
					CONST.	100	100	80
					PF			
					CPFF			
					FP			

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		

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 General Electric Company.

Relocation of an existing unit and installation of unit #4 remains to be done. A work order supplement to cover cost to completion has been issued by the AEC to J. A. Jones Construction Company.

J. A. Jones forces started work 10-24-61 on the remaining work to complete the project.

PROJ. NO.	TITLE	FUNDING
CAH-921	Geological & Hydrological Wells - FY-61	61-j

AUTHORIZED FUNDS				COST & COMM. TO 9-30-61	$ 62,792
$ 79,000	DESIGN $ 1,000	AEC $ 69,500		ESTIMATED TOTAL COST	$ 79,000
	CONST. $ 78,000	GE $ 9,500			

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN 4-15-61	DATE AUTHORIZED 3-24-61		DESIGN 5-15-61			WT'D.	SCHED.	ACTUAL
CONST. 5-22-61	DIR. COMP. DATE 12-31-61		CONST. 12-31-61		DESIGN	100	100	100
					TITLE I	100	0	0
					GE-TIT. II			
					AE-TIT. II		75	75
					CONST.	100	95	78
					PF	0		
					CPFF	3	87	75
					FP	97	66	78

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	7	780
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

Contractor is working two nine-hour shifts per day on each of two rigs. Approximately 3640 feet of hole has been completed.

Construction work is behind the contractor's own schedule.

1231476

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CGH-922	Burst Test Facility for Irradiated Zirconium Tubes	62-k

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$ 29,600	CONST. $	GE $	ESTIMATED TOTAL COST	$ 228,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN	11-15-61*	10-23-61	DESIGN	5-15-62*		WT'D.	SCHED.	ACTUAL
CONST.		DIR. COMP. DATE	CONST	12-1-62*	DESIGN	100		
					TITLE I			
					GE-TIT. II			
					AE-TIT. II			
					CONST.	100		
					PF			
					CPFF			
					FP			

ENGINEER

FEO - H Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project will privide 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.

AEC Directive No. AEC-199, dated October 23, 1961 authorizing $29,600 for design has been issued. Work Authority No. CAH-922(1) dated October 25, 1961 was received.

*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 10-15-61	$ 4,983 (GE)
$ 31,000	CONST. $27,800	GE $ 6,350	ESTIMATED TOTAL COST	$ 31,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN	5-1-61	3-27-61	DESIGN	10-15-61		WT'D.	SCHED.	ACTUAL
CONST.	10-15-61	DIR. COMP. DATE 2-28-62	CONST	2-28-62	DESIGN	100	NS	100
					TITLE I			
					GE-TIT. II		NS	100
					AE-TIT. II			
					CONST.	100	1	1
					PF			
					CPFF			
					FP			

ENGINEER

FEO - LF Higginson

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project will 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. Design is 100% complete. Construction material take-off has started.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

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 12-15-61*		DESIGN 3-1-62*	
	CONST. 4-1-62*	DIR. COMP. DATE	CONST. 8-1-62*	

ENGINEER

FEO - QM 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. The project proposal was returned to the Commission for further review and approval.

*Based on AEC authorization by 11-15-61.

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 $ 62,500	COST & COMM. TO 10-15-61	$ 7,209 (GE)
	CONST. $ 76,000	GE $ 17,500	ESTIMATED TOTAL COST	$ 80,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 6-15-61		DESIGN 2-15-62	
	CONST. 10-15-61	DIR. COMP. DATE 3-31-62	CONST. 7-15-62	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER - Bovay Engineers	2	85
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	50
TITLE I			
GE-TIT. II			
AE-TIT. II	100	100	50
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.

It has been decided that a project proposal revision should be written to accomplish the changes necessary such as design cost and schedule increases and construction completion date. The revision is being drafted.

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SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 71535

DATE 10-30-61

PROJ.NO.	TITLE	FUNDING
CAE-936	Coolant Systems Development Laboratory	62-k

AUTHORIZED FUNDS				
$ 93,000	DESIGN $ 12,000	AEC $ 81,000	COST & COMM TO 10-15-61	$ 10,634
	CONST. $ 81,000	GE $ 12,000	ESTIMATED TOTAL COST	$ 93,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN 9-8-61	DATE AUTHORIZED 8-9-61		DESIGN 1-1-62			WT'D.	SCHED.	ACTUAL
CONST. 4-10-62	DIR. COMP. DATE 10-31-62		CONST. 10-31-62		DESIGN	100	46	80
					TITLE I			
					GE-TIT. II			
					AE-TIT. II	100	46	50
					CONST.	100	NS	NS
					PF			
					CPFF			
					FP			

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER - Bovay Engineers	4	100
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

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 2700 sq. ft. laboratory facility on the west side of the 1706 KE Building.

Directive AEC-198 Mod. 1 dated October 27, 1961 authorized HOO-AEC total project funds in the amount of $93,000 and established a directive completion date of October 31, 1962.

Design problems have been resolved by frequent communication between the Bovay Engineers and the General Electric Company project personnel. Disposal of waste liquids from the "hot" laboratory room is being resolved with Radiation Protection Operation personnel.

PROJ. NO.	TITLE	FUNDING
CGH-937	Safety Improvements to 231-Z Building	61-j

AUTHORIZED FUNDS				
$ 45,000	DESIGN $ 5,500	AEC $	COST & COMM. TO 10-15-61	$ 39,720
	CONST. $ 39,500	GE $ 45,000	ESTIMATED TOTAL COST	$ 45,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN 7-12-61	DATE AUTHORIZED 6-29-61		DESIGN 9-29-61			WT'D.	SCHED.	ACTUAL
CONST. 7-10-61	DIR. COMP. DATE 5-15-62		CONST. 2-1-62		DESIGN	100	NS	
					TITLE I			
					GE-TIT. II		NS	100
					AE-TIT. II			
					CONST.	100	NS	20
					PF			
					CPFF	100	NS	20
					FP			

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides supplemental ventilation and installation of a fire detection system in the 231-Z 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.

Fire Alarm System is approximately 40% complete. The exhaust fans are due on about November 15, 1961. Duct fabrication is underway.

TECHNICAL ADMINISTRATION OPERATION

MONTHLY REPORT

PROFESSIONAL PLACEMENT

Advanced Degree - Three Ph.D. applicants visited HAPO for employment interviews. Five offers were extended; two acceptances and two rejections were received. Current open offers total three.

Technical Graduate Program - Five Technical Graduates were placed on permanent assignment. Current program members total eighty-three.

TECHNICAL INFORMATION

Several changes in the criteria for classifying plutonium were authorized by the AEC. Information on these changes was distributed to the field via HW-71412 "Classification: Plutonium". A Classification Information Bulletin entitled, "NPR Events," which announced current policy on classifying the dates related to NPR completion and startup was also distributed.

The current backlog of reports in Technical Publications stands at 35. In 1961 to date, 121 formal R&D reports have been released to 300 Files for distribution. This already surpasses the total (118) for the entire year 1960.

An inquiry was received from the United Kingdom Atomic Energy Authority, Atomic Weapons Research Establishment, Aldermaston, Berkshire, for a supply of the IBM routing forms which we use in our classified document inventory system. The Establishment wishes to introduce a similar system, but the required forms cannot be manufactured in the United Kingdom. Arrangements have been completed for a temporary supply (2,000 forms) to be transmitted to them through the Hanford Operations Office.

Work Volume Statistics

Document Distribution and Files	September	October
Documents routed and discharged (copies)	16,056	15,764
Documents issued (copies)	10,491	13,327
Documents sent offsite (copies)	4,912	8,310
Document reserves filled (copies)	774	767
Documents picked up and delivered	17,524	18,038

Document Accountability

Holders of classified documents whose files were inventoried	173	179
Documents inventoried in Files (copies)	---	---
Documents destroyed or retired (copies)	5,607	5,738
Documents revised (copies)	1,113	1,508
Documents pulled and documents filed (copies)	11,127	14,465
Documents reclassified	173	54
Documents microfilmed	1,824	1,182
Accountable copies of SECRET and DOCUMENTED	197,256	198,538

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Library Acquisition and Circulation

	September	October
Books ordered (volumes)	430	345
Periodicals ordered	84	52
Books circulated (volumes)	2,195	1,757
Periodicals circulated (issues)	3,737	3,372
Inter-Library loans	78	160
Films borrowed or rented	36	23
Industrial film showings	52	39
Bound periodicals added to the collection	153	80
Bound periodicals discarded	14	22

Library Collection

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	32,296	8,707	1,867	2,082	44,952
No. of bound periodicals	15,127	19	1,940	23	17,109
	47,423	8,726	3,807	2,105	62,061

Classification and Declassification

	September	October
Documents, including drawings and photographs reviewed for downgrading or declassification	53	38
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	29	34
Documents submitted to Declassification Branch, Oak Ridge	3	3

O. E. Boston, Manager
Technical Administration

OEB:lmh

TABLE II. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1961 to October 31, 1961

	Visits to Richland				Offers				
	Cases Considered	No Interest	Invited	Visited	Offered	Rejected	Accepted	Open	On the Roll
PhD	128	21	36	17	12	4	5	3	1
Exp. BS/MS	71	48	-	-	-	1	-	-	-
Prog. BS/MS	29	16	-	-	-	1	1	-	-

B. Technical Recruiting Activity - HL - September 1, 1961 to October 31, 1961

	Visits to Richland				Offers				
	Cases Considered	No Interest	Invited	Visited	Offered	Rejected	Accepted	Open	On the Roll
Phd	128	21	36	17	11	4	4	3	-

In addition to the above activity, 16 technical graduates have accepted off-program placement in HL to date.

C - Technical Graduate Program
Month ending October 31, 1961

Number Personnel on Assignment	83
(HAPO Tech Grad Program 68	
(Engineering & Science Program 15	

Distribution of Assignments by Departments

IPD	34
HLO	30
CPD	13
FPD	6
C&AO	0
CE&UO	0

Distribution of Assignments by Function

Research & Development or Engineering	61
Other	22

FINANCIAL OPERATION MONTHLY REPORT
OCTOBER 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-8 Add. 1	Decontamination Coupons for APED	In process.
AT-52	Expanded Use of Whole Body Counter	In hands of Commission since 6-29-61. AEC feels further study is required.
AT-104 & Add.1	Fission Products Dispersal Handbook	Commission is still considering.
AT-105	Symposium on the Biology of Transuranic Elements	Washington AEC still considering.
AT-194	Participation in Standardizing Activities.	Approved 10-31-61.
AT-195	AIBS Medical Education for National Defense Program	To AEC 10-20-61.
AT-196	Participation in Standardizing Activities	In process.
AT-198	Miniature Swine for Hammersmith Hospital	In process.

Two requests for agreement under Agreement No. AT-6 were received and accepted as noted below:

Number	Date of AEC's Letter	Accepted be GE	Subject
FY62-11	9-28-61	9-29-61	Appointment of Dr. B. R. Leonard to Division of Research Nuclear Cross Section Advisory Group. This is a continuation of an assignment which Dr. Leonard has filled since October 1957.
FY62-12	9-12-61	10-10-61	Review Article for IAEA. This is in regard to a request that Dr. Spencer Bush prepare a review on the subject of "Special Materials for Reactor Construction and Production Methods" for the International Atomic Energy Agency, Vienna, Austria.

Travel activity continues at a level approximately 20% below that of the last two years. To date in FY 1962, 369 trips have been started compared with 463 at the end of October 1960.

Equipment procured by HAPO to support University of California Lawrence Radiation Laboratory research and development programs valued at $699,350 with a reserve of $82,335 was transferred to HLO during the month. This equipment was added to record by use of the Non-Fund Adjustment Account. The dollars will remain in our 90- Unclassified Account until we can apply dollars to approximately 300 individual units of property.

The physical inventory of HLO 300 Area fixed property was completed during the month of October. Reconciliation of inventory count to accounting records is in progress. Upon completion of the reconciliation individual units of property will be assigned a fixed property identification number and forwarded to Data Control for key punching as media for the new mechanized system. It is estimated the reconciliation will be completed during December business.

Preparations were completed for transfer of custodianship of the Hot Semiworks from Hanford Laboratories to Chemical Processing Department. The dollar value will be transferred in November after CPD completes their verification of individual units of property.

Reconciliation of the annual physical inventory of precious metals and special materials is nearing completion. As in the past years, there are a few discrepancies for which explanations are now being obtained from field personnel. A report of results will be issued in November.

Excess Yttrium from Lockland Aircraft Reactors Operations Office weighing 267.5 lbs. was received, valued at $31,830. This material was added to Inventory as a non-fund adjustment and an inventory reserve in equal amount was established. In addition CPD transferred 208.2 lbs. of the same material valued at $15,606.67.

A rough draft of the unitization report for Project CAH-747, Plutonium Fabrication Pilot Plant (308 Building) was prepared during the month. This will remove $4,198,609 from our unclassified account to classified plant accounts. Due to the size of the report (165 pages) and the large number of property units issuance of the unitization report and removal of dollars from the unclassified account probably will not take place until December business.

The Manual of HAPO Source and Nuclear Materials (Document No. HW-50300-K) was submitted to HLO components for review of Manual procedures and for updating with current HLO changes. Upon receipt of requested information from the field the Manual will be revised and reissued.

Heavy Water losses chargeable to operating cost for the month of October amounted to $36,121. This includes an adjustment to the reported September loss which was understated 1400 lbs. valued at $19,544. At October 31, 1961, accumulated scrap for return to Savannah River totaled 14,222 lbs. valued at $173,013. This is a reduction from previous month total by 2,790 lbs. and $38,073. The reduction in scrap is due to an effective filtering process used by PRTR to remove oil from that material with a purity in excess of 90%. The classification of this material has been changed from "scrap" to "used".

A Plant to Plant Transfer from AEC was received during the month for $809,200 representing Non-Fund depreciation on Heavy Water acquired from SROO for PRTR (AEC-167) initial loading. The Fund cost plus the Non-Fund will be capitalized however, the Non-Fund will not be charged against funds obligated.

Thirty tons of Hastelloy valued at $82,858 and graphite valued at $11,000 was received at the Laboratory Pool during the month. The graphite is being stored for the convenience of Radiological Physics Operation to provide laboratory space for other uses, and the hastelloy consisting of sheet, wire, billets and plate received from ANP is being stored and controlled for the convenience of Reactor and Fuels R&D Operation.

Ninety-nine equipment items valued at $61,519 were received at the Laboratory Pool during the month. Twenty-nine items valued at $15,524 were loaned or transferred in lieu of placement of requisitions and 2 items valued at $688 were withdrawn by custodians. There are currently 936 items valued at $527,355 physically located in the Pool of which 173 items valued at $22,777 are uncataloged type items and 103 items valued at $187,790 are being held for the convenience of others.

Action as indicated occurred on the following projects during the month:

New Money Authorized HLO

CAH-916	Fuels Recycle Pilot Plant	$285 000
CAH-919	Air Conditioning 314 Building	(1 500)
CAH-922	Burst Test Facility for Irradiated Tubes	29 600

Physical Completion Notices Issued

CAH-901	*Structural Materials Irradiation Test Equipment - ETR
CGH-935	Metals Storage Building

* AEM Services Only

Construction Completion and Cost Closing Statements Issued

CGH-785	In-Reactor Studies Equipment
CAH-870	*Facilities for Recovery of Radioactive Materials
CGH-907	Strontium-90 Interim Program

* AEM Services Only

Effective October 28, 1961, Facilities Engineering Operation transferred all Title III funds on PAC Projects under their control to Construction Engineering and Utilities Operation. CE&UO will retain funds necessary for Field Inspection and issued work orders to HLO-FEO for field engineering. Reactor and Fuels R&D has proposed that they continue Title III work on the two projects under their control, by letter to J. M. Heffner, CE&UO, dated October 30, 1961. No reply has been received to this letter to date.

Eight suggestions were received for evaluation during October. Three have been accepted and minor awards paid. Four have been rejected. One held pending further investigation. We have accepted the responsibility of evaluating all suggestions submitted by Technical Information.

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Eight new forms were established and three existing forms were revised for Hanford Laboratories.

COST ACCOUNTING OPERATION

HOO-AEC submitted Financial Plan #3 to HAPO in October. Changes in program funds involving Hanford Laboratories are as follows:

(Dollars in Thousands)	Increase (Decrease)
04 Program	
Plutonium Recycle Program	$ (85)
Plutonium Utilization Study	200
Euratom	20
Reactor Fuels and Materials	(100)
Capital Equipment	(105)
Net Change - 04 Program	(70)
06 Program	
Environmental Radiation Studies	55

A new section in Hanford Laboratories entitled Technical Administration Operation was established on October 1, 1961; concurrently, the Professional Placement and Relations Practices Operation was disbanded. Cost codes and organizational titles established for the Technical Administration Operation are as follows:

Code	Component
7200	Technical Administration Operation
7210	Professional Recruitment
7220	Advanced Degree Personnel
7230	Placement Programs
7240	Technical Information
7241	Reference and Publication
7242	Library Acquisition and Circulation
7243	Document Distribution and Files
7244	Document Accountability
7250	Advanced Engineering Courses

The annual budgets and fiscal year-to-date costs through September for the components comprising the Technical Administration Operation were transferred from the former organizations and incorporated in October financial statements on the basis of the new organization.

Preparation of the FY 1962 Mid-Year Budget Review is underway. During October, personnel requirements were compiled, approved by the Manager - Hanford Laboratories, and submitted to Contract Accounting. Requirements by quarter-ending date are as follows:

6-30-61 actual	1 432
9-30-61 actual	1 419
12-31-61 budget	1 402
3-31-62 budget	1 397
6-30-62 budget	1 408

The following work identification codes were established during the month:

Code	Title
.26	Critical Facility
.35	CPD - Waste Management (02 Program R&D)
.36	CPD - Fission Product Recovery (02 Program R&D)
.64	Strontium - Process Technology

One special request code was established during the month, .1W to accumulate the costs associated with the foreign travel of J. R. Triplett in connection with the EAES Symposium.

In response to a request by HOO-AEC, a forecast of D_2O requirements for the PRTR operation for fiscal years 1962, 1963, and 1964 was prepared and submitted. The purchases and returns to Savannah River were as follows:

	In Pounds	
	Purchases	Returns
FY 1962	25 000	20 000
FY 1963	38 500	17 000
FY 1964	31 000	17 000

A review for approval authority was made of store orders processed during the first week of October by Reactor and Fuels Research and Development Operation. A report was made to managers concerned.

W Sale:bk
November 14, 1961

INVENTIONS OR DISCOVERIES

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

INVENTOR	TITLE OF INVENTION OR DISCOVERY
E. M. Sheen	A Pulse Triggered Semiconductor Tone Generator, HWIR-1430.
R. H. Moore	The Use of $SnCl_2$ to Improve Separation of Uranium from Plutonium in Immiscible Salt Systems (HW-71448)
R. H. Moore	A Process for Extraction of Plutonium from PRP "Spike" Elements into a Typical "Salt Cycle" Fused Salt Solvent Preliminary to Electrodeposition of PuO_2-UO_2 (HW-71196).

Paul F. Gast for HMP

[redacted]

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