729410

DECLASSIFIED

HW-72590
[redacted]
HAN-81219

HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

JANUARY, 1962

FEBRUARY 15, 1962

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

GENERAL ELECTRIC

DECLASSIFIED

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

1250072

CLASSIFICATION REVIEW FOR DECLASSIFICATION BUT LEFT UNCHANGED

By JPD/...

Date 5/ /7

U. S. AEC Division of Classification

[redacted]

HW-72590

This document consists of 171 pages. [redacted]

[redacted]

HAN - 81219

HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
JANUARY, 1962

Classification Cancelled (Change to

By Authority of D S Lewis

8-11-92 CG-PR-2

By JaBallard 8/25/92

TL Phillips 8/26/93

Compiled by
Operation Managers

February 15, 1962

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

[redacted]

PRELIMINARY REPORT

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

Route To:	P. R. No.	Location	Route Date	Signature and Date
HOO				
Attn: J. E. Travis				

[redacted]

1250073

DISTRIBUTION

Copy Number	
1	W. E. Johnson
2	H. M. Parker
3	F. W. Albaugh
4	C. A. Bennett
5	O. E. Boston
6	J. L. Boyd
7	F. E. Crever, GEAPD
8	I. H. Dearnley
9	W. E. Foust
10	P. F. Gast
11	A. R. Keene
12	H. A. Kornberg
13	W. H. Reas
14	W. D. Richmond
15	W. Sale
16	H. P. Shaw - W. P. McCue
17	R. E. Tomlinson
18	W. K. Woods
19 - 22	Atomic Energy Commission, Hanford Operations Office Attn: J. E. Travis
23 - 25	F. P. Baranowski, Director, Division of Production Washington 25, D. C.
26	Savannah River Operations Office, Aiken, South Carolina
27	300 Files
28	Record Center

TABLE OF CONTENTS

TABLE I. HLO FORCE REPORT

DATE: January 31, 1962

	At beginning of month		At close of month		
	Exempt	Salaried	Exempt	Salaried	Total
Chemical R & D	129	117	129	113	242
Reactor & Fuels R & D	172	154	170	155	325
Physics & Instrument R & D	91	59	90	59	149
Biology	36	48	36	52	88
Operations Res. & Syn.	17	4	18	4	22
Radiation Protection	41	91	41	92	133
Laboratory Auxiliaries	31	132	30	136	166
Financial	19	16	20	15	35
Technical Administration	95	59	84	59	143
Programming	18	3	18	3	21
General	3	4	3	4	7
Test Reactor & Auxiliaries	36	72	35	74	109
TOTAL	688	759	674	766	1,440

1250076

[redacted] DECLASSIFIED

BUDGETS AND COSTS

January operating costs totaled $1, 650, 000; fiscal year-to-date costs are $15, 393, 000 or 56% of the $27, 555, 000 control budget. January's costs include a reduction of $574, 000 in connection with the continuity of service expense adjustment related to CY 1961 Pension Plan costs. Hanford Laboratories' research and development costs for January, compared with last month and the control budget are as follows:

(Dollars in Thousands)	COST Current Month	Previous Month	FY To Date	Budget	% Spent
HLO Programs					
02 Program	$ 43	$ 47	$ 309	$ 605	51
03 Program				175-a)	
04 Program	727	881	6 343	10 925	58
05 Program	66	82	498	1 088	46
06 Program	163	182	1 373	2 720	50
	999	1 192	8 523	15 513	55
FPD Sponsored	74	120	794	1 400	57
IPD Sponsored	98	115	756	1 325	57
CPD Sponsored	122	147	942	1 570	60
Total	$ 1 293	$ 1 574	$11 015	$19 808	56

(a- Represents a new authorization to extend the current plutonium metallurgy effort related to programs sponsored by UCLRL (Project Whitney) and CPD.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

Experimental Zr/U coextrusion studies indicate that it is possible to nearly match the extrusion constants of uranium and Zircaloy by careful control of extrusion temperature and chemical composition of the Zircaloy.

Large Zircaloy-2 grains in a Zr/U coextrusion billet were found to cause roughness of the cladding surface and at the U-Zr interface of subsequent coextruded N fuel.

1250077 [redacted]

Charging force studies for present reactors have disclosed a soluble oil which significantly reduces the friction between fuel elements and process tubes with an accompanying decrease in galling.

Long-term irradiations of NPR graphite are under way in two capsules in the GETR at sample temperatures ranging from 325 to 750 C.

Forty-one boiling burnout points were obtained for vertical flow through a heated test section that was used previously in a horizontal position to obtain data for the center portion of the NPR fuel elements. Gravity has little effect on the steam-water flow patterns influencing boiling burnout for the conditions studied.

Using an electrically heated test section inside of a glass process tube fitted with "self supports" of various thicknesses, observations were made of the heat transfer conditions to be expected around "self supports" of production reactor fuel elements. Considerable boiling was observed under the supports at conditions in which the rest of the fuel element still experienced all-liquid cooling.

No hydride platelets were found in the Zircaloy-2 tube removed from KER Loop 3, after reactor service for about two years. Irradiated portions of the tube burst (at room temperature) at hoop stresses comparable to an unirradiated control specimen.

The in-reactor creep test of 20% cold-worked Zircaloy-2 at 310 C and 30,000 psi has been terminated after 1500 hours and a specimen strain near 1%. Analysis of creep data shows that creep rate is little reduced immediately after reactor shutdown (flux reduction); the observed great increase in creep rate during shutdown apparently occurs somewhat later, following removal of irradiation-induced defects.

A hot swaged and a vibratorily compacted 19-rod cluster element and a nested tubular element are all operating satisfactorily in PRTR with heat generations in excess of one megawatt.

The vaporization of UO_2 in the immediate vicinity of a moving fission fragment has been demonstrated by electron microscopy and diffraction. An amorphous carbon film retards this vaporization.

Detailed examination of UO_2, irradiated to 37,000 MWD/T, revealed distinctive characteristics different from those previously shown to exist in low exposure material. In particular, the radially oriented single grains were noticeably long and thin.

A vibrationally compacted stainless steel clad UO_2 fuel element was discharged from the VBWR after a successful irradiation to 1200 MWD/T.

Tensile tests of magnetic force welded closures on aluminum cermet (SAP) reveal that a joint is made which is as strong as the parent material.

A UO_2-PuO_2 PRTR prototype 7-rod cluster (GEH-11-7) has completed its irradiation of 23 full power days in the ETR 3x3 loop. An injection-cast 7-rod cluster (GEH-11-6) containing Al - 2.53 w/o Pu - 2.0 w/o Ni alloy core material is now being irradiated in this facility. A UO_2-PuO_2 cosine enriched 7-rod cluster element (GEH-11-8) has been completed and sent to the ETR for a later irradiation.

Inspection of four aluminum-plutonium spike fuel elements during the last PRTR outage disclosed various amounts of rod shortening.

Six special low-exposure plutonium spike fuel elements for measuring radial and axial flux patterns within a cluster have been delivered to the PRTR. Fuel element rods for the final six low-exposure spike fuel elements are being prepared for cluster assembly, making a total of 67 Mark I-H aluminum-plutonium elements fabricated for the PRTR. Fabrication has begun on fourteen aluminum-plutonium spike fuel elements containing high-exposure (16.5 a/o Pu-240) plutonium.

Six PRTR process tubes monitored in-reactor during January appear satisfactory, with no significant changes in ID or gas gap with the shroud tube.

Special 1/4-inch wide support ribs on PRTR fuel appear to cause less wear-corrosion penetration of the process tube than the standard 1/16-inch wide ribs.

A new "Breakaway Corrosion Loop" is being put into service for ex-reactor corrosion testing of metals in water at "hot-spot" temperatures up to 1100 F and 3500 psi.

Creep rupture tests on two annealed, unirradiated sections of PRTR Zircaloy-2 process tubing indicate that for an equivalent strain, the stress in the tube wall must be twice that in a tensile specimen machined from rolled strip.

Stress corrosion susceptibility tests in boiling 42 w/o $MgCl_2$ continued. Hastelloy X, PRDL-102, AISI-406 SS, and Incoloy are the most resistant among the 35 alloys tested.

In the development of a liquid shim rod for PRTR severe cadmium plating and precipitation from cadmium sulfate solution was encountered in the presence of aluminum. Further laboratory work will be done to discover a means of preventing these reactions.

The Gas Loop test channel inner tube was completed and delivered to the reactor. This completes all planned Equipment Development work for the Gas Loop.

2. <u>Chemical Research and Development</u>

Initial results, obtained under adverse experimental conditions, show that the addition of sodium silicate at a concentration of 10 ppm (as Si) to the reactor cooling water effects a reduction in concentration of As-76, Np-239 and Cr-51 in the effluent by about a factor of two. Further testing under favorable experimental conditions is planned.

The three technetium-99 product fractions from anion exchange runs on Purex 103-A waste supernate were combined and processed through a second ion exchange cycle for additional purification; ten grams of very pure technetium were obtained.

The extraction of cesium-137 from actual, full level Purex 1WW and 103-A wastes by dipicrylamine (in nitrobenzine) was demonstrated. No solvent degradation was noted. The cesium was easily and completely stripped from the organic solvent with dilute nitric acid, and good separation from sodium was observed.

Plutonium recoveries (as PuO_2) of 80 to 90 per cent and promethium decontamination factors of 370 to 1500 can be achieved by sparging LiCl-rich LiCl-NaCl molten salt solutions with chlorine-oxygen gas mixtures. Good quality UO_2 can also be produced by electrolytic reduction in these melts. Attempts to co-deposit UO_2 and PuO_2 electrolytically from these systems have thus far given poor separation from rare earths.

Engineering scale tests on the electrodeposition of UO_2 from molten salt solutions show that the production of reactor grade material is significantly impaired if the melt contains undissolved U_3O_8. Use of HCl, vice chlorine, for drying a melt containing U_3O_8 results in further product degradation over that caused by U_3O_8 alone.

Attempts to electrodeposit UO_2 from all-sulfate, all-fluoride and fluoride-containing chloride molten salt systems have been successful in part.

The rate of the photochemical reduction of uranyl nitrate to uranium(IV) nitrate was found to be dependent on the source of the uranyl nitrate solution. The rate of reduction of either Redox or Purex uranium product solutions is twice that of uranium solutions from pilot plant operations or of that prepared by the dissolution of UO_2.

Conversion of the jiggler ion exchange contactor from continuous to intermittent operation has significantly improved the over-all operability of the unit. Initial tests show high extraction efficiency and good control of resin movement.

Laboratory studies with simulated, Purex coating removal waste indicate that a volume reduction of about 6 is required to produce a slurry which will solidify completely at 80 C.

Using a rotary core bit, a sample of Purex underground stored waste sludge was obtained. A waste tank sluicer has been constructed, has successfully passed mechanical and hydraulic cold tests and is ready for installation.

The maximum temperature difference of water flowing through each of 24 pumps located in the 181-B building pump house was found to be two degrees (Centigrade). Thus, the thermally-hot spring water entering the 181-B forebay is not completely mixing with river water before entering the pumps.

The concentrations of tritium in all surface-ponded and steam condensate stream samples were found to be very near the detection limit, i.e., 1×10^{-5} µc/cc.

As evidenced by tritium analysis of monitoring well samples, contaminated ground water appears to branch into two plumes about 4 to 5 miles southeast of the 200 Area; one plume moves southeast and then east toward the Columbia River and the other continues southeast toward the 300 Area.

A Micro Pilot Plant run is in progress to evaluate the efficiency of Amberlite IR-120 for the extraction of cesium-137 and strontium-90 from Purex Tank Farm condensate. Thus far, the cesium-137 and strontium-90 concentrations in the ion exchange effluent have been less than their respective MPC_w values in over 10,000 column volumes of feed.

The reactor effluent As-76 monitor has been significantly improved. Sodium-24 and chlorine-38 interferences have been eliminated and drastically reduced, respectively, by the replacement of the ion exchange column with a three-fold larger unit.

The drilling of 18 new monitoring wells on Project CAH-921 has been completed.

3. Physics and Instrumentation Research and Development

In the NPR program, plans for the reactor system simulator were advanced through completion of a scoping study of the functional applications and the equipment requirements. The information developed was transmitted to IPD for incorporation in a project proposal.

Also for the NPR, experiments continued to determine the reactivity effects of flooding of the graphite and fabrication of instrumentation for the forthcoming nuclear purity tests of the laid-up stack was completed. One of two improved calculational methods gave satisfactory agreement when tested against the measured value of K_{∞} of the NPR lattice.

Hazards studies on existing production reactors were aided through the use of simulation methods which allow representation of the variation of control strength and power distribution in space as well as time. In the current method the reactor can be divided into six horizontal slabs. A further improvement to allow division into eleven regions is being developed.

Also in support of the existing reactors, the new process tube distortion, traversing mechanism was used to measure, with errors less than 3/16 inch, the contour of a 40-foot tube in a mockup.

A new radiation monitor instrument design was developed to meet the recently revised IPD functional specifications for updating reactor building monitoring equipment. Based on two previous developmental models, this new design provides a six-decade logarithmic response with transistorized circuits and a scintillation detector.

In a brief study of the use of fast reactors for plutonium production, it was observed that, for the same quality of plutonium (equal Pu-240 content), the exposure, MWD/T, in the fast reactor can be much longer than in a thermal reactor, yielding a greater quantity (50 to 100 times more) of plutonium before reprocessing is required.

In the Plutonium Recycle Program measurements of the resonance capture of Pu-240 in reactor fuel, in a PCTR experiment, indicated considerable self-shielding as the concentration of this isotope was increased.

New insight into the effect of crystal binding in the moderator on the neutron spectrum is being gained through improved analysis of results of rethermalization experiments in graphite. An attempt to represent this effect through a fictitiously large mass for the moderator nuclei is being explored.

Further improvements have been obtained in the microwave method for measurement of in-reactor creep reported last month. By use of a two-cavity balancing method the sensitivity has been increased by a factor of five, now giving results reproducible to two microinches. Long term stability was also improved and tests are continuing to determine the extent of this improvement.

A liquid effluent monitor with improved stability, reliability, and sensitivity was developed to replace the present system used in the PRTR containment trip circuit.

The experimental program continued at the Critical Mass Laboratory with the completion of eleven experiments during the month, most of them designed to test the effectiveness of concrete as a neutron reflector. Somewhat surprisingly it has turned out, in experiments to date, to be more effective than an equal thickness of water. Meanwhile, calculational methods for treating the interaction between neighboring subcritical assemblies have given satisfactory results when checked against experimental data on U-235 solutions obtained at ORNL.

Several advances were made in nondestructive testing research. Sensitivity of the broadband eddy current multiparameter equipment was significantly improved through new circuits. A new radiometer increased the resolution of the experimental heat transfer test so that a 1/4-inch-diameter bond defect could be detected in an aluminum-clad fuel element. Ultrasonic mode conversions predicted from Lamb wave theory were clearly observed with schlieren imaging methods. Some encouraging results were obtained in the development of an ultrasonic test to detect transverse cracks in installed aluminum process tubes.

Reproducibilities of 100 microinches or better are being obtained with the groove depth microscope recently developed for CPD Finished Products Technology and now installed. Visitors from two other laboratories have expressed a desire to have similar instruments made for them.

In the course of testing work on NPR primary piping, an interesting procedure was developed for obtaining laboratory quality metallographic examinations in the field. Weld-end preparations are hand-lapped and replicated with electron microscopy replication techniques. After shadowing with uranium dioxide, microscopic examination of the replica at 100X allows an excellent evaluation of grain structure, oxide inclusions, and extrusion effects.

Satisfactory results were obtained from first tests of an experimental transistorized instrument intended as a potential replacement for the obsolescent portable GM radiation monitor instruments now in use at HAPO.

Field experiments in atmospheric dispersion and transport resumed at Cape Canaveral, Florida, on January 11, under the direction of Atmospheric Physics personnel. The anticipated resultant data will complement data collected during May and June 1961 for the East Coast Summer climatic regime.

Future air diffusion experiments may be aided by a continuous ZnS particle monitor now under development. Field tests with the first experimental model showed a sensitivity of 4×10^{-8} gm/ft^3 compared to 2×10^{-9} gm/ft^3 for the filter collection and tedious counting techniques now used.

Further improvement was made in the P-32 counter by removing the light pipe. This eliminated considerable background--probably that due to Cerenkov radiation. It was demonstrated that P-32 from eating Columbia River whitefish could be detected in human subjects.

4. Biology

The effect of pH on gut absorption of Sr and Ca turned up some interesting suggestions as to mechanisms of absorption. At least at some pH's, the two ions appear to be absorbed by different mechanisms. It also seems that at very low and high pH's, the ability of the gut to discriminate between the two ions is lost.

The Sr^{90} chronic toxicity experiment in swine is progressing well. Pathological responses are becoming apparent in animals being fed the higher levels of Sr^{90}. Some difficulty, however, is being experienced in obtaining satisfactory radiographs with our equipment, due to long exposures and movement of the animals.

Some preliminary results are now available on the effect of I^{127} released to an atmosphere containing I^{131}. I^{127} does not seem to decrease I^{131} inhaled and deposited in the body. However, it does decrease the amount deposited in the thyroid, but not nearly as much as one would expect from simple isotopic dilution theory.

5. Programming

The MELEAGER physics code was compared with other physics codes, including a multi-group physics code named SPECTRUM, and the former code consistently yielded reactivities for given plutonium enrichments which were lower than the reactivities produced by the other codes. Hence, the use of the MELEAGER physics code generally results in computation of plutonium values which are less than the values which would be computed if other physics codes were used. There are grounds for believing, however, that the use of the MELEAGER physics code may overemphasize the increase in plutonium values which is sometimes computed for reduced U-238 spatial concentration.

Document HW-71811, "PUVE - A Computer Code for Calculating Plutonium Value," was issued. The report on hazards of shipping cerium-144 is being delayed to permit evaluation of new data on the hazards associated with strontium contamination in cerium.

The final shipment of separated and decontaminated high exposure plutonium for the Plutonium Recycle Program has been received.

TECHNICAL AND OTHER SERVICES

Based on an appropriate adjustment for the number of tubes charged, a system of control charts has been recommended for monitoring charge-discharge performance during individual reactor outages.

Major progress has been made on a computer program to produce magnetic control tape for the Gorton lathe. A series of tests designed to examine the program's reliability in distributing the proper signal along the tape have all been successful.

Closed form general solutions were obtained for a set of three ordinary nonlinear differential equations which arose from reactor shielding studies.

A second order, second degree differential equation, relating rate to time for a particular postulated mechanism of aluminum corrosion was integrated and the functional parameters estimated.

No new cases of plutonium deposition were confirmed by bioassay analyses during the month. The total number of plutonium deposition cases that have occurred at Hanford remains at 283, of which 205 are currently employed.

Measurements of the concentration of P^{32} in whitefish caught between Ringold and Richland in January indicate that the 1961 seasonal maximum occurred in late November or early December. This concentration was less than half of the 1960 seasonal maximum, undoubtedly reflecting the effects of the special influent water treatment of the production reactors.

The average concentration of air-borne radioactive fallout materials in the Pacific Northwest was essentially unchanged from last month. The concentrations were in the range of 3 to 9 $\mu\mu c/m^3$.

There are 15 currently active projects having combined authorized funds in the amount of $5, 797, 600. The total estimated cost of these projects is $10, 661, 000. Total expenditures on them through December 31, 1961 were $2, 968, 000. In addition project proposals have been submitted to the Commission requesting $224, 000 total project funds on two new projects.

Project CAH-921, Geological and Hydrological Wells - FY-1961 was completed during the month. Estimated final cost is $79, 000 compared to $79, 000 authorized funds.

SUPPORTING FUNCTIONS

The PRTR output was 955.11 MWD plus 36 hours of shutdown experimental time, resulting in a plant efficiency of 44% and a total experimental time efficiency of 48%. Total energy to date is 4593 MWD. Exposure for maximum UO_2 fuel element is 1360 MWD/T and for maximum Pu-Al is 62.7 MWD or 37.4% burnup. The sixth refueling was accomplished 1-17-62. Total elements remain at 39 Pu-Al and 46 UO_2. Three new Pu-Al test elements were charged and the nested tubular UO_2 element was moved into a higher flux zone.

Heavy water losses chargeable to PRTR operating cost during January amounted to $18, 000. Accumulated scrap for return to Savannah River is valued at $209, 000.

The Plutonium Recycle Program Critical Facility is nearing completion, startup plans have been issued for review and operating procedures were completed in draft form. The fuel element rupture test facility is not quite up to schedule (75% complete compared to 84% scheduled). Design tests are in progress on portions of the gas cooled loop.

Reorganization of supporting functions in HLO was completed with the establishment of the Finance and Administration Operation and the discontinuance of the Laboratories Auxiliaries Operation.

Educational Courses - Thirteen participants completed the Creative Approach Seminar. Autumn Quarter Tuition Refund payments were processed for 81 successfully completed courses.

Recruitment - In the advanced degree area, nine PhD applicants visited for employment interviews, four new offers were extended, one acceptance and three rejections were received and four offers currently remain open.

In the BS/MS area, two offers were made for direct placement making a total of three such offers now open.

Three offers were extended for the Technical Graduate Program, one acceptance was received, and three offers are currently open.

Technical Graduate Program - Eight Technical Graduates were placed on permanent assignment, two were terminated, leaving a total of 63 currently on the program.

Paul F. Gast

for Manager
Hanford Laboratories

HM Parker:PFG:st

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Dual Cycle Chromic Acid Autoclaving of Aluminum. The chemical composition of the oxide films removed from three X-8001 coupons exhibiting the greatest corrosion resistance was determined and found to be 36% Al and 20% Cr (average). Traces of an interfering ion, possibly Fe or Ni, were noted during the analysis.

A modification of the dual cycle chromic acid autoclave process is also being developed. The new process appears to provide the same, if not better, corrosion resistance and yet is free of "worm-tracking" and galvanic coupling effects. The process consists of a water autoclave pretreatment and a potassium dichromate-sodium hydroxide final autoclave treatment (pH $\sim$5 to 9). The alkaline dichromate process has an additional advantage in that the resulting films are a light grey-brown and hence easily inspected.

Corrosion of Zr-Be Brazed End Closures and Copper Bonded End Closures. An investigation of the corrosion characteristics of zirconium-beryllium brazed end closures and copper bonded end closures is being conducted. Tests in both 360 C water and 400 C steam have shown that the welded beryllium braze closure corrodes approximately twice as fast as the unwelded braze and 4-1/2 times as fast as the Zircaloy-2 cap. Corrosion penetrations of 0.7 mil (three months, 360 C water) and 0.8 mil (six weeks, 400 C steam) were measured for the welded braze closure, as compared with 0.16 mil for the Zircaloy-2 caps. The 360 C water test appeared to produce more white oxide on the welded braze area than the 400 C steam test at similar weight gains.

The copper bonded end closures are being tested in both 400 C steam and 360 C water but have not received sufficient exposure to allow evaluation of the corrosion results.

In-Reactor Resistance-Measurement Capsule. Laboratory experiments have shown that measurement of electrical resistance across a zirconium oxide film may serve as a monitoring system for detecting hydriding conditions. An in-reactor capsule is being prepared to examine irradiation effects on film resistance. The capsule has been designed and most of the parts have been fabricated. Assembly and testing will be complete within another month. The capsule will be charged in 2A side-to-side test hole at 105 KE during the scheduled reactor outage in late February or early March.

Zircaloy Components for NPR Fuel

The average grain diameters of Zircaloy-2 components for coextruded fuel normally range from a low of 0.008 millimeter to 0.026 millimeter. A few components have been encountered with grain diameters up to 0.250 millimeter. To demonstrate the effect of grain size on clad quality, an N fuel outer coextrusion was made using an inner sleeve in which large grains, about 2 millimeters in diameter, had been purposely grown. The extremely rough clad surface and U-Zr interface that resulted emphasizes the desirability of fine grained Zircaloy components for coextrusion.

Clad thickness variation or "wanderlust" in N fuels may result from areas in the Zircaloy components which have different extrusion characteristics. If one area extrudes easier than another, then thick and thin cladding could result. Hanford has experienced this inconsistent response of Zircaloy to extrusion forces on many occasions. For example, a Zircaloy sleeve made from a hexagonal forging coextruded to a clad that was round on the outside but of hexagonal shape on the inside. From the preferred orientation imparted by forging, the metal had a memory of the previous working.

In analyzing the manufacture of components, asymmetrical or uneven working was present in the forging operation employed by all vendors. In forging, the metal working is done in discrete steps along and around a solid ingot over a considerable temperature range. These circumstances would cause local differences in preferred orientation and possibly lead to variations in clad thickness via the memory mechanism. To test this hypothesis a cooperative program with FPD has been started to compare clad variations between components made with and without forging. In the manufacture of the test components, the forging will be replaced by primary extrusion to provide even and symmetrical metal working.

Radiometallurgy Laboratory Studies

Metallography of a 2 percent Zr-U alloy KER size tube-in-tube element, GEH-12-8, indicated the presence of a second phase in the highest temperature zones. Replicas for electron microscope studies are being made for further examination (RM 589). Six clad fuel rod sections were cut into pieces 4 inches long and shipped to Chemical Research to dissolve out the fuel. The cladding will be used for burst tests at a later date (RM 591). A longitudinal section through the end closure of an NIE element exposed to 1000 MWD/T at simulated NPR conditions was examined. The end closure was in excellent condition with no cracking or voids in the braze, and the uranium and braze were well bonded (RM 592). Three NIE elements irradiated to 2300 MWD/T in which the enriched uranium core was alloyed with iron and silicon were examined visually and measured. The elements appeared to be in excellent condition with no bumping or significant dimensional changes being found (RM 593). The appearance of the etched Zircaloy-2 process tube from KER-3 at 13 feet and 26 feet from the front end was the same when compared metallographically. Burst tests on three tube sections were completed. NaK capsules GEH-14-94, 95 & 99 were opened successfully with newly modified equipment. Test specimens from the capsules have been quite badly swollen and split open (HL [illegible]).

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

Basic Metallurgy Studies

Notch Sensitivity of Zircaloy-2. Mechanical properties of Zircaloy-2 clad test elements are being investigated. In support of these studies, notched tensile samples of Zircaloy-2 rolled sheet are being tested in the irradiated and unirradiated condition. Comparison of data will demonstrate the change in strength and elongation caused by combined effects of notch strengthening and radiation damage. An irradiation capsule has been designed which will permit tensile specimen irradiation at essentially reactor bulk water coolant temperatures. This capsule is tubular in shape and allows coolant to flow around the external capsule surface, through the annulus containing the test material, and through a central bore. The specimens, 30 in each capsule, are held in a spacer with their transverse axis extending radially. Calculations indicate a film ΔT of 1.1 F and a specimen surface temperature of 121.1 F. Two of these capsules have been assembled for a proposed exposure of approximately 1×10^{20} nvt (fast) in the ETR core. This irradiation will provide tensile samples of 0.020 inch rolled Zircaloy-2 sheet with V notch depths varying from 0.001 inch to 0.010 inch. In addition, several unnotched tensile specimens formed from coextruded Zircaloy-2 cladding are included for irradiation effects studies.

Electron and Optical Microscopy. A formal report, HW-72114, "Fission Induced Vaporization of UO_2 from a Source and Subsequent Condensation on Collectors Exposed to Fission Fragment Bombardment," has been prepared. This paper presents evidence that UO_2 in the immediate vicinity of a moving fission fragment does vaporize from a fission source film. The deposit which condenses on collectors during vacuum irradiations has been identified by electron diffraction as UO_2. Long fission fragment tracks in the collector can be attributed to fission fragments originating from the deposit on the collector. It was found that a 200 A thick amorphous coating of carbon on the surface of the UO_2 fission source film greatly reduces the vaporization. Three types of collectors, amorphous carbon, carbon with a thin coating of platinum, and large grained aluminum, which were bombarded with fission fragments from carbon coated UO_2 sources, display holes and tracks. Fission fragment damage in these targets differ as to track geometry and amounts and uniformity of material ejected.

Metallic Fuel Development

Charging Force Studies for Present Reactors. Additional [illegible] are under way to determine if lower friction coefficients and [illegible] process base galling is primarily a function of addition of lubricant, or of circumferential orientation of the fuel supports. Several additional tests have been completed, and observations supported by calculations indicate that the 10 percent solution of A-60 soluble oil in the water lowers the coefficient of friction. The soluble oil solution also reduced the galling of the process tube. Quantitative and qualitative data have been compiled.

Fuel Irradiations. Irradiation of the first full-sized NPR fuel element has continued in the 6x6-M3 Loop in the ETR. Outlet temperatures were maintained at 270 C and the maximum cladding surface temperature was approximately 300 C. On January 2, 1962, the reactor was shut down after the fuel element had accumulated a total average exposure of 550 MWD/T. The fuel element was removed from the reactor, disassembled and measured. The warp of both the inner and outer tubes had reversed itself during the last reactor cycle as was expected (the fuel element was rotated 180 degrees about its longitudinal axis when it was reinserted at the beginning of the last cycle). The warp of the outer tube changed from 50 mils warp in a direction away from the center of the reactor core to 50 mils toward the center of the reactor core. The inner tube changed from 25 mils away from the center of the reactor core to 40 mils toward the center of the reactor core. Within the accuracy of the measurements, there was no change in the OD of the outer tube. No OD measurements were made on the inner tube. Three supports were missing from the inner tube when the fuel element was disassembled, two from the mid-length and one from the lower end. It has not been determined whether the supports broke off while the fuel element was in the reactor or during handling before or after the last reactor cycle. The inner tube will not be irradiated further and the spare inner tube is being used during the remainder of the test. When the fuel element was recharged into the reactor for the current cycle, it was rotated 180 degrees to its original position to see if the warp would again reverse itself. The irradiation is proceeding satisfactorily and at the present time the total average exposure is 630 MWD/T.

The production brazed irradiation test at the MTR, GEH-4-63 and 64, is now in the ETR canal where periscope measurements and pictures are being taken. The over-all appearance of the fuel is good. After sufficient cooling, the elements will be returned to Hanford for detailed radiometallurgical examination.

The variable braze thickness test, GEH-4-68, 69 and 70, has satisfactorily completed its second cycle of irradiation and is now in its third cycle. Five cycles of irradiation have been requested.

Pre-Irradiation Evaluation. Charts and file folders were made up showing the progress of elements to be irradiated in the modified KER Loops 3 and 4. The file folders contain all the data which has been collected on these elements to date. These data include: billet and component numbers, dimensions, and chemical analyses; individual assembly, preheat, and extrusion information; angular orientations of components and extruded tubes; dimensions of elements before copper strip; warp measurements on each element before and after heat treatment; special clad thickness measurements by eddy current showing the specific clad thickness at 60 degree intervals around the element and at three positions along its length; and thermal expansion measurements on each of the elements to be used in the charges.

The elements to be charged have been chosen on a basis of billet type and position in the extruded tube. Alternates have been selected for each charge in case of support or autoclave rejects. As soon as autoradiograph film is received on these elements, they will be autoclaved, and Sheffield warp and wall thickness measurements can begin. The thermal expansion measurements were made by obtaining the change in length of the element between 25 C and 100 C in oil bath. The measurements gave an average coefficient of thermal expansion of 13.0×10^{-6} per C on thirty-four inners tested, and 12.7×10^{-6} per C on fifty-nine outers tested. The coefficient for the outers seems to increase at the head end of the extruded tube, and the coefficient for both the outers and the inners seems to be at a minimum at the center of the extruded tube. These measurements show that the cladding restrains the expansion of the uranium, since bare uranium has a coefficient of thermal expansion of about 18×10^{-6} per C.

Pre-irradiation measurements of geometry, density and clad thickness were completed on the single tube element which is to be irradiated in the ETR, and the element was shipped to the reactor site. The basket assembly which will hold the element in position in the loop was redesigned to provide radial support in the event the centering supports which are attached to the element fail during the test. The new assembly was fabricated and shipped to the ETR. Measurements characterizing the shape of the element were obtained with the Sheffield measuring machine. Processing of the data indicated negligible warp, ovality, wall variance, or departure from design diameters in the tubular shape.

Fuel Swelling. An analysis of KSE fuel swelling data obtained for mean fuel temperatures in the range 400 - 470 C and an exposure range of 1200 - 3600 MWD/T, indicates that fuel swelling from the theoretical minimum to the theoretical maximum at 1600 psi occurs in the temperature range 350 - 500 C. The theoretical minimum swelling is that which results from the gain of fission product atoms at the expense of fuel atoms and may be expressed, Theo.Min. $\% \Delta V = 2.5$ (a/o B.U.). The theoretical maximum swelling is that which results from the agglomeration of gaseous fission product atoms to form bubbles in the fuel material that are at pressure equilibrium with restraining forces. An expression for the theoretical maximum, considering KER loop coolant pressure of 1600 psi as the only restraining force, is

$$\text{Theo.Max. } \% \Delta V = 2.5(\text{a/o B.U.}) + \frac{(\text{a/o B.U.})(440)(T_{ma})(14.7)}{(273)(1600)}$$

T_{ma} = vol. mean fuel temp., absolute.

swelling of the higher temperature 2000 and 3000 MWD/T exposure KSE's appears to have attained the theoretical maximum calculated by the above expression. Irradiation tests at higher fuel temperatures would be desirable to determine if the transition from minimum to maximum fuel swelling has indeed been achieved, and whether or not the coolant pressure is the only significant restraining force that limits the swelling.

Extrusion Behavior and Properties of Zirconium Alloys. A series of zirconium alloys have been prepared by double vacuum arc melting that will be used to determine extrusion constant versus temperature data, resulting structure, mechanical properties, and corrosion behavior. The object of the work is to determine whether a corrosion resistant alloy more nearly matching the extrusion behavior of uranium and with greater ductility than Zircaloy-2 can be developed by altering the tin and oxygen content of a nominal Zircaloy-2 composition. Two zirconium sponge blends are being used to yield a high (1300 ppm) and low (560 ppm) oxygen content and for each blend the tin content is being varied from 0.10 to 1.50 w/o. The iron, nickel, and chromium contents are being held at the nominal Zircaloy-2 composition.

Final extrusion of the above alloys has been completed. A total of 68 extrusions were made. Each of the 16 alloy compositions were extruded at four different temperatures -- 500, 600, 640 and 750 C. Four uranium extrusions were made under identical conditions for comparison. The extrusion data are currently being evaluated. Some of the results are as follows:

(1) Zircaloy-2 with 1300-1400 ppm O_2 has an extrusion constant of 23.2 to 17.4 tons/in^2 in the 500-750 C temperature range. This same alloy with 500-700 ppm O_2 has an extrusion constant of 21.8 to 16.8 tons/in^2 in the same temperature range.

(2) Pure zirconium with 1300-1400 ppm O_2 has a constant of 19.9 to 14.3 tons/in^2 in the 500-750 C range. Lowering the oxygen to 500-700 ppm puts the constant at 17.2 to 13.6 tons/in^2 in the same temperature range.

(3) Uranium in the 500-640 C range has an extrusion constant of 17.1 to 12.0 tons/in^2.

(4) Preliminary examination shows that at about 530 C, both uranium and the pure zirconium of 500-700 ppm O_2 have the same extrusion constant of 15.8 tons/in^2.

Hydrogen in Uranium. Nine NOE and two NIE uranium coextrusion billets having greater than 2 ppm hydrogen by ingot analysis were given an alpha vacuum treatment to reduce the hydrogen level. One NOE billet was sampled before and after heating to determine hydrogen gradients. The cycle used was eight hours at 600 C at a pressure of approximately 2×10^{-5} mm Hg. The hydrogen content was 2.0 to 2.5 ppm as received and was reduced to 0.9 - 1.1 ppm at the inner and outer quarters and to 1.8 - 2.0 ppm at midwall. These data indicate that the hydrogen was reduced to within specification but that the cycle time should be increased to reduce the concentration gradient.

Fuel Deformation Studies. Four cladding studies capsules were charged into DR reactor on January 7, 1962, and are performing satisfactorily. The temperatures at present are somewhat higher than those desired. Cladding surface temperatures in three of the capsules is calculated at 330 C and in the fourth capsule at 400 C. When the reactor reaches equilibrium operating conditions, these temperatures will approach those called for in the test.

Fabrication of components for a second irradiation test of fuel rods with non-uniform thickness Zircaloy-2 cladding is progressing. Machining of the capsule parts is 90 percent complete. Preparation of billets for primary extrusion of the fuel is one-half complete.

Six fuel rods clad with Zircaloy-2 were removed from NaK capsules that were irradiated in the MTR. The cladding on all rods was split, in several cases to the point where uranium extruded out of the split and came in contact with the capsule can wall. The cladding failures appear to have been ductile, but NaK residue prevented a close examination. Cladding surface temperatures were in the range of 325-350 C.

In order to formulate material models for reactor fuel elements, the mechanical behavior of both the fuel and cladding material must be known under the conditions encountered during reactor irradiation. Since the cladding is being strain-cycled due to the difference of the thermal expansion of the fuel and cladding materials, its resistance to increasing straining induced by the fuel material swelling must be determined under incremental strain-cycling conditions. The modifications of an apparatus and an internal extensometer used to make such material measurements are completed. An initial test was run without buckling of the specimen during the compression portion of the straining cycle. In order to measure the resistance of the uranium to deformation and failure by strain-cycling, an in-reactor strain cycling capsule for uranium has been designed. Assembly of this capsule is completed. The analysis for shaped cylindrical fuel elements based on a fluid or viscous behavior of the uranium was described in HW-70501. The results of this analysis indicated that minimal stress conditions occur in corrugated cylinders if the inner to outer arc radii of the corrugations are in ratios of 0.2 to 0.4. The values for these ratios decrease when the arc length to base circle circumference and the number of corrugations decreased.

Closure Development. Approximately 100 short lengths (4-3/4 inches long) of NPR inner tubes were hot headed on one end by the same heading technique used for the hot headed projection welded closure. These headed tubes will be used for the evaluation of other closure welding techniques on the hot headed ends. These short tubes were contained in a full length heading container and the conventional heading dies were used. The fuel elements were induction heated to 640 C for the heading operation. The Zircaloy-2 shoulders on the OD of the hot headed end thickened very satisfactorily. The ID Zircaloy-2 shoulders, however. did not thicken above the ID cladding thickness. The thinner ID shoulders, while not desirable, may not be restrictive to the closure welding.

Recent weld tests on NPR inner fuel with projection welded brazed closures are similar to results obtained on KER inner tubular fuel with the same joint configuration. Micrographic examination of the weld shows the OD projection weld to have 100 percent fusion between the cap and cladding while the ID projection has small cracks on the inner Zircaloy surface. The difference in weld quality between the ID and OD is caused by current distribution across the cap and may be adjusted by contouring the movable electrode. Favorable results were obtained with a 30 to 36-inch radius electrode. The bond between the wedge shaped cap (75 degree included angle) and uranium is abetted by immersion plating copper on the Zircaloy-2 cap to form eutectic alloy with uranium. Formation of the copper-uranium alloy occurs early in the braze portion of the closure cycle which provides filler metal for voids caused by misalignment or machining. Non-uniformity of copper content and alloy thickness presents some question in regard to the physical characteristics of the bond, i.e., ductility, thermal shock resistance, strength and heat transfer. Tests to determine these and other characteristics have not yet been conducted. Slight alteration in the weld schedule and joint configurations have improved uniformity of the eutectic alloy and thickness and further adjustment is also expected to improve the bond.

Continuing the work described in the last reporting period, the concept of forming self-brazed closures by passing heavy current longitudinally through the assembled and end-welded fuel element was pursued further. To prevent distortion of the fuel element under axial load when it becomes plastic, a full length steel restraining die with a ceramic insulating liner was prepared, together with a pair of insulated copper electrodes to be attached to the heavy-duty Sciaky spot welder. An already welded and pressed fuel element with poor closure bonding was placed within the die and supported axially between the two electrodes under about seven T pressure. Several pulses of high amperage current were passed through the element. Subsequent examination of the element indicated that the closure zones at both ends had been heated considerably more than the intervening body of the element, although neither end had attained a temperature quite sufficient to permit plastic flow with diffusion bonding. The experiment will be repeated with increased power applied.

<u>Fiber Metal Welding</u>. Fiber metal welding techniques are being investigated for application to the fabrication of fuel element closures. Fiber metal welding involves the use of thin mats made from small diameter fibers which may be placed between the faying surfaces of parts to be joined. Although heat and pressure may be applied by several techniques to join the parts, resistance heating appears to have some advantages over other methods. These advantages accrue

 [redacted]

because of the localized heat generation which is a result of the inherent multiplicity of high resistance contact surfaces. These mats may consist of one metal or alloy, or they may contain combinations of metal or alloy fibers. Another variation may be a mat containing metal or alloy fibers which are impregnated with a lower melting alloy. The application of this process to the development of a fully bonded end closure of the "hot-headed" type will be investigated.

N Fuel Supports. Fatigue tests were started on vendor-produced N Reactor inner fuel tube supports to see if fatigue is a potential cause of support failure. These tests were started because of the occurrence of broken inner tube supports on an N Reactor assembly irradiated vertically in the ETR, disassembled and recharged into the reactor after the first irradiation period. Out of six supports tested through a cyclic compression of 0.020 inch, four broke between 1×10^5 and 1×10^6 cycles.

Demonstration of the inner support feeding mechanism for the magnetic force welders in 333 Building has been awaiting availability of inner supports in quantity. The supports have arrived. These supports when welded with the weld schedule developed for hand crafted supports would not pass the shear test. The weld schedule has been modified and the supports are now showing an acceptable tangential shear strength near 800 pounds. Metallographic examination has shown no bond damage, uranium grain growth, or other undesirable properties resulting from the new weld schedule. The support feeding mechanism has been demonstrated. The magazine section requires further work to function properly; however, the unit works well as a manually loaded single support feeder.

2. REACTOR PROGRAM

Corrosion and Coolant Systems Development

Diffusion of Water Vapor Through NPR Core Graphite. Water vapor transport rates were measured through graphite thimbles of 5/8 and 5/16-inch thickness to supplement earlier studies of a 1-1/8-inch thick thimble. Measurements were made at several temperatures and partial pressures of water vapor. The effective diffusion coefficient for NPR core graphite was calculated to be between 0.1 and 0.01 cm^2/sec, indicating fairly high permeability of the graphite. The diffusion coefficient varied with both graphite thicknesses and water vapor concentration in the helium indicating chemical reactions were affecting the water transport rate. Experimental work on this program is concluded and will be summarized in a formal report.

NPR Fuel Rupture Testing. A programmer was installed on TF-4 Loop to carry out rupture tests at controlled cooling rates. One predefected fuel element, a coextruded KER inner tube, was tested using the programmer. The rupture was initiated at 300 C and the start of the rupture was determined with a hydrogen detector. After 15 minutes at 300 C, the element was cooled using the NPR slow cooldown rate.

[redacted]

NPR Corrosion Studies. The Breakaway Corrosion Loop, [illegible], was installed in 1 C0 KE and successfully tested. During heating and cooling, slight leaks developed at the heater and pump flanges, but at temperature (900 F, 5000 psi) only a very slight leak at the pump flange was noticeable. It is believed that these leaks can be eliminated by changing heating and cooling rates and changing pressure conditions on cooldown. New improved seal rings are also being obtained from Gray Tool Co. No temperature control abnormalities were noted as the temperature was raised from 600 to 720 F past the critical temperature of water. The heat loss from the loop was very low.

The test to determine the corrosion rates of NPR secondary system materials of construction in NPR secondary system boiler water is continuing. Test conditions are deionized water at 100 C containing 30 to 50 ppb hydrazine and sufficient NH_4OH to raise the pH to [illegible].

After 2400 hours of exposure the corrosion rates of 304 S/S, Admiralty metal, 70-30 Cu-Ni, and silicon bronze are 0.012, 0.11, 0.0[illegible], and 0.03 mil/year, respectively. The corrosion rate of A212 carbon steel has fallen from an initial rate of 0.6 mil/year after 1400 hours of exposure to 0.08 mil/year after 2400 hours of exposure. Deposition of a nonadherent, black oxide from the carbon steel loop piping continues to be a problem.

The test to determine uniform corrosion rates of materials in raw Columbia River water at 210 F is continuing. After 5000 hours of exposure, the carbon steel corrosion rate is 5 mils/year; the attack is characterized by numerous small pits. The stainless steels and 70-30 Cu-Ni corrode uniformly at very low rates; Admiralty metal corrodes at a rate of 0 mils/year.

After six weeks, 0.1 percent LiOH has still caused no accelerated attack on stainless steel, carbon steel, or Zircaloy-2.

NPR Decontamination Studies. Two new decontamination agents were obtained from TURCO. Turco 4306-C, improved, containing no chlorides, fluorides, or oxalic acid; and Turco 4513, improved, containing no oxalic acid. The oxalic acid has previously caused trouble by redeposition of ferrous oxalate. Preliminary tests showed these reagents were comparable to the 4306 C and 4513 in laboratory evaluations. Two materials from Kelite Corporation were ineffective.

A bisulfate decontaminant from Oakite was very interesting in that after eight complete cycles, there was no accelerated attack at the weld junction. The attack over the carbon steel sample was very uniform and averaged about 3 to 4 mils after eight cycles. This may be compared with the 14 mils attack at the weld junction after six cycles with inhibited phosphoric acid. The Oakite compound still is too corrosive giving a uniform corrosion rate of ~0.24 mil/hour, about three times as high as is desirable.

1250097

[redacted]

The dendritic attack of Stellite by the alkaline permanganate still continues to be a problem, although the attack has been largely inhibited by use of phenylthiourea. Since the principal action of the phenylthiourea appears to be as a chemical reducing agent, other reductants have been tested. Some compounds, such as sodium sulfite and formaldehyde, appear promising.

Several chemical mixtures have been tested to evaluate their effectiveness for dissolving the uranium oxides in a reactor system after a rupture of a fuel element. Quite different rates have been obtained for dissolution of reagent grade UO_2 and dissolution of oxides from a rupture. Analyses of the oxides from a rupture showed about 45-50% U^{+6} and 50-55% U^{+4}.

Stress Corrosion Cracking of Brass Fittings on "C" Inlet Piping. Brass sleeves recently installed with Inconel front pigtails have shown a few failures. Samples of brass sleeves and nuts were tested in an ammonia atmosphere for 96 hours. Three reference samples of Admiralty brass were all cracked during this exposure, but neither the replacement nor the original brass samples from the reactor showed any cracking. The new brass sleeves were found to be quite hard and "brittle". Several unexposed sleeves were broken by mechanical force, with less than 10 percent deformation.

Structural Materials Development

Pre- and Post-Irradiation Examination of Zircaloy-2 Pressure Tubes. The 50 percent cold worked Zr-2 tube removed from KER-3 after reactor service for about two years has been examined and tested. A section of the tube subjected to an intermediate flux level exhibited a completely cold worked structure and no hydride platelets were visible. The microstructure duplicated that of the section from the high flux zone.

Room temperature burst tests were performed on sections from various locations along the tube.

Location	Internal Burst Pressure, psi	Hoop Stress, psi	Fracture Type
Unirradiated control	16,700	108,000	90% cleavage
Rear Shield	17,900	111,000	Cleavage
Low Flux	18,700	116,000	Cleavage
High Flux	18,300	114,000	Cleavage

Based upon visual comparison, the amount of bulging associated with the fracture of the irradiated tube sections was about the same as the unirradiated sections; however, there was a difference in fracture appearance. The fracture of the control sample initially propagated through the wall by a cleavage mechanism and then progressed the length of the sample by a shear mechanism. Fracture of the irradiated tubes including the piece from the rear shield zone appeared to have propagated by a 100 percent cleavage mechanism.

Room temperature load-deflection curves for crushing rings cut from various locations along the length of the tube indicated an increase in strength for those rings subjected to neutron irradiation. When tested at 300 C, however, no significant difference was measured.

Nonmetallic Materials Development

Graphite Burnout Monitoring. Burnout monitoring samples in Channel 2577 since September 1960 were discharged recently from DR Reactor. The results indicate that conditions have contributed to local high oxidation of the moderator, as shown by the data below.

Position of monitor from front of graphite stack, in.	Measured burnout rate, % per 1000 operating days
43	0.46
47	0.66
51	1.42
55	2.23
59	3.22
160	16.91
164	9.58
168	8.25
172	7.05
176	6.64
277	0.43
281	0.29
285	0.22
289	0.14
293	0.08

The data show that the oxidation profile has a sharp peak in the front half of the channel. This same phenomenon has also been observed in the latest monitoring samples from C, D, F, H and KE Reactors.

Localized Oxidation of Full-Size Graphite Bars. In the course of a visual inspection of the graphite in VSR Channel 47 at C Reactor during the early part of August 1961, it was noted that significant oxidation on some of the graphite blocks had taken place. Several aspects of this phenomenon are significant: (1) the oxidation was substantial only on the ends of the bars rather than along the sides; (2) the oxidized area was usually circular and was most often located in the center of the ends of the bar; (3) the craters were estimated to range from 1/2-inch to 2-1/2 inches across and 1/4 inch to 1 inch deep; and (4) the sides of the craters were perpendicular, never concave or dished out.

The reasons for this type of localized corrosion have been investigated in the laboratory, and it is concluded that impurities remaining in the graphite after manufacture were responsible for catalyzing the oxidation. A full-sized bar of F-purified graphite which had been used in

 [redacted]

an experiment in the Thermal Test Reactor was obtained from the Reactor Lattice Physics Operation. In the center of one end of the bar was a crater about 1-1/4 inches across and 1/2 inch deep. After cutting the bar into 1/2 inch slabs perpendicular to the extrusion axis, the slabs were completely oxidized. The resulting ash patterns showed that: (1) relatively large amounts of a dark-red material, about 1-1/2 inches in diameter, were concentrated in the center of the slabs; (2) the intensity of the color and the quantity of the ash residue diminished progressively along the length of the bar to a distance of about 20 inches from the end; (3) along the remaining length of the bar there was only a uniform deposit of the impurities. An analysis of the chemical composition of the ash is not complete yet.

NPR Graphite Irradiations. The first capsule, H-4-1, in the series of long-term irradiations for proof testing of NPR graphite has successfully completed its first cycle of operation. It is being irradiated in a guide tube in the D-7 position of the General Electric Test Reactor. The Number 4 thermocouple failed a few hours after startup of the second cycle of irradiation, but the other eight thermocouples are operating satisfactorily. Sample temperatures vary from 350 C to 750 C along the length of the capsule. The capsule contains NPR graphite samples removed from three positions (center, midway, and edge) cut transverse to the extrusion axis of the bar to determine whether bar edge effects are present. Also being tested are: parallel samples of NPR graphite; transverse samples of TSGBF graphite; and CSF graphite used as a reference material at each sample position.

The second capsule, H-5-1, containing NPR graphite was installed in the F-7 position of the GETR on January 8, 1962. All nine thermocouples are operating satisfactorily. Sample temperatures vary from 325 C to 750 C and agree within 15 C with the corresponding sample position in the H-4-1 capsule.

Several modifications were made to the H-5-1 capsule and its supporting in-core beryllium filler piece just prior to reactor installation. These modifications were necessitated when a wear pattern was observed on the prototype dummy capsule that had been in operation for one reactor cycle. To alleviate this problem the aluminum wear surfaces on both the capsule and the filler piece were replaced with 304 stainless steel surfaces. A collar was slipped onto the dummy capsule to eliminate further wear and the capsule was reinstalled in the GETR to serve as a prototype for the thermocouple leadout system of the H-5-1 capsule.

Surface areas and helium densities have been determined on four samples of TSX and two samples of CSF graphite to be exposed in capsule H-6-1, which is scheduled to be charged into the GETR on March 12.

Irradiation Damage to Plastics. A complete equation for carbonyl formation in gamma irradiated polyethylene has now been achieved with the addition of an empirical relationship between the diffusion coefficient and the dose rate. The equation is:

$$A = Cr \, (\rho \, D_o)^{1/2} \, \left(\frac{1 - e^{-k\delta}}{\delta}\right)^{1/2} \delta \left(1 - e^{-\beta L}\right)$$

where A is the optical density of the carbonyl at $\sim 1720 \text{ cm}^{-1}$, C, ρ and k are constants, r is the total gamma exposure, δ is the dose rate, and L is the sample thickness. β is given by

$$\beta = \left(\frac{a}{D}\right)^{1/2}$$

where the reaction probability factor, a is given by $a = \rho \delta$ and

$$D = D_o \, (1 - e^{-k\delta})$$

It has been shown that D_o can be taken as the value of the diffusion coefficient (for oxygen) in the unirradiated polymer.

Thermal Hydraulic Studies

Heat Transfer Conditions for Eccentric Annuli. Experiments were continued to determine the heat transfer conditions when fuel elements are not situated in a coaxial position within the process tube. Data applicable to I&E fuel elements were obtained using two different test sections 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.)

One of the test sections consisted of a 13.6-inch long electrically heated rod, 1.304 inches in diameter, placed within a 1.504-inch glass tube. Metal support strips fastened to the rod for spacing were insulated so that heat was generated only in the rod. Boiling conditions were observed and recorded with high speed motion pictures at several pressures and water flow rates.

Boiling invariably started between the support strips and the rod where the water was relatively stagnant. The bubbles would be forced out into the annulus where they would be swept downstream where they condensed in the subcooled water. As the heat flux was increased and the boiling became more vigorous, the bubbles would collect together forming large areas of steam which would be swept downstream. In one case the heat flux was increased until boiling burnout conditions existed. In this case, film boiling began underneath a support strip and then spread to cover a region about four inches long and 1-1/2 inches wide before the power was reduced to prevent overheating the test section. It was concluded from the observations that should the supports on fuel elements become crushed so that the fuel element lies eccentrically within the process tube, considerable boiling will take place beneath the support piece. This would no doubt decrease the boiling burnout safety factor and would possibly influence the corrosion rate.

 [redacted]

In a separate test section, boiling burnout was investigated with a model simulating four fuel pieces, 75 percent eccentric in a C overbore process tube. At a flow of 41 gpm and a pressure of 141 psig (which represents the annulus flow conditions in a central zone tube) boiling burnout was encountered when the heat flux was increased to 715,000 B/hr-sq ft at a bulk water temperature 122 F below the boiling temperature. In this case the boiling burnout conditions were not detected soon enough and a hole was melted in the test section.

Heat Transfer Characteristics of NPR Fuel Elements. The studies to determine the boiling burnout conditions for the NPR tube and tube fuel elements were continued. The data obtained last month with a 46-inch long electrically heated test section simulating the outer heating surface was compared with previous data. It was found that the data showed close agreement with data from a test section of identical cross-section geometry but only 23 inches long. At mass flow rates above 2,000,000 lb/hr-sq ft the burnout heat fluxes for these two test sections were lower than those obtained for test sections simulating the middle flow annulus and the center flow channel. On the other hand, at flow rates below 500,000 lb/hr-sq ft the burnout heat flux for the outer flow annulus was slightly higher than that for the other two flow channels. No reason for this difference was apparent.

All of the boiling burnout data for the NPR have been obtained with the test sections in a horizontal position. In order to better compare these data with results of investigations at other sites, one of the NPR test sections was installed in a vertical position. Forty-one boiling burnout points were obtained for vertical flow through an electrically heated test section identical to one used in a horizontal position to obtain data for the center hole portion of the NPR fuel elements. These data, obtained at 1500 psig and various flow rates, compared closely with the data from the horizontal test section. It was concluded that gravity has little effect on the steam-water flow patterns influencing boiling burnout for the conditions studied.

Hydraulic Work. Laboratory data were obtained which showed that a Van Stone seal insert could be modified to reduce flow in an empty BDF tube during chemical cleaning of the rear header fittings. It was found that placing some masking tape over the outlet ports of the Van Stone seal insert resulted in the desired flow rate. The tape would withstand the relatively high pressures put on it previous to the chemical cleaning operation and would also permit about 75% of ordinary empty tube flow at full header pressure in case the device should be left in the tube inadvertently after the cleaning operation.

Shielding Studies

The neutron and gamma distributions through the 105 DR bulk shielding facility using ferrophosphorus concrete (the composition used was that obtained after the concrete had been baked at 300 C for three weeks) as the biological shield was calculated using the shielding code. The thermal neutron fluxes compared with experimental results within a factor of two. A study of group fluxes (from 10 mev to thermal) revealed the neutron spectrum to be dominated by the "1/E" energy range due to the low hydrogen and high iron content. Because of this type of spectrum the thermal flux measured with gold foil is really a flux between thermal and the cadmium cutoff (about 0.4 ev). The activation of a bare gold foil is:

$$I_o = \frac{NW}{M} \left[\sigma_{th} \; \phi_{th} + \phi(u) \int_{E_{th}}^{\infty} \sigma(E) \frac{dE}{E} \right]$$

and the activation of a cadmium-covered gold foil is

$$I_o^{Cd} = \frac{NW}{M} \phi(u) \int_{0.4 \text{ ev}}^{\infty} \sigma(E) \frac{dE}{E}$$

so that

$$(I_o - I_o^{Cd}) = \frac{NW}{M} \left[\sigma_{th} \phi_{th} + \phi(u) \int_{E_{th}}^{0.4 \text{ ev}} \sigma(E) \frac{dE}{E} \right]$$

When the cadmium ratio (I/I_a) is high, then the quantity $\phi(u) \int_{E_{th}}^{0.4 \text{ ev}} \sigma(E) \frac{dE}{E}$ adds little to the thermal maxwellian activation. When the cadmium ratio is low, this same quantity adds a very significant amount to the thermal activation. This point was very nicely brought out by the computer program. If the calculated maxwellian flux (0 E .07 ev) is compared with the thermal flux determined experimentally, the calculation is low by about a factor of ten. However, if the fluxes from 0.4 ev to thermal are added to the maxwellian flux, there is less than a factor of 1.5 difference in most cases. There remains a question as to how well the gold foil is calibrated when the cadmium ratio is low. The gamma calculation agreed within a factor of two with the experimental results. A gamma calculation was also made for the iron-masonite configuration. Again, the calculations reproduced the experimental data very closely, to within a factor of two.

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

Component Testing and Equipment Development

PRTR Components. A test to determine the reaction of aluminum in cadmium sulfate solution was conducted by Chemical Metallurgy Operation. Aluminum coupons (Type 6061-T6) were immersed in a strong cadmium sulfate solution having an initial pH of 3.6. Solution was maintained at room temperature. After a month, the following observations were made:

a. Coupon weight loss was equivalent to a corrosion rate of one mil.
b. Coupons appeared to be plated with a uniform thin layer of cadmium.
c. Some cadmium metal was precipitated out of solution.
d. Solution pH increased to about 4.5.

A liquid poison shim rod system consisting of cadmium sulfate in aluminum housing tubes does not appear to be practical. Additional laboratory tests will be made, however, to determine possible means of inhibiting the plating and precipitating reactions.

Design of the Environment Control Test Assembly for shim rod evaluation has continued. Design is approximately 50 percent complete.

Plutonium Recycle Critical Facility Components. Considerable difficulty was encountered when aluminum threaded connections in the PRCF fuel element transfer thimble were backwelded. After many attempts and with the assistance of a welding consultant these connections were made leak tight. Two threaded connections between stainless and aluminum pieces continued to leak. A new block die has been ordered and it is anticipated that use of this new die will make a leak-tight connection possible. The new block die is due for delivery in early February, 1962.

Fabrication and assembly of all three PRCF control rods is complete. Considerable difficulty was encountered with aluminum welds during the housing leak test. The control rods are now ready for reactor installation.

One PRCF safety rod is complete with cadmium plated tube. Testing of this assembly is being continued in an effort to uncover and correct unforeseen problems pending receipt of the cadmium plated safety rod tubes for the remaining two safety rods. The latest delivery promise for these two tubes is February 1, 1962. After receipt approximately one man-week of electrical work and one man-week of machinist work will be required to complete the safety rods.

The adjustable weir has been returned from the reactor for the installation of an adjustable mechanical stop to limit weir travel. This adjustable stop is being designed and it is scheduled that the weir assembly be returned to the reactor by February 6, 1962.

Gas Loop Components. Assembly of the in-reactor inner tube has been completed. This tube, which is to be used in the "B" cell mockup, has eighteen thermocouples attached to it. These thermocouples will give a temperature pattern from inlet to outlet of both the inner tube and the pressure tube. The assembly has been delivered to the reactor. This completes all Gas Loop work assigned to the Equipment Development Operation.

Rupture Loop Components. Pressure testing of the calrod installation in the Phase I Test Loop pressurizer disclosed three welds with pin holes and one ruptured calrod. The ruptured calrod has been replaced and the pin holes repaired. The unit was pressure tested and found to be acceptable. Assembly of the in-reactor test section has been started but progress is impeded by the improper fitup of parts already made.

304 Laboratory Modifications. To obtain additional testing and mockup space and to provide better access to the Phase I loop control and instrument panel, the Phase II loop, which was used for testing a full size PRTR primary pump, was dismantled and removed.

To provide more general and descriptive names for the laboratory facilities, the PRTR Single Tube Prototype Facility or Phase I Loop has been renamed Equipment Development Experimental Loop I (EDEL-I). The small Flexure Loop shall be designated EDEL-2.

PRTR Technical Assistance

The new and revised drawings for relocating the PRTR helium bottle manifolding (including dryers, filters, makeup control valves, etc.) were completed. Also, the new and revised drawings for modifying the gas bottle storage shed off the 309 M&M Building were completed. It is planned to issue two separate Design Changes covering these modifications.

Continued assistance was given Technical Planning Operation, TRAO, during the month. Principal activities consisted of planning the sixth reactor refueling, providing operational physics information and planning experimental programs for 1962. The final report on PRTR critical test results was completed except for some additional appendices and graphics work. All startup reactivity results were recalculated with more accurate delayed neutron data. The final results now appear to be approximately twenty percent lower than the preliminary reactivity values reported.

Hazards Analysis

PRTR Process Specifications. Two PRTR Process Specifications were revised and approved during the month.

Plutonium Recycle Critical Facility. Procedures have been developed to limit the excess reactivity available at the PRCF console. A review of the experiments planned for the critical facility has shown that nearly all of the experiments can be performed with no more than one dollar of excess reactivity available at the console. For those tests requiring greater excess reactivity, the maximum which will be needed is two dollars. In some of the planned core loadings the reactivity worth of a PRTR Pu-Al fuel element assembly can be relatively large, 1 to 10 dollars. Therefore, when loading to critical it may be necessary to charge individual Pu-Al rods to meet the one dollar excess reactivity criterion.

The maximum height to which the moderator level can be raised from the console will be limited by an adjustable mechanical stop on the weir elevating mechanism. This mechanical stop will be adjusted in the reactor cell before the moderator is raised and will be adjusted to limit the total available excess reactivity inserted by raising the moderator or withdrawing the control rods to one dollar. In addition to controlling the amount of excess reactivity available, design and procedures will limit the maximum rate at which reactivity can be increased.

Plutonium Fuels Development

PRTR Aluminum-Plutonium Fuel Elements. The six low exposure plutonium spike fuel elements for measuring radial and axial flux patterns within a cluster have been delivered to the PRTR. Six similar elements will be required with the high exposure plutonium loading; however, the fabrication is expected to be much less complicated in that special zirconium alloy (Zircaloy-2 - 1 w/o cobalt) spacing wires will be used for monitoring purposes.

The fuel element rods for the final six low exposure spike fuel elements are being prepared for cluster assembly. This will make a total of 67 Mark I-H aluminum-plutonium elements fabricated for the PRTR.

Fabrication has begun on the aluminum-plutonium spike fuel elements containing high exposure plutonium (16.5 a/o Pu-240). In order to furnish the same reactivity as the low exposure spikes the enrichment has been increased as follows:

Type	% 240	Grams of Plutonium/Cluster
Low exposure spike	6.0	263
High exposure spike	16.5	378

Tubing for approximately forty 19-rod clusters has been received from inspection and normal preparation of identifying, cleaning, gaging, machining, and welding of the first end cap is in process.

One hundred thirty-four Al - 2.6 w/o Pu - 2.0 w/o Ni billets were cast from the Al-Pu master alloys previously made. The plutonium contained 16.46 w/o Pu-240. The 134 billets are sufficient material for 14 clusters; remelting the scrap generated in subsequent fabrication will yield an additional three clusters. From PuO_2 to cast billet the yield was 96 percent, 4 percent of the plutonium was lost to crucible skulls and flux. The usual loss to crucible skulls is 3 percent so that the incremental loss in going through the PuO_2-cryolite reduction process was 1 percent. The plutonium content in the crucible skulls is recovered by chemical reprocessing.

Irradiated Fuel Element Inspection. Four aluminum-plutonium spike fuel elements were inspected in the PRTR storage basin during the last reactor outage. The results of all the data taken to date (Table I) seem to indicate that the rod shortening is a function of at least three things:

1. Thermal cycles
2. Minimum diametrical gap between core and cladding at room temperature
3. The effectiveness of the cluster banding in maintaining a straight-line movement of the rods during thermal cycling.

In the upcoming high exposure plutonium spike fuel element fabrication the diametrical gap will be increased one or two mils and the number of strip type bands will be varied between six and eighteen. An improvement was made in the gage for measuring rod length under eight feet of water. The new gage can be brought above the water for reading the dimensions whereas the previous method required reading the scale underwater; accuracy is ± 1/64-inch now versus ± 1/16-inch before. Two of the elements (5061 and 5070) were clusters which have operated since the first core loading and were rebanded underwater following the corrosion incident. The other two elements (5086 and 5087 were charged in September as experiments to eliminate the wire loosening problem. Cluster 5086 had an increased cold gap between core and cladding and 5087 used graphite coated cores.

TABLE I

Fuel Element No.	Inspection Date	Exposure and % Goal	Max. Wire Gap	Avg. Rod Δ L	Type Bands	General Observations
5061	9/27/61	26.4 MWD 31%	3/16"	-(.19)	Wire	Maximum gap between wire and rod 3/16" at center of cluster. Some wires show no gap toward ends of cluster.
5061	1/16/62	58.7 MWD 70%	1/4"	-(.2)	Wire	Wire wraps loose 1/16" at ends of cluster and increasing to 1/4" in the center. All scratches on element show white corrosion product.
5070	9/27/61	25.2 MWD 30%	3/16"	-(.1)	Wire	Gap varies from 0 at ends to 3/16" in the center.
5070	1/16/62	55 MWD 65%	1/4"	-(.16)	Wire	Wire gap maximum of 1/4" in center of cluster and decreasing to no gap in the first 2' from each end.
5086	12/6/61	23.8 MWD 28%	None	+(.04)	Strip	Over-all cluster appearance excellent. All wires tight.
5086	1/17/62	29.4 MWD 35%	1/64"	+(.03)	Strip	Same appearance as above. All wires appear tight except for one wire in the center of cluster which has 1/64" gap.
5087	12/6/61	22.9 MWD 27%	1/64"	+(.03)	Strip	All wires tight except in the center where there is 1/32" gap in two wires. General cluster appearance very good.
5087	1/16/62	28.3 MWD 33%	1/32"		Strip	All wires loose in the center of the element with 1/32" gap; toward ends only 1/64" gap. Corrosion appearing in scratches and where nuts were staked. Rod lengths varied with some shortening and some lengthening.

Phoenix Experiment. The Phoenix capsule (GEH-21-1) containing plutonium with 6.25 w/o Pu-240 has now completed its third cycle of irradiation in the MTR and reactivity measurements will be made following an adequate cooling period. The capsule containing plutonium with 10.33 w/o Pu-240 (GEH-21-3) has successfully completed its second cycle of irradiation. Some difficulty was encountered in removing capsule GEH-21-9 (27.17 w/o Pu-240) from its holder following the second cycle of irradiation and a hole was inadvertently cut through the cladding with the underwater hacksaw. A spare capsule containing identical sample material was sent to the MTR as a replacement and pre-irradiation reactivity measurements were made. The irradiation scheduling of this sample will be such that the total exposure of each sample in the group of three will be about the same. It was planned to make a fourth irradiation sample using plutonium containing about 40 percent Pu-240 when such material became available. The shipment in which this material was to have been included has arrived and no plutonium with this high a Pu-240 content was received. The status of this material is being investigated.

Aluminum-plutonium-boron alloys have been made for use as ARMF poison standards in connection with the Phoenix experiment. Alloying and chemical analysis difficulties have been encountered throughout this effort. By the use of aluminum-boron master alloys, many of the alloying problems have been alleviated. It is essential, however, that the boron content of this material be accurately determined for use as ARMF standards. Reactivity measurements of the alloy will be made in the PCTR in an attempt to accurately determine the boron content and homogeneity of the material. The reactivity effect of the boron will be determined by comparing measurements made on aluminum-plutonium and aluminum-plutoni boron alloys.

Irradiation Testing. A UO_2-PuO_2 PRTR prototype seven-rod cluster (GEH-11-7) has completed its irradiation of 23 full power days in the ETR 3x3 loop. This amounts to an average exposure of about 440 MWD/T or a maximum of about 800 MWD/T. The element which is 42 inches long was enriched with plutonium which contained 16 w/o Pu-240. The UO_2-PuO_2 fuel rods were cold swaged to 89 percent of theoretical density using swageable type end caps, therefore, there was no end clearance between the end cap and the fuel material. The maximum heat flux was about 345,000 Btu/hr-ft^2 and the maximum calculated core temperature was 1850 C. It will be returned to Hanford for examination.

An injection-cast seven-rod cluster (GEH-11-6) containing Al - 2.53 w/o Pu - 2.0 w/o Ni alloy core material is being irradiated in the ETR 3x3 loop. Because of difficulties with the loop, it has accumulated only one full power day of irradiation time. As a result of the loop difficulties, the thermocouples on the experiment were destroyed and no power generation determinations were made.

The UO_2-PuO_2 cosine enriched seven-rod cluster element (GEH-11-8) has been completed and sent to the ETR for irradiation. The PuO_2 enrichment was varied in such a way that the element will generate about 84 kw/ft along its entire length. Irradiation is scheduled to commence about the third week of February. Sixteen irradiation capsules containing ZrO_2-PuO_2 and MgO-PuO_2 have been sent to the MTR/ETR for irradiation. Irradiation is scheduled to commence during cycle 169 on January 29.

Radiometallurgical examination continued on the UO_2-PuO_2 seven-rod cluster (GEH-11-3) which had sintered and ground pellets as the core material. All seven rods were sectioned at the center of the element which permitted an examination of the core material. The UO_2-PuO_2 core in all of the rods was cracked. The cracking was general and random in direction. Most of the fuel rods showed very little, if any, recrystalized grains while the core material in one of the rods, which was presumably closest to the center of the reactor, had recrystalized and formed large, equiaxed grains in the center. This phenomenon was predicted for high-density sintered pellets operating in the 1600 to 1800 C temperature range. These observations indicated that the calculated core temperature predictions for this material were good.

The irradiated Zircaloy-clad capsule (GEH-14-27) containing an Al - 2.1 w/o Pu - 2.0 w/o Ni alloy core and fabricated by injection casting was recharged into the MTR. The specimen will complete the last of the four requested additional reactor cycles on January 29, 1962. Goal exposure for the capsule is a minimum of 50 percent burnup of the plutonium atoms.

The eleven discharged high and low density UO_2-PuO_2 capsules are currently being examined radiometallurgically. The results of the examinations made to date are shown in Table II. If it is assumed that the physics calculations and flux measurements are correct, then there is some indication that the thermal conductivity of the UO_2-PuO_2 improves with increasing PuO_2 concentrations. The central void formations in the specimens were shaped as follows: (1) GEH-14-22, smooth and uniform (approx. 1/4 inch diameter) over specimen length; (2) GEH-14-21, smooth teardrop contour and located near one end; (3) GEH-14-66, smooth teardrop contour and located near one end; (4) GEH-14-65, highly irregular surface with teardrop contour and located near one end, and (5) GEH-14-82, small void (details unknown).

The four specimens (GEH-21-13, 14, 15 and 16) each containing UO_2-0.154 a/o PuO_2 and UO_2 (1.00 a/o U-235) pellets, for the tests in the VH-4 Hydraulic Rabbit Facility at the MTR, will be charged during the present MTR Cycle 168. The delay was caused by modifications in the reactor safety circuit for the VH-4 Facility. The final test proposal (HW-72287-RD) was completed and is being prepared for issuance. It appears now that during irradiation, the capsules will have a specific power of 20 kw/ft and a core center temperature of about 3600 F (2000 C). During discharge the temperature will be increased by about 90 F (50 C). Preparatory work continued on ICARUS (high specific power Rabbit Test), HELIOS (in-reactor temperature measurements), and ARGUS (in-reactor fuel element property measurements). Fabrication of two complete assemblies for the ICARUS Experiment is currently in progress. The flow tube mockup components were completed and delivered. The design work on the HELIOS Experiment is

TABLE II

Data on Irradiated UO_2-PuO_2 Capsules

GEH-14 No.	UO_2-PuO_2 (a/o PuO_2)	Density (% of Theo.)	Exposure, (10^{20} nvt)	Total Gas Volume, (ml @ STP)	Examination Status	Remarks
21	0.0259	65	2.88	11.2	Done	Central void formation.
22	0.0259	65	28.40	16.8	In Progress	" " "
65	0.137	65	6.00	9.7	Done	" " "
66	0.137	65	21.83	21.9	In Progress	" " "
67	1.46	66	1.13	0.06	Done	
68	1.46	65	7.39	9.8	In Progress	
70	3.47	64	0.528	10.6	Done	
69	3.47	64	3.45	7.4	In Progress	
72	5.46	63	0.39	7.6	Done	
71	5.46	63	2.15	4.7	In Progress	
74	7.45	63	0.272	4.5	Done	
73	7.45	63	1.91	7.8	In Progress	
19	0.0259	91	4.03	0.63	Done	
20	0.0259	90	18.73		In Progress	
90	0.0259	90	3.22	--	Done	
91	0.0259	90	31.80	6.3	In Progress	ΔD = -0.008 inch
83	1.02	93	1.22	0.17	Done	
82	1.02	93	11.62	4.3	In Progress	Central void formation, ΔD = +0.012"
84	2.57	93	0.588	0.53	Done	
85	2.57	91	4.79		In Progress	
87	4.13	91	0.438	0.45	Done	
86	4.13	91	3.26		In Progress	
88	5.67	91	0.222	0.22	Done	
89	5.67	91	1.69	--	Done	

continuing. Contacts were made with vendors to determine construction feasibility of proposed thermocouple assembly. One vendor indicated an interest in preparing the initial model. The exploratory work on the ARGUS Experiment is continuing. Of the replies received from a number of vendors with respect to the proposed off-site development work, it appears at present that only one is fully capable of accomplishing the required equipment development.

Oxide Fuel Development. Fabrication was completed on the seven-rod cosine enriched irradiation cluster. The fuel rods will be x-rayed and given a fluorescent penetrant examination prior to assembly.

High exposure PuO_2, to be used in the fabrication of 19-rod PRTR clusters, was calcined at 950 C for two and one-half hours. The resultant weight loss for the oxide following this calcination was 2.70 w/o. The calcined oxide was screened; the +325 mesh particles and agglomerated material were ball-milled and recalcined. Samples were taken to determine O/Pu ratio and Pu analysis. The PuO_2 (-325 mesh) is being blended with -325 mesh normal fused UO_2 for use in the incremental loading procedure. This blend contains 4.05 w/o PuO_2 which will give a fuel core content of 0.45 w/o PuO_2 when diluted with the coarse UO_2 increment. Variations in finished length of swaged compacted fuel elements are caused by variations in the Zircaloy tubing in which the wall thickness may vary ten percent. Close control of the weight per unit length of individual Zircaloy will permit greater control of the fuel rod length after swaging. The tubing has been weighed and classified into weight classes for further processing.

Development of oxide fuel elements by vibrational compaction continued. Adequate fuel densities have been obtained with UO_2 rods and methods were developed for safely handling PuO_2-bearing fuel rods. However, experiments indicated a non-uniform distribution of fines (-325 mesh UO_2) along the length of fuel element. Current fabrication procedures yield UO_2 rods in which the distribution of fines shows a variation of $\pm$ 15% of the mean for a six-inch sample length. If PuO_2 is added in a physical mixture with -325 mesh UO_2, it would be expected to follow a similar distribution pattern. Further evaluation of the expected plutonium distribution in vibrationally compacted rods is continuing.

UO_2 Fuels Development

PRTR Fuel Elements. Two PRTR 19-rod cluster fuel elements, one of which had been accidentally damaged during discharge, were inspected during a reactor outage. The undamaged element, No. 1054, revealed no evidence of wire wrap loosening or surface damage. The damaged element, No. 1051, showed severe surface abrasion on six rods, approximately 32 inches from the bottom end. The abraded section was approximately six inches long and it is estimated that the Zircaloy had been removed to a depth of 0.010 to 0.020 inch. The outer wire wrap was also broken. This element will not be recharged into the reactor.

Three special test fuel elements (vibrationally compacted 19-rod cluster, hot swaged 19-rod cluster, and vibrationally compacted nested tubular

tubular assembly) operated satisfactorily at full power in the PRTR. The nested tubular fuel element was moved into a different reactor tube, to increase the heat generation rate by ~50 percent. The heat generation of this element was 1,011 KW during operation of the reactor at 70 MW.

Remote Fabrication Studies. Construction of the enclosure for fuel element remote fabrication studies was completed and vibrational compaction equipment installed. An assembled Mark II-C fuel element (161 lbs) suspended from a vibrating resonant beam sustained no externally visible damage (except failure of one shear pin) during vibration between 200 and 3600 cps at accelerations to 60 g. This study will continue to determine the feasibility of remotely compacting recycled fuel into pre-assembled and tested cladding assemblies.

Hot Swaging. Fuel densities of 96-97 percent TD were obtained in fuel rods for fundamental studies by hot-swaging fused UO_2 in heavy wall stainless steel sheathing. The fuel rods initially were clad in 0.750 inch OD, 0.035 inch wall Zircaloy or 1.25 inch OD, 0.035 inch wall steel tubing. After cold-swaging to approximately 0.67 inch OD, the fuel rods were inserted in 1.00 inch OD, 0.140 inch wall stainless steel tubing, cold swaged (one pass) and hot-swaged (5 passes) to 0.563 inch OD at ~900 C. The heavy wall cladding drastically reduced the amount of elongation normally encountered in hot swaging. Visual examination of this hot-swaged UO_2 revealed an extremely hard core having the appearance of a sintered pellet. The hardness of the UO_2 made it very difficult to drill through the fuel core. A series of spiral fractures throughout the UO_2 probably indicate that the maximum swageable density was achieved, with further reduction simply causing the bonded UO_2 to fracture. Fuel rods with thin wall cladding (0.008 inch stainless steel) also were hot swaged. No appreciable damage to the cladding occurred. The major problem involved loading of the UO_2 into the tube.

Vibrational Compaction Studies. Porous, fused UO_2 (95 percent bulk density) was vibrationally compacted to 88 percent TD. This corresponds to a compaction efficiency of 93 percent, which is the highest thus far reproducibly achieved. Shattering of porous agglomerates during the high intensity vibration is believed to be a possible explanation for this improved vibrational compaction result.

Magnetic Force SAP Welding. Elevated temperature tensile tests were performed on fuel element end closures completed with SAP material. Ultimate stresses were 38,200 psi at room temperature, 29,200 psi at 200 C, and 12,700 psi at 400 C. Failure occurred both in the tube material and at the welded joint, indicating approximately equal strength in the base material and in the weld.

Corrosion and Materials Studies

PRTR Activity Monitoring Program. A program is being developed to determine the behavior of radionuclides in the PRTR. It is necessary to start the program early to obtain information concerning changes in film, crud and activities as functions of PRTR operation. The first part of the program, consisting of a complete measurement of activities in different parts of the system, has been outlined. The preliminary description of a mockup tube, necessary for these studies, was given to PRTR personnel for comments.

Secondary System Coolant Quality Control. A study showed that the present method of operation of the secondary system coolant quality control equipment is unsatisfactory because possible stress corrosion conditions exist in the heat exchanger and possible caustic embrittlement conditions exist in the boiler. Conversion from 300 Area water to Columbia River water would make it practical to eliminate caustic embrittlement conditions in the boiler but would not significantly reduce the possibility of stress corrosion in the heat exchanger. Possible methods of eliminating both undesirable conditions include (1) split-stream softening with hydrogen and sodium zeolites followed by degasification, and (2) acid injection, degasification and neutralization with caustic soda. Of these methods the former is the most attractive from a technical aspect while the latter is somewhat more economical.

Inspection of the PRTR Steam Generator. The secondary side of the main steam generator (HX-1) was entered the last of December and a sample of scale from the tubes was collected. Although detailed examination of the generator was not made because of a field of 200 mr/hr emanating from the primary side, some pitting of the carbon steel components was noted. The corrosion coupons were not removed.

The scale sample was analyzed by x-ray diffraction and emission spectroscopy. The major constituents found, in the order of decreasing concentration, were Si, Mg, P, Fe, Cu, and Al. Interpretation of the x-ray analysis is incomplete but indicates silicon dioxide and complex calcium and magnesium phosphates. The bulk scale was easily scraped from the tubes but an inner dark layer was firmly attached. The thickness of these layers was not determined.

Heat Treating of Zirconium Oxide Films. Zirconium coupons were autoclaved for 28 days in 400 C water vapor. Vacuum heat treating of the coupons was then carried out at 510 C for 5, 20 and 60 minutes and at 600 C for 5 and 60 minutes. Films on samples heat treated for 60 minutes at 600 C were noticeably lighter in color due to considerable dissolution of the oxide under these conditions. The other heat treatments did not produce obvious differences in sample appearance. The samples were autoclaved for an additional five days following heat treatment. Only the samples treated at 600 C for 60 minutes showed abnormally high weight gains. Weight gains for all other heat treated specimens were similar to or smaller than weight gains of nonheat-treated control samples. For comparison, off-site investigators (WAPD-10-T-1078) heat treated Zr-2 specimens for 40 and 60 minutes at 590 C and observed abnormally high weight gains in subsequent corrosion testing.

Corrosion of Stainless Steel and Nickel Base Alloys. After 30 days of exposure in 550 C 300 psi steam the corrosion rates for stainless steels and nickel base alloys tested appear to fall into four separate groups. An experimental Fe-Cr-Al alloy (5.6% Al, 24% Cr), Hastelloy "X", Incoloy, Inconel "X", PDRL-102, and 446 stainless steel corrode most slowly, penetrations ranging from 0.01 to 0.04 mil. Hastelloy "N" and experimental Fe-Cr-Al-Y alloy (3% Al, 25% Cr, 1% Y) are slightly higher than the first group at 0.07 mil. Carpenter 406 stainless steel and 304-L stainless steel exhibited similar corrosion penetrations of 0.2 mil. The remaining two heats of 406 stainless steel (Allegheny Ludlum and Weldrawn Tubing), and 430 stainless steel corroded the most, 0.3 mil.

A comparison with previous results obtained for some of these alloys in 500 C, 1000 psi steam suggests a slight reduction in corrosion at the higher (3000 psi) pressure.

Stress Corrosion Susceptibility Tests. Stress corrosion susceptibility tests were continued. The results are in good agreement with those of earlier tests, especially in regard to the behavior of the 200 series stainless steels. AISI 201SS and 202SS being austenitic steels, cracked like all other austenitic alloys within the first few hours of immersion in boiling 42 w/o $MgCl_2$. On the other hand, neither the AISI 405SS, which contains up to 0.3% Al in addition to 12 to 14% Cr, nor the AISI 430 and 446SS ferritic and the 502SS martensitic type stainless steels did crack. However, these stainless steels and some of the experimental Fe-Cr-Al alloys are attacked by general or preferential edge corrosion in varying degrees after 168 hours of immersion. Hastelloy X, PDRL-102, AISI 406SS, and Incoloy seem to be the most resistant of the alloys tested.

Pre- and Post-irradiation Evaluation of PRTR Pressure Tubes. The wear-corrosion marks on the inner surface of the Zircaloy-2 pressure tube removed from PRTR channel 1756 were replicated. During the first two weeks of reactor power operation when an excursion in water quality occurred, this process tube was charged with a fuel element with standard 1/16-inch wide support ribs. The maximum depth of wear-

[redacted]

These stresses are twice those required to produce equivalent deformations in tensile specimens machined from strip. Neither specimen has failed.

A third sample containing a seamlike defect that caused the rejection of the tube during manufacture was being heated to the test temperature when localized failure occurred. During the initial three hours in the furnace and just prior to failure the specimen had reached 480 F at a stress equal to 80 percent of the expected burst strength for a defect-free specimen. Three surface blisters formed along the seam on the inner surface and these skin-blisters burst. The longest crack in the group, about 1/2-inch long on the ID surface, propagated through the wall of the tube but did not extend beyond 1/4 inch long at the outer surface of the tube. With the loss of water through this very small crack the temperature dropped to 300 F, but the pressure remained constant for 19 hours giving a stress of 75 percent of ultimate at the lower temperature. There was no apparent further propagation of the crack length during this period.

In-Reactor Monitoring. Six PRTR process tubes were examined in-reactor during the month, three of which were last inspected in December 1960, and the other three in November 1961. No general increase in inside diameters was noted. Gas gaps changed slightly in magnitude and direction on all tubes but none have gaps less than 115 mils. Visual examination disclosed a few new wear-corrosion marks at the points of contact with the upper and lower fuel element support ribs. Tube 1659 had several spiral wire-wrap wear-corrosion marks in addition to the top and bottom fuel-support marks, and this tube was removed from the reactor for destructive testing.

The Mark III PRTR tube-monitoring probe-insertion equipment was received from the vendor. The nozzle extension drive unit is being modified for easier maintenance. A mockup test facility to check out the equipment was constructed in the 314 Building. The Mark III ID-gage has been received and is being calibrated. Delivery on the Mark III gas-gap gage has been delayed two weeks because of scheduling difficulties encountered by the vendor. Optical difficulties experienced on the Omniscope for the Mark III monitoring equipment have been overcome, and shipment is scheduled for the last week in January.

04 Program Radiometallurgy Studies

The first full-size irradiated PRTR fuel element was received and successfully sectioned during the month. Burnup samples are being dissolved and the center rod is being examined (RM 750 & 673).

No evidence of hydrogen pick-up was seen in the Zr-2 cladding of the purposely defected UO_2 element, HD-5. The metallography was typical of Zr-2 tubing which had burst from internal pressure (RM 640).

An enriched UO_2 capsule, GEH-14-177, irradiated at high surface heat flux to 37,000 MWD/T was examined metallographically. The two transverse sections examined exhibit different microstructures (RM 641). The Zr-2 cladding of UO_2 capsule GEH-3-52, exposed to about 50,000 MWD/T in the MTR, had burst during the irradiation testing, but the aluminum shield contained the gas. The UO_2 was completely recrystallized in the form of large, radial, columnar grains with the exception of a thin layer adjacent to the cladding (RM 642).

Localized recrystallization of the UO_2 was observed at the site of enrichment in Rod #2 from GEH-4-62. A composite of the entire cross section was made at 75X (RM 643). Metallographic examination of a stainless steel thermocouple sheath which failed in the PRTR revealed failure was caused by intergranular corrosion that penetrated one-half of the sheath wall (RM 646).

Complete recrystallization of the UO_2-PuO_2 fuel in capsules GEH-14-22 and GEH-14-66 occurred during their irradiation in the MTR (RM 653 & 654). Four high-density UO_2-PuO_2 capsules were examined and measured to determine dimensional changes which occurred during irradiation. Capsules 82 and 91 showed significant dimensional changes and are being examined metallographically whereas capsules 85 and 86 will be sent back for additional irradiation (RM 655). Metallographic examination of all seven rods from the UO_2-PuO_2 element, GEH-11-3 was completed. All of the cores exhibited a compact uniform small grain structure, although there is an indication that some segregation of the PuO_2 had occurred. X-ray diffraction exhibited only UO_2 lines, the Pu concentration being too low to be detected (RM 668). Wear-corrosion marks were examined in the bottom section of a PRTR process tube. Although most of the marks were quite shallow, one was found to be 0.4 inch long by 0.1 inch wide by 6 mils deep (RM 356).

A two-inch long fuel rod was successfully impregnated with an epoxy resin over its entire length (RM 639). After annealing GEH-14-281 at 650 C for 100 hours, little change was ivisible in this Basic Swelling Studies sample. Two microcracks were observed in the enriched uranium but no recrystallization was noted (RM 513).

The total of 17 samples were dissolved for burnup analysis, five samples were dissolved for iron analysis, and 15 fission product gas samples were collected for measurement.

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

2. PLUTONIUM UTILIZATION STUDIES

Plutonium Carbides

Three Pu-C alloys in the 36-41 a/o C region which had given the anomalously high lattice parameters previously reported in this region, were re-melted four times each under argon. X-ray examination showed that the lattice parameter horizontal in this region, which had been attributed to influence by the zeta reaction, was not absent and that the lattice constant varied uniformly with carbon content. Based on these data, the lower limit of the nonequilibrium PuC phase field is 39.7 a/o C with an associated lattice parameter of 4.9580 A. This apparently is the limit of the metastable phase which can be quenched from the melt. The most reasonable explanation for lack of a horizontal on these samples is cooling rate. Previous samples were on the order of 8 grams and apparently the interior of this quantity cools slowly enough to follow the composition changes predicted by the PuC phase diagram. The sample size of the specimens, which were repeatedly melted and which showed no horizontal, were on the order of 4 grams. The cooling rate of these specimens is probably great enough to quench in the high temperature carbon deficient structure.

Arc-melted samples containing between 30 and 52 a/o C were annealed in vacuum just below the ϵ + PuC phase field (575 C). A 30 kw resistance furnace was used without a controller, so line voltage fluctuations caused a variation in temperature with time. This variation extended from 400 to 550 C over 91 hours. Debye patterns are presently being analyzed, but preliminary data show that the PuC phase field after this anneal, extended from about 43 a/o C to 47 a/o C.

A least squares fit was applied to 26 data points resulting in an equation which can be used to determine the amount of carbon lost during arc-melting alpha Pu + C.

$$C_f = 0.995\, C_i - 2.364 \quad (30 < \text{a/o C} < 57)$$

C_f = a/o C in the final alloy

C_i = a/o C in the initial charge.

The equation fits for four melts and may vary slightly if a greater number of melts is used.

Kilogram quantities of PuC have been made by arc-melting plutonium and graphite in a converted welding box. By using a specially designed hearth and porous graphite it is possible to convert about 300 grams of material per hour with an efficiency of greater than 99%. Analysis of some 60 buttons made by this technique has shown all but two of these to be in the range of 42 to 48 a/o C. The two buttons which were low in carbon were obviously arc-blown during the melting as spalled-off graphite was found outside the hearth. A new hearth design has corrected this trouble. It has been found that one to two atom percent carbon is usually lost during the melting process. With appropriate corrections and carefully controlled melting conditions it is possible to hold the material in the 46-48 a/o C composition range with greater than 90% efficiency.

The arc-melted material shows surprisingly good machinability. X-ray results show only PuC lines with one or two of the stronger Pu_2C_3 lines sometimes detected. Metallographic examination confirms the fact that the material is essentially single-phase.

The arc-melted material has been crushed to -325 mesh, mixed with 1/2% carbowax plus 1/2% Ni, pressed at 13 tsi, and sintered in vacuum at 1500 C. The experiment was repeated with 1% Ni. No difference was noted with the additional nickel additive.

Plutonium Nitrides

Plutonium mononitride was synthesized by arc-melting alpha plutonium under one atmosphere of nitrogen. The material consisted of two phases, 95 percent PuN and 5 percent alpha plutonium. Quantitative estimates were derived from x-ray diffraction data. Density determinations yielded a value of 15.42 g cm^{-3}, 9 percent higher than the calculated theoretical value of 14.20 g cm^{-3}. A 1.4 gram sample of the above material was heated in a platinum crucible in oxygen. Ignition of the specimen occurred at 350 C, then the temperature was increased to 800 C and held for one hour. Even though some material was lost in a reaction with the platinum crucible, an apparent weight gain of 11.7 percent was seen. One would expect only 7.4 weight percent if the specimen were pure PuN. Preliminary data indicate a melting point greater than 2400 C, and some evidence of a decomposition or volatilization was observed at 1800 C. In order to eliminate the residual alpha plutonium, a small specimen was remelted several times in nitrogen. X-ray diffractometer analysis shows only PuN lines. The density as determined by immersion in tetrabromoethane is 14.13 g cm^{-3}, 99.5 percent of the theoretical value.

3. UO_2 FUELS RESEARCH

Fuel Evaluation

Irradiation Testing. Ceramographic examination of swaged UO_2 irradiated to a relatively high exposure (37,000 MWD/T_U) revealed characteristics which have not been observed in UO_2 irradiated to low exposures under similar conditions: (1) large columnar grains surrounding a small central core were very long and extremely thin; (2) no distinct band of void-free material was evident in the cross-section; (3) small, angular inclusions were present in the recrystallized portions of the fuel. This 0.5 ID capsule contained sintered and crushed UO_2 enriched to 2.42 w/o U-235 in U and swaged to a bulk density of $\sim$85 percent TD. (The particle density was approximately 95 percent TD.) The capsule was irradiated at a maximum surface heat flux of $\sim$600,000 Btu/hr-ft^2.

A vibrationally compacted, thin-wall stainless steel clad UO_2 fuel element (HAPO-2) was discharged from the VBWR. The nine-rod cluster, clad in 0.008 inch, 0.010 inch, and 0.015 inch wall stainless steel, accumulated an estimated exposure of 1200 MWD/T_U at peak surface heat flux of 280,000 Btu/hr-ft. Preliminary examination revealed (1) no bowing of any of the rods; (2) scratches on the outer rods, due to handling; and (3) several wrinkles and dimples near the tops of four rods. (Some minor deformations were visible on some rods before irradiation.)

A single crystal of UO_2 was irradiated to approximately one a/o burnup at an ambient temperature less than 300 C. Surfaces appeared to be macroscopically unchanged by irradiation. Extensive microscopic examinations are being conducted.

Photomosaics (75X) were constructed to display entire fuel cross-sections of two 0.5 inch diameter irradiated fuel rods: (1) sintered UO_2 pellets containing 0.1 w/o TiO_2 irradiated at a surface heat flux of approximately 1,000,000 Btu/hr-ft^2; (2) swaged UO_2 irradiated to 37,000 MWD/T_U at a surface heat flux of 600,000 Btu/hr-ft^2.

Fission Product Redistribution. An irradiated, sintered UO_2 fuel core (GEH-14-189) which showed evidence of fission product migration on autoradiographs is being examined by radiochemical microanalyses. It is anticipated that the data will help to confirm and define the extent of plutonium and fission fragment redistribution.

Materials

Impact Formed UO_2. A tungsten carbide punch was used for high energy impaction of UO_2 at impact pressures twice as great as those which cause failure of the best tool steel punches. Impact conditions previously produced only on a small sample using a "Bridgman anvil" technique and expendable steel sample holders, can now be applied to a much larger sample in a die of conventional design.

UO_2 Elutriation. An elutriation method for separating impurities and relatively porous material from fused or electrodeposited UO_2 was investigated. Water, passing through a fluidized bed of UO_2 particles with a narrow size distribution, removed the lighter particles. Porous agglomerates were separated from a sample of -6+8 mesh fused UO_2 by this technique. The bulk densities of the two resulting fractions were 5.8 and 4.5 g/cc, respectively. Fused UO_2 previously rejected because of a high content of porous particles is being upgraded by the elutriation method and used in vibrationally compacted fuel elements.

Vibratory Milling. Vibratory milling of UO_2 was investigated. Rapid attrition of the particles occurs with relatively little gross fracturing. Consequently, the product is composed of rounded, large particles and a relatively large quantity of fines.

Electron Microscopy

Replication techniques for electron microscope examination of irradiated UO_2 fuel cross-sections were evaluated. Experiments with several replicating methods demonstrated that the most useful for small irradiated pieces are the Fax-film - PVA - carbon, and Fax-film-carbon methods previously used at Hanford. The former technique was used to replicate known areas of polished irradiated UO_2 cross sections. Data now being obtained by electron microscopy of these areas will be correlated with existing optical micrographs of the same sample. To examine the detailed structure of irradiated single crystals, special methods of handling, fracturing, replicating and examining the crystals are under development. Both transmission and reflection electron microscopy will be applied to examine polished, etched and fractured surfaces.

High Temperature Studies

Resistance Heating of UO_2. A short length of a swaged fuel rod was assembled with a layer of insulation brazed between the fuel rod cladding and the end closure caps. A tungsten electrode was imbedded into each end of the UO_2 fuel core. The insulators and fuel cladding were water cooled. Current was passed through the UO_2 fuel section to heat the UO_2. The current was gradually increased to 500 amperes, at which point overheating of the fuel cladding occurred. Sectioning of the element revealed that sintering had occurred over a large section of the core. The heating pattern is being determined. Additional experiments will be performed in an attempt to simulate fuel heating that would occur under various reactor conditions.

4. BASIC SWELLING PROGRAM

Irradiation Program

Two controlled temperature general swelling capsules, #13 and 14, were charged in tandem into a reactor. Capsule 13 is being operated at a constant temperature of 575 C and capsule 14 is being operated at a constant temperature of 625 C. Temperature control and monitoring are being furnished with the new instrumentation and heater supply facility recently activated at the reactor. It is planned to charge capsules 11 and 12 at the next reactor shutdown. They, too, are connected in tandem for charging into the same test hole. Capsules 7 and 8 are cooling in the reactor discharge basin before shipment to Radiometallurgy for post-irradiation examination. Each of the above capsules contain three, hollow, split cylinders of uranium.

Two unmonitored NaK-filled capsules containing U-U diffusion couples for fission product mobility studies by post-irradiation annealing received an additional irradiation cycle in the MTR. They are scheduled for removal after one more cycle. They will then be shipped along with the two already irradiated to Radiometallurgy for specimen recovery and examination.

Post-Irradiation Examination

Except for one specimen, 4-2, the radiometallurgical examination of the specimens from capsules 4, 5 and 6 is complete. Specimen 4-2 is being annealed at 650 C for 100 hours in order to determine how the pore size distribution changes when the specimen is exposed to a temperature higher than the irradiation temperature. The burnup analyses were completed and are as follows:

Specimen	4-3	4-4	5-1	5-2	6-1 & 3
Calculated burnup percent	0.28	0.28	0.05	0.16	0.03
Analyzed burnup percent	1.66	0.33	0.06	0.18	0.04

The analyzed value for specimen 4-3 appears much too high. The analysis is being rerun. All of the other analyzed values appear to be slightly higher than the calculated, but the discrepancies are not large enough to be of concern.

Uranium specimens identical to those that were irradiated in capsules 5 and 6 were examined after being annealed in a NaK environment in laboratory capsules. These samples were given the same thermal history as their in-reactor counterparts. No microstructural changes were observed in specimens annealed in the laboratory capsules. Simulated capsule 6 specimens (thin, split, hollow cylinders) showed a very slight density increase, while simulated capsule 5 specimens (spheres) showed a very slight density decrease. Both changes were small and of questionable significance. The microhardness of the laboratory capsule 5 specimen was the same as that of the spheres irradiated in capsules 4 and 5. Electron microscopy on these specimens is not yet complete. Two other capsules duplicating the thermal histories of in-reactor capsules 7 and 8 are also being annealed. These tests will be completed in about a month.

Second Phase Distribution in Dilute Alloys of Uranium

A study of the characteristics and thermal stability of the "delta" phase in uranium has been initiated. These data will serve as a basis for designing swelling experiments to determine the role of second phase particles on the mechanism of swelling in uranium. Specimens from each of three uranium alloys have been heat treated and are now being examined by light and electron microscopy to study the "delta" phase in uranium. Ten conditions are being examined for each composition. These are: (1) as-received (alpha-rolled), (2) high alpha solution treated (643 C for seven hours and water quenched), (3) beta solution treated (730 C for five hours and water quenched), (4) gamma solution treated (800 for two hours and water quenched), (5) treated as in (2), (3), and/or (4) plus low alpha precipitation treated (538 C for two hours and water quenched), and (6) treated as in (2), (3) and/or (4) plus medium alpha precipitation treated (590 C for one hour and water quenched). Each of the thirty samples will be examined for the presence of a second phase, and the grain size will be recorded.

The spectrochemical analyses are completed and tabulated below:

Element	High Purity Dingot (a) Top	High Purity Dingot (a) Bottom	Dingot Alloy (b) Top	Dingot Alloy (b) Bottom	Dingot Alloy (c) Top	Dingot Alloy (c) Bottom
Al	50*	50	20	20	50	20
Cr	5	5	50	50	2	1
Fe	45	44	110	105	180	190
Ni	5	5	1	1	10	10
Si	10	16	32	36	58	60

*All values in ppm by weight.

These analyses are to be compared with the nominal compositions which for alloy (B) was 86 ppm Fe and 69 ppm Si and for alloy (C) was 150 ppm Fe and 100 ppm Si.

5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

The in-reactor creep test of 20 percent cold worked Zircaloy-2 at 310 C and 30,000 psi has been terminated after 1500 hours of successful operation. The test was terminated because specimen strain was approaching one percent, which is believed to be near the strain at which third stage creep will begin. The onset of third stage creep was avoided so the specimen would not fracture and preclude the measurement of specimen length upon removal of the capsule from the reactor. Measurement of specimen length with conventional apparatus after the test is desirable to verify the validity of the strain measuring system of the capsule. Before the capsule is removed from the reactor, a determination of the activation energies for creep will be conducted in the 280 C to 450 C range with the reactor operating.

Three shutdowns occurred during the course of the creep test. In-reactor creep behavior before the first shutdown has been reported in previous monthly reports. After the first and second shutdown, the creep rate in-reactor was in the range of 1×10^{-7} to 2×10^{-7}/hr, while the ex-reactor rate, determined in a standard creep apparatus, was from 1×10^{-6}/hr to 9×10^{-7}/hr. No data were obtained after the third shutdown as the test was terminated just after the next startup. The strain occurring during shutdown was found to account for more than seventy-five percent of the total observed creep strain. Detailed analysis of creep data during shutdowns has shown that immediately after shutdown the creep rate is very nearly the same as that before shutdown and increases to a greater value only after sufficient time has elapsed to initiate removal of radiation induced defects which interfere with the creep process.

Pre-Irradiation Material Characterization

Additional analysis of creep activation energy data has shown that the temperature at which the activation energy peak occurs is stress dependent. This behavior is a contradiction to some existing theories which have been proposed to explain the activation energy peak. The shift of the peak with stress does, however, partially explain the stress dependency of strain aging effects observed in the creep of Zircaloy-2.

6. GAS-GRAPHITE STUDIES

EGCR Graphite Irradiation

The H-3-4 irradiation capsule containing EGCR graphite is being modified at Vallecitos in preparation for insertion into the E-7 position of the General Electric Test Reactor during the next shutdown. A new guide tube for supporting and protecting the capsule is being fabricated. The modifications and new guide tube were made necessary due to the wear pattern observed on the prototype dummy capsule which had been irradiated for one reactor cycle. Fourteen of the samples in the H-3-4 capsule have been previously irradiated to varying exposures, the highest of which is 8.7×10^{21} nvt, E > 0.18 Mev.

Heat Treatment of Graphite

A series of samples were heated to 3150 C at the General Electric Research Laboratory to determine whether the crystallinity could be significantly increased. The c and a crystal lattice spacings and the apparent crystallite size in the c direction (L_c) and in the a direction (L_a) were measured on lampblack carbons. The results are shown below:

Heat treatment Temp., °C	c, Å	a, Å	L_c, Å	L_a, Å
3000	6.798	2.458	156	165
3150	6.789	2.460	155	289

The changes in the a and c spacing and L_a from heating to 3150 C are statistically significant and are indicative of an increase in crystallinity. The increase in L_a is the most significant change and indicates an increase in the degree of order in the carbon layer planes. Samples of TSGBF, CSF and WSF graphite were also heated to 3150 C. No significant c spacing changes were observed, although the L_c increased by 30 to 50 percent. Measurements of a and L_a are in progress.

Creep of Graphite

Work on the creep of graphite at 1100 F under a tensile load of 1000 psi has continued. One sample of NC-8 graphite was tested for 2300 hours. The extension measured, in excess of the short time elastic change, indicates a deformation rate on the order of 10^{-12} in/in/sec. This was measured using a dial gage capable of measuring a 10^{-5}-inch change. This preliminary result will be checked with a test now under way.

A second sample of NC-8 was tested under the same conditions except that an optical extensometer was substituted for the dial gage. The purpose of the test was to check the stability and sensitivity of the optical device. A variation in temperature of the steel mounts for the optical extensometer caused enough differential thermal expansion to affect the readings. All parts are now being fabricated from molybdenum - 1/2% titanium alloy to minimize this effect.

Graphite-Water Vapor Reaction under Gamma Irradiation

A final series of measurements in the Co^{60} gamma facility on the rate of oxidation of a solid cylinder of TSX graphite weighing about 8.3 grams by helium containing a small partial pressure of water vapor was completed. The water vapor concentration employed for these measurements was about 50 ppm. The net oxidation rates obtained are compared in the following table with those found previously at different water vapor concentrations.

Water Vapor Concentration, ppm	Oxidation Rate, 10^7 g/g/hr T = 600 C	T = 700 C
50	2.18	6.17
90	--	7.12
155	5.29	8.90
300	5.42	10.13

At a given temperature the pressure dependence of the rate can be represented by an equation of the form

$$R = R_L\ (1 - e^{-kp})$$

where R_L is the limiting value of the rate, p is the partial pressure of water vapor, and k is a constant. The limiting values of the oxidation rate at 600 and 700 C are about 5.5×10^{-7} g/g/hr and 10.5×10^{-7} g/g/hr, respectively. Future work on this reaction will be concerned with the effects of sample geometry, dose-rate dependence, and inhibitors.

Heater for PRTR Gas Loop

One of the proposed designs for the PRTR Gas Loop utilizes a ceramic oxide as an electrical insulator between silicon carbide heating elements and Hastelloy-X heat transfer surfaces. The compatibility of silicon carbide with Al_2O_3, SiO_2, and ZrO_2 at 1050 C was investigated. A silicon carbide rod was placed inside a Hastelloy-X tube and the 0.15 inch annulus was filled with oxide. A silicon carbide rod surrounded by Al_2O_3 failed after three hours of operation. It appeared that the surface had been eroded leaving the larger silicon carbide particles loosely bound to each other. A silicon carbide rod packed with silica powder failed after 66 hours of operation. Silica had diffused throughout the silicon carbide rod. The surface appearance of the silicon carbide heated 168 hours in contact with zirconia stabilized with 4% CaO indicated that this combination of materials will not be compatible for operation over an extended period of time. An alternate heater design containing no ceramic insulating material in contact with silicon carbide is under consideration in order to eliminate the materials compatibility problem.

7. GRAPHITE IRRADIATION DAMAGE STUDIES

Electron Microscopy of Graphite

Examination in the electron microscope of replicas taken from polished and cathodically etched graphite which had been impregnated with liquid bismuth has suggested a method by which the surface of pores in graphite may be examined. Bismuth is removed more rapidly than graphite during cathodic vacuum etching leaving a step at the interface between graphite and bismuth in the pores. The step is approximately 3 μ in height, and features of the cathodically etched pore boundary can be distinguished from those of the sectioned and polished surface. The pore boundary surface is characterized by a pitted appearance. Pits are often aligned along grooves which, in some cases, are an extension of grooves on the polished and cathodically etched surface. To determine whether the pits are a result of cathodic etching, the bismuth will be further etched in HCl and the additional step surface exposed will be compared with that exposed by cathodic etching.

8. ALUMINUM CORROSION AND ALLOY DEVELOPMENT

New Aluminum Alloy Testing

The dynamic corrosion behavior of some new aluminum alloys (1.2% Ni, 1.9% Fe, in high purity, 99.995, Al) is being investigated in deionized water. Present tests are conducted at 340 C at flow rates of 25 fps in a refreshed system. Comparisons will be made with X-8001 aluminum in the same test and also with static data already available for the new alloys (HW-68253).

In-Reactor Corrosion Test

The aluminum coupons containing silver foils were autoclaved, and many swelled. This is believed to have resulted from entry of water and production of hydrogen due to corrosion. Destructive testing showed the weld to be only a few mils deep. Since the use of these coupons in-reactor in H-1 Loop would create a danger of release of Ag-110 activity, new coupons with silver foils are being made with a new design providing a deep filler weld. A hazards review and production test, required before starting the first test, are awaiting approval.

Ex-Reactor Corrosion Testing

The test in TF-6 continued during the month using chromic acid to control the pH at 4.5. After 960 hours at 300 C, the corrosion of the X-8001 was about 0.8 mil/month, X288 was 0.5 mil/month, and carbon steel was 0.01 mil/month. The corrosion rate of X-8001 is considerably higher than either H_3PO_4 (0.06 mil/month) or H_2MoO_4 (0.34 mil/month). Although the rate for carbon steel is low, small pits were found in crevice areas indicating insufficient inhibitor. The crud levels were higher than in other systems at pH 4.5.

Heat Transfer Corrosion Testing

Corrosion testing of X-8001 cladding at a heat flux of 228,000 Btu/hr-ft^2 continued during the month at a bulk water temperature of 600 F, using high purity deionized water. The temperature-drop across the water, oxide, and crud films is now 50 F, compared with the original 43 F value. The temperature-drop continues to build up gradually between loop outages and drop when the loop is restarted after an outage. Coupons of X-8001 and A-288 exposed to 600 F water show corrosion rates of 2.25 and 1.75 mils/month, respectively, after 1800 hours of exposure. The film retention characteristics of the A-288 alloy began to show marked improvement over the X-8001 alloy after about 1000 hours. Penetrations after this time started to show significant differences for the two alloys; at 1800 hours the penetration of the X-8001 alloy was 7.4 mils, compared with 5.8 mils for the A-288 alloy.

9. USAEC-AECL COOPERATIVE PROGRAM

Ultrasonic Testing of Sheath Tubing

Two sets of notches, 30 mils long by 3 mils deep, were successfully electrojet-machined on both inside and outside surfaces of 0.680 ID sheath tubes. The smallest notches made previously by this method were 62.5 mils long. The electrode material used was tungsten ribbon. One set of outside and inside surface notches was machined parallel and the other perpendicular to the axis of the tube.

Using the transverse 30-mil long notches and a cylindrically focused transducer, the ultrasonic response was measured as a function of entry angle of the ultrasound into the tube wall. In varying the angle of entry from 16 to 30 degrees from vertical, peak responses were obtained at 17.5, 21 and 26 degrees. Under actual test conditions, whether a defect will trip the reject circuit will be dependent upon the magnitude of the reflected peak response at the time the defect rotates and translates into and out of the preset gate in the ultrasonic instrument. Attenuation of the peak response with length of metal path from point of entry of the ultrasound to the defect will be a major factor in determining the magnitude of this response. Measurements of attenuation for each peak revealed a sharply decreasing amplitude with increasing length of path for the peaks at 17.5 and 26 degrees and a more gradual decrease for the peak at 21 degrees. Thus, a more effective test would result from setting the crystal at 21 degrees. Both the emission and receiving properties of an ultrasonic transducer vary over the fact of the crystal and from transducer to transducer. For example, rotating the transducer used in the above measurements 180 degrees about the axis normal to its face caused a general shift in the location of the peak responses. The optimum angle under these conditions would be 19.5 degrees which corresponds to the location of a valley in the response curve for the original orientation of the transducer. Apparently calibration of each transducer will be essential in achieving a reproducible test.

Two other variables were studied; the length of water path, to which the amplitude of the peak response is quite insensitive and the amount of misalignment between the centerline of the tube and the centerline of the transducer. Moving the transducer 7.5 mils off-center decreased the response by 10 percent.

19-Rod Bundle Boiling Burnout Studies

The installation of the 19-rod boiling burnout test section with 0.015-inch spacing between rods for boiling burnout tests was delayed pending the receipt of electrical insulators which will be used to prevent shorting of the bundle to the coolant tube. It is expected that the installation will be complete and the testing started in three weeks.

The experimental plans for use of the 0.015-inch spaced 19-rod bundle were made. The reduction in rod spacing of this bundle from the previous 0.074-inch spaced bundle was accompanied by increasing the rod size from 0.564 to 0.629 inch OD. The larger rods have a larger cross-sectional area and, hence, have a smaller flow area when installed in the same coolant tube. The larger tubes also have a larger heat transfer area. The net result of these is that the 0.015-inch spaced test section has about a 65% greater increase in coolant enthalpy than had the 0.074-inch test section for the same heat flux and mass flow rate. Experimental plans were devised so that the outlet enthalpy of the 0.015-inch bundle will be approximately the same as those found for the 0.074-inch spaced test section.

Fabrication of the test section with 0.050-inch spacing between rods was started. This test section is quite similar to those with the 0.074 and 0.015-inch rod spacing except the rod diameter will be 0.587 inch. This test section will have a new method of installation of thermocouples to detect the occurrence of boiling burnout.

The method of thermocouple installation used on the 0.074 and the 0.015-inch spaced test sections was to place a thermocouple near the inside surface near the end of the electrically heated tubes used to simulate the rods of the bundle. The experiments with the 0.074-inch spaced bundle showed that such a thermocouple was quite responsive to the occurrence of boiling burnout on the surface at the thermocouple location but was inadequate in detecting the occurrence of boiling burnout at a point as little as 60 degrees around from the thermocouple position. To provide a means of detecting boiling burnout at any circumferential location at the end of the tube, the thermocouple will be installed in the center of a copper plug which will fit into the end of the heater tube. The copper plug will be coated with a 5 to 10-mil coat of flame sprayed aluminum oxide to provide electrical insulation between it and the heater tube. Such a thermocouple will read some sort of an average circumferential rod surface temperature. Tests were made which indicated that thermocouples installed in this manner should have an adequate response upon the occurrence of boiling burnout on the surface of the heater tube.

10. IRRADIATION EFFECTS IN STRUCTURAL MATERIALS

The purpose of this program is to investigate the combined effects of radiation and reactor environment on the mechanical properties of structural materials. Special attention is being given to the determination of mechanical property changes produced in metals by irradiation at elevated temperatures in contact with water. Thirty-six Zircaloy-2 tensile specimens, irradiated to about 2×10^{19} nvt (fast) in the G-7 hot water loop of the ETR, were shipped to HAPO for testing. These specimens were exposed to water at 280 C (536 F) for 84 hours over a period of 29 effective days of reactor operation.

Sections cut from tested Zircaloy-2 tensile specimens were examined metallographically. It was noted that the transverse specimens exhibited substantial twinning within the grains; whereas, no twinning was observed in the longitudinal specimen. This confirms other reports that under a tensile stress, slip is the major deformation mechanism for the longitudinal direction and twinning is the major deformation mechanism for the transverse direction of rolled plate. Attention was also focused on voids that formed within the necked region of the sample. These voids are initiated shortly beyond the maximum load point of the stress-strain curve, and reduce the density of the specimen. It was noted that the number and size gradient of the voids varied among like specimens tested at different strain rates.

11. REACTOR STUDIES PROGRAM

Advanced Reactor Concepts

Consideration of reactor types during this report period was limited to fast reactor concepts with compact cores potentially suitable for remote location or space application. Both solid fuel and molten fuel systems are being studied. The current status of solid plutonium fuel technology was reviewed. Reported information on materials of interest for advanced application, such as carbides, nitrides, borides, silicides, etc., is very limited. The amount of information available at present on these materials is insufficient to support more than rather preliminary design concept studies. Materials and corrosion problems with molten fuels were also reviewed. Much experience has been obtained with tantalum and plutonium alloy systems at Los Alamos, but development problems are still formidable and alternate structural materials appear to have limited promise.

Both thermal and direct energy conversion systems are being studied. The feasibility of incorporating thermionic conversion in fast reactor fuel elements is being investigated.

It is expected that three general reactor concepts will be compared during this fiscal year: (1) a solid fuel fast reactor with Rankine cycle power conversion, (2) a solid fuel fast reactor with thermionic power conversion, possibly in combination with a Rankine cycle converter, and (3) a molten fuel fast reactor with Rankine cycle conversion.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Work associated with the preparation of molybdenum specimens for irradiation has continued. Single-crystal tensile specimens and x-ray specimens of controlled impurity levels, and polycrystalline specimens, are being prepared. Forty single crystal rods, intended for tensile specimens, have been oriented and mounted for grinding. Shorter sections have been similarly oriented for x-ray study and have been ground and polished. A 90-second electropolish in the HCl-H_2SO_4-alcohol solution at 15 volts appears to remove most if not all of the worked layer. Diffraction experiments are being performed to evaluate the effectiveness of this surface treatment.

E. CUSTOMER WORK

Radiometallurgy Service

Core drill samples from the bottom of a Purex waste storage tank were removed and selected samples were shipped to CPD for further analysis and study. The material was found to be partially soluble in water and alcohol but dried to an extremely brittle mass. A five-gram sample of the sludge was found to have a density of 2.2 ± 0.1 gm/ml. An x-ray diffraction pattern was run on samples of the sludge but not enough definitive lines were obtained to identify any of the compounds present (RM 347).

The closures on both ends of two transversely cracked dingot production elements were in excellent condition. The uranium adjacent to the spire of one element was examined, and evidence of cracking in the surface of the fuel was observed. The results from an x-ray diffraction sample indicate that the grain structure in this production fuel element has a preferred orientation (RM 437).

Metallography Laboratories

Fuel element assemblies with copper plated Zircaloy caps are being examined for FPD. The copper plated caps are placed inside the end of a coextruded fuel element with the can wall extending to the top of the cap. The entire assembly is then vacuum welded and pressure bonded. The resulting diffusion bonds have been of good quality. With a proper bonding cycle all of the copper is alloyed with both the uranium and Zircaloy as intermetallics. Shortened bonding cycles produced specimens in which some free copper was present, yet even those specimens were well bonded.

In conjunction with a study being conducted by FPD to determine the cause of the warp in coextruded fuel elements, photomacrographs of the uranium cores have shown a distinct variation in grain size. The grain size varies around the extruded rod within any given transverse plane as well as along the length of the rod. The observed warp appears to be related to the pattern of grain-size variations. In turn, the grain size variations could be explained by uneven cooling effects on the billet just prior to extrusion.

An examination was made of Faxfilm replicas of the core of a coextruded U-Zr KER element which had received a 3600 MWD/T exposure and resulted in 4.5% swelling. Replicas were shadowed and photographed to enable statistical analyses of void fraction, density, and size distribution of pores.

Electron microscopy service also included the examination of the microstructure at the interface of coextruded, duo-enriched (depleted centrally and enriched peripherally) uranium rods in both the as-extruded and beta heat treated conditions, and the examination of replicas from UO_2 - 0.5 w/o PuO_2 elements which had received about 2300 MWD/T in the ETR.

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

Samples Processed During the Month:

Total samples	1111
Replicas	67
Photographs	
Micrographs	512
Macrographs	175
Electron Micrographs	162
	849

N Reactor Charging Machine

Modifications. Modification of the electrical system is estimated 85% complete. Further modification work on the electrical system has been postponed pending completion of more testing work which might require additional desirable electrical modifications.

All mechanical modifications which are currently required have been completed with the exception of replacing gears in the vertical lift four-way miter box. Gears have been received and work has started on their replacement.

Testing. Testing of the new and thrust stabilizers has been terminated because deflections are still much larger than tolerable. Analysis of the data is continuing to determine the cause of the excess deflection so that it can be remedied.

Ten magazines have been loaded with fuel elements and/or dummy fuel elements. These are now available for load testing of the machine. The water pump which supplies the high pressure (350 psig) water used in charging fuel elements has been installed and connected. The test of fuel element foot wear using prototypical fuel element feet and parts of an actual outlet nozzle is estimated 85% complete. No difficulties, so far as abnormal wear is concerned, have appeared in this test. The "C" elevator magazine support has been reassembled and is ready for testing.

Plutonium Samples for Phillips Petroleum Company

Further development for the fabrication of 72 fission product transient samples is continuing. The tubular elements are to be 5 inches long with a nominal 0.8 inch OD. The inner and outer cladding is aluminum 0.020 inch thick and the Al-U and Al-Pu cores are 0.020 inch thick. Multiple-core co-extrusions have been made using aluminum and aluminum-uranium alloy cores to determine core configurations for minimizing extruded end effects. A 10 degree compensation angle machined on the 0.4 inch long billet cores resulted in an extruded core length of 4-1/8 inches with a 1/2 inch end effect. An extrusion with a 15 degree core configuration appeared to have a shorter end effect, but the extrusion blistered badly and a re-evaluation will be necessary.

Special Fuels - Critical Mass Physics

The electroless coating of PuO_2-polystyrene matrix fuel cubes was started this month. Initial attempts were plagued with the splitting of fuel cubes in the coating bath. Macroscopic examination of the crack revealed a multitude of veined, unwetted PuO_2 particles on the fractured surface. These layers of fine sized PuO_2 particles have large amounts of adsorbed gases tending to fracture the cube when heated in the nickel reduction bath.

The PuO_2-polystyrene cubes were coated in three successive nickel baths to decrease the carryover of alpha contamination to a level less than 500 d/m. After a week's storage of coated cubes it was observed that some small blistering was propagating in a work-like fashion. Cursory macroscopic examination indicated that the surface under a blister has an area of PuO_2 agglomerate. This pocket of oxide is probably filled with nickel coating solution during the electroless reduction process. When this area is coated over with a layer of nickel the reduction process will still continue in the entrapped solution with the evolution of hydrogen gas and the subsequent formation of blisters. A thorough microscopic examination is planned by sectioning a cube around a blister and polishing the sample in small increments through the blistered area with close observation during the incremental polishing.

Breeder-Type Neutron Detector

Coating rates of pyrolytic carbon upon stainless steel from acetylene gas are being determined by metallographic examination of coated specimens.

The surface porosity of the carbon coating is being determined by the relative absorbtivity of uranium nitrate and/or plutonium nitrate solution compared to an uncoated specimen. A nonradioactive specimen is used for the standard or background alpha radioactivity counting.

F.W. Albaugh

Manager, Reactor and Fuels Research and Development

FW Albaugh:kb

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

JANUARY 1962

FISSIONABLE MATERIALS - 02 PROGRAM

REACTOR

N-Reactor Exponential Experiments

The process tubes used for the flooding study have been wrapped with polyethylene to simulate 150% flooding in the annulus around the process tubes. Measurements are in progress for the pile without control rods.

Optimization of C-Pile Retubed Lattices

The buckling of the wet C pile has been remeasured with the central safety rod void plugged. The result was 20 μB lower than the result with the void present. Thus the unusually small wet-to-dry difference reported last month for C-Pile can be explained by the effect of the void on the vertical traverse which is taken only 4" away from the void. The dry case will be remeasured with the hole plugged.

Data Correlation and Analysis

A talk was given to a Nuclear Engineering Seminar at the University of Washington. The title was "Lattice Parameter Measurements in Graphite-Uranium Systems".

A quarterly report was submitted on methods of reducing harmonic corrections for exponential piles. Careful placement of sources and counter can reduce the correction below 1%. A special traverse was taken to illustrate the technique.

The fast source harmonic theory has been extended (HW-71747) to include the effects of pile boundaries on fast neutrons. The results are within 0.1% of the results of the present method for the cadmium shutter technique. The new correction might be needed for experiments without the shutter, but the present analysis is good if the shutter is used.

The Modified Heavy Gas Model and Neutron Spectra

Although Hurwitz-type spectra compare well with British fast chopper data at high temperatures, discrepancies become apparent near room temperature. These discrepancies are undoubtedly due to crystal binding effects and suggest modifying the heavy gas model. The French have suggested such a modification by allowing a varying slowing down power. The functional form of this modification should be obtainable from the scattering kernel of the material in question. However, since the model only approximates the actual scattering behavior of the material, only certain features of the scattering kernel can be retained. Analyses of rethermalization experiments indicate that the average energy loss per collision is the important quantity in a slowing down process. We, therefore, choose to modify the heavy gas model so that the average energy loss per collision from a Maxwellian spectrum is correctly reproduced. This uniquely determines the variation in slowing down power from the scattering kernel. Comparisons of spectra generated directly from scattering kernels and generated by the modified heavy gas model are planned.

Lattice Parameter Calculational Methods

A promising method for analyzing U-238 resonance absorption using group diffusion theory is being tried on solid uranium rod experimental data. The model, which at present is purely empirical, assumes that resonance energy neutrons fall into two groups. Group one, the "volume" group, has a relatively low absorption cross section and changes relatively slowly across a fuel rod. Group two, the "surface" group, has a high absorption rate and rapidly goes to zero as a function of rod penetration. A semi-quantitative analysis, using the least squares code GLEX to analyze Hellstrand's data on the spatial distribution of resonance absorption, indicates that the diffusion lengths in the two groups are about 1.5 cm and .003 cm. A quantitative analysis has failed to yield results, because of round-off problems. These problems are being eliminated.

A Recipe for Lattice Calculations

In the interest of providing a method for computing the quantities which are measured in a PCTR lattice experiment, namely, k_∞, δ, CR of 238 capture, CR of 235 fission, and 1/v traverses, using locally available machine codes and pending development of more sophisticated methods, a brute force approach has been used to compute the condensed NPR lattice experiment. Although the calculation of all of the above mentioned quantities has not been completed, the value of k_∞ is within 10 mk of the measured value.

The method consists of the following steps:

(a) Compute a parameter set of monoenergetic flux depression factors, g, to be used in program C-Fine for obtaining self-shielding factors for resonance absorbers.

(b) In program C-Fine obtain

$$\frac{\int g\sigma_a du}{\int du} = \overline{g\sigma}_{a_n} \text{ and } \frac{\int g du}{\int du} = \bar{g}_n$$

where the integration is over the interval associated with each level of the 19-level nuclear data tape. Define $\bar{\sigma}_{a_n} = \overline{g\sigma}_{a_n}/\bar{g}_n$.

(c) Run program G-2 for the lattice, using C-Fine digitalized cross sections already on the 19-level tape. Since these cross sections have been computed as

$$\sigma_n = \frac{\int \sigma du}{\int du}$$

from the C-Fine tape, define g_n for use in program G-2 for resonance absorbers as $g_n = \frac{\bar{\sigma}_{a_n}}{\sigma_{a_n}}$.

The basic assumptions on which the method depends are that a 19-level slowing down diffusion calculation with a Maxwellian thermal group is adequate when cross sections are slowly varying, that spatial self-shielding of sharp resonances can be obtained from monoenergetic calculations, that in complex cells having fuel regions of different isotopic concentrations sharp resonances in one isotope do not overlap those of any other isotope present, and do not appreciably reduce the absorption integral of any other isotope present, and that the effect of Doppler broadening can be ignored.

In the present calculation, program S-X was used to obtain S_4 monoenergetic fluxes in each region of the lattice, using Σ_a of the fuel as a parameter and setting all other cross sections to a nominal value characteristic of the more important resonance region (about 8 ev). Although the parameter values of Σ_a must span the entire range from the minimum in the resonance region to the maximum at the peak of the largest resonance, only about five values are required to span the range from white to black. The flux in non-fuel regions remains constant once the fuel is black and $\Sigma_a\bar{\phi}$ of the fuel region is a constant. Since the S_4 calculations with consistent albedo calculation averaged about 15 minutes of computer time apiece to achieve solid convergence, a great reduction in the cost of this method could be achieved by using some other means of computing monoenergetic flux depression factors.

In the C-Fine calculation of g_n for U-235 and U-238, about eight minutes is required because the program reads all 2756 energy levels from the C-Fine tape. It would be faster to recompute sufficient cross sections directly from the Breit-Wigner formula for the resonance region g-factor weighting. It would be possible, for about ten more minutes of machine time, to Doppler broaden the cross sections in the resonance region before applying the g factor weighting.

The G-2 calculation itself takes between two and four minutes, depending on how much output is requested, for a typical lattice of 100 mesh points.

Computational Programming Service

The reactor kinetics code TRIP004, incorporating all desirable features of previous versions of TRIP, is now in operating condition, and a copy of the program deck has been delivered to the customer. In addition to improvements described earlier, an optional procedure for better peak delineation has been added.

Fast source theory - cadmium shutter harmonic corrections for VTØCL, the exponential pile data reduction program, have been checked out. Since their use produces results varying only slightly from those in the present version of VTØCL, the new corrections will not be incorporated into the production deck at this time. They will, however, be available should cases be encountered where the effect of the new corrections might be greater.

An improvement to CØFIT2, the horizontal traverse cosine-fitting code, has been written. All input and output options will now be printed and identified for each case, making it simpler for the users to determine the difference in input conditions for several sets of similar output. This corresponds to a parallel improvement in VTØCL reported earlier.

Instrumentation

Fabrication was completed, including all transistorized preamplifiers and BF_3 tube shroud housings, for all five probes to be used for the NPR graphite purity tests. Tests were completed in the 326 Building standard pile of one complete probe assembly with satisfactory results. Seven commercial BF_3 proportional counters were tested and four were selected as being equal in quality to the original tube. Six more tubes were ordered on a returnable basis to select at least two more satisfactory units. Prior agreement with the vendor permits such exchange to secure seven quality and identical units. The source holder was completed and tested. Five linear amplifiers and two fast scalers were obtained on loan to be used for the tests at N-reactor. General electronics system testing progressed satisfactorily.

Several other BF_3 proportional counters were also tested during the month in efforts to obtain fully satisfactory units for later experimental work. Of the units tested, only one, fabricated on site, showed a reasonably adequate pulse height distribution. Further stability tests are planned with this particular tube.

The PIRDO effort concerning instrumentation for the NPR graphite purity tests is now nearly complete. Major items remaining are the selection of two or three more quality BF_3 tubes and final probe assembly. Two minor items, completion of a scaler-timer and fabrication of some delay lines, also remain. IPD personnel will perform the actual graphite purity tests with advice and assistance from PIRDO.

The Slow-Scan portion of the NPR Fuel Failure Monitoring System, fabricated to HAPO design by GE-APED, has not yet been shipped. Performance tests are being done at GE-APED. Plans were established for complete testing by PIRDO after equipment arrival.

A new radiation monitor instrument design was developed to meet the recently revised IPD functional specifications for updating reactor building monitoring equipment. Based on two previous developmental models, the new design provides a six-decade logarithmic response with scintillation detector and transistorized circuits. All detailed HAPO drawings were completed and fabrication was started. Only the switching, high voltage, and alarm relay sections were changed from the original development prototypes which have both logarithmic and multi-decade linear response ranges.

Vendors' "approval" circuitry prints on NPR nuclear instrumentation were reviewed and returned to the NPR Project Section with pertinent comments. Comments were also prepared on a review of bids for supplying fission chambers for the NPR.

Meetings were held at Information Systems, Inc., on January 16 to discuss the proposed design of the Integrated Data and Temperature Monitoring System for NPR, and to review newly prepared approval drawings. The proceedings of the meetings were summarized in a letter to NPR Project Section. To date, sixty-five vendor drawings have been reviewed.

The Mark III or 12-inch horizontal-vertical (HV) process tube distortion traversing mechanism was tested on a 40-foot long process tube at 189-F Area. The unit gave the contour of the tube with errors less than 3/16 inch. Similar tests of the Mark II or 6-inch model give contours that are in error as much as 0.6 inch. The Mark III model was also tested in 105-F reactor. Measurements had to be discontinued because the tube was distorted so much that the readings went off scale. The Mark III has now been modified to reduce its sensitivity and increase its range. This 12-6 HV model has been calibrated on the 189-F tube and is now ready for use during the 105-H shutdown. Satisfactory programs were developed for using the IBM-7090 to make the process tube distortion calculations.

Systems Studies

A series of analog computer tests to determine equivalent reactor structure on a simulated distributed reactor was concluded with what appears to be very good results. The tests were designed to provide information on interrelationships and responses as functions of flux distribution, temperature effects, and locations of flux detectors and control rods in the reactor.

Equipment was installed at 100-KW Area to obtain magnetic tape recordings of statistical fluctuations in reactor flux (reactor "noise"), using the neutron in-core flux monitors installed recently. One attempt to make the recordings was unsuccessful because of a tape recorder malfunction.

An intensive study of the complete NPR process was initiated in preparation for the scoping of an NPR simulation facility. A simplified block diagram of the NPR processes and control system to be included in the simulator was made as a first step in outlining the proposed simulator functions. The primary loop and the water-to-water to water-to-steam conversion simulation requirements were outlined. A detailed list of the control, indicating and recording instrumentation was then prepared for cost estimating purposes. Sketches of the control consoles were made to show the proposed amount and arrangement of control room detail which is to be included in the simulator. Typical procedures for startup, equilibrium and normal shutdown were prepared.

The reactor instrumentation simulation studies have been completed and results forwarded to IPD. The simulation provided computation of fuel and water temperatures and power at each of six top-to-bottom nodes in the reactor for flux distortion studies. Also studied were effects at each node due to a high power level scram at a single node, and effects due to scram initiated by high coolant outlet temperatures. It is planned to simulate the problem again in the near future with an 11-node model. This will require equipment not presently available; the 11-node model will be programmed on the EASE and GEDA computers as soon as the necessary equipment has been received.

An 11-node kinetics improved simulator for reactor instrumentation studies is being designed. This problem will use up all available analog equipment and will take four to five weeks of computer time.

SEPARATIONS

Criticality Studies With Plutonium Solutions

Critical mass experiments were continued with plutonium nitrate solutions in a 14-inch diameter stainless steel sphere reflected with a four-inch-thick spherical shell of concrete. Eleven experiments were performed. Criticality was studied as a function of the plutonium concentration and acid molarity of the solutions. Some data were also obtained for evaluating the effect of the stainless steel shell of the criticality vessel (the thin SS shell slightly reduces the effect of the concrete reflector). Several experiments were run to check the consistency of the measured results.

The plutonium concentration and acid molarity were varied so as to obtain criticality in the nearly full sphere for acid molarities of 5.6, 2.9, and 1.2. From the data obtained, the critical mass for a Pu-water mixture is then estimated to be $\sim$633 g Pu. If further corrections are made for the effect of the SS shell, and for the effect of Pu^{240}, the critical mass becomes $\sim$550 g Pu^{239}. This value is in general agreement with the early Hanford experiments in the case of a 14-inch sphere fully reflected with water[1]. A comparison of these data shows the four inch concrete reflector to be essentially equivalent (within the experimental uncertainties) to an effectively infinite water reflector. Further, the critical mass of 550 g Pu^{239} in the four-inch concrete reflected sphere does not differ appreciably from the minimum water reflected value of 510 g Pu^{239} which is reported for an aqueous plutonium solution[1]. In subsequent experiments an additional layer of concrete will be used to increase the reflector thickness to ten inches.

Miscellaneous Experiments for Nuclear Safety Specifications (Measurement of k_∞ in the PCTR for Aqueous U^{235} Solution)

Irradiations were completed in the PCTR for determining the limiting critical concentration of an aqueous U^{235} solution. The purpose of the experiment is to re-evaluate and check the maximum concentration of U^{235} for which k_∞ is $\geq$ unity in an aqueous solution--this concentration is a useful quantity for nuclear safety applications. The results of these measurements will be compared with those reported by ORNL and will serve as a further cross check between the two laboratories. The measurement will also provide another "known value" for checking the PCTR method.

---

1 Kruesi, F. E., J. O. Erkman, and D. D. Lanning, Critical Mass Studies of Plutonium Solutions, HW-24514 DEL.

This measurement was originally undertaken in February of 1961, but a reaction between the solution and the aluminum tank walls occurred during the experiment, invalidating the results. The tanks used in the current experiment were treated with Glyptol, since tests had shown this would eliminate the previous trouble.

For the experiment, the buffer tanks were filled with solution at a concentration of 13 gms of U/ℓ and the three core tanks with solutions at 11, 13, and 15 gms of U/ℓ, respectively. The measurement consists of reactivity comparisons of the three core tanks with an identical tank filled with helium. Preliminary results indicate the limiting concentration of the 93% enriched UO_2F_2 solution to be ≈ 12.95 gms of U/ℓ (12.0 gms of U^{235}/ℓ), which is in good agreement with the value obtained at ORNL.

In addition to the reactivity measurements, gold foils were irradiated in lateral traverse tubes through the buffer and core tanks to give values of the cadmium ratios through the system. Preliminary results of these irradiations indicate the cadmium ratios in the core tanks to be about nine.

Computational Program in Support of Plutonium Critical Mass Experiments

Effect of Pu^{240} on the Criticality of Plutonium Nitrate Systems

The effect of Pu^{240} on the criticality of plutonium nitrate systems has been computed as a function of the Pu^{240} content for incremental changes of 2.5%. The results are reported in detail in the Physics Research Quarterly Report for October, November, December 1961.

The effect of the nitrate ion concentration, apart from the effect of the Pu^{240} poisoning, was also evaluated. In this case it was observed that the incremental effects of the nitrate concentration were such that added increments of nitrate concentration had larger effects. This can be expected from the decrease in H/Pu ratio when large amounts of nitrate are introduced into the solution. The computed effect ranged from ~ 2 liters/mole increase in critical volume at 30 gm/ℓ to ~ 1.5 liter/mole at 700 gm/ℓ.

A Model for the Fast Fission Parameter δ

A quantity of importance in the calculation of critical volumes for slightly enriched-water moderated lattices is the ratio of fast fissions in U^{238} to fissions in U^{235}. The ratio, δ, has previously been successfully calculated for isolated rods of uranium. However, for closely packed lattices, a fission neutron has a finite probability of suffering its first collision in a neighboring fuel rod. A model for the calculation of δ, which includes the interaction effect, has been developed. The results obtained using the model are in excellent agreement with experimental values for hollow and internally moderated fuel elements.

Interactions of Subcritical Systems

Criticality data for ten reflected cylindrical assemblies from ORNL was used to evaluate the approximations made in the subcritical interaction program. These experiments were calculated to be 0 to 4 percent low by the albedo and leakage method. An attempt to extend the method to interacting slabs was made. This attempt was hindered by a lack of medium-range experimental data (that is, between no interaction and total interaction). The solid angle approximation also presents a difficulty.

The critical matrix for interacting components has been formulated with the solid angle as a parameter. Machine iteration for solution of the matrix has not been completely successful, but simple revisions in the form of the boundary condition equations may give better numerical results.

Consulting Services on Nuclear Safety

Nuclear Safety in HLO

Specification K-1 covering fuel element storage and handling in the PRTR Operation was revised to include UO_2-0.47 w/o PuO_2 fuel elements.[1,2,3]

Specification B-2 was issued to cover the handling of 93% U^{235} enriched uranium foils in the Experimental Reactor Operation.[4] There are 263 foils (3.8 Kg U).

At the request of the Radiometallurgy Laboratory[5], an estimate was made of the fraction of a critical mass represented by the fissile materials currently on inventory in the 327 Building[6]. Assuming optimum conditions of geometry, water moderation, and water reflection, the December inventory represents 0.85 of one critical mass. The largest fraction is 163 lb. of 1.6% U^{235} enriched uranium (0.24) and the next largest is 112 g of plutonium (0.22).

---

1 Letter from W. B. Lewis to E. D. Clayton, Mixed Oxide Fuel Element Criticality, January 5, 1962.

2 Letter from E. D. Clayton to W. B. Lewis, same subject, January 9, 1962.

3 HLO Safety Specification No. K-1 (REV), Rules for the Storage and Transporting of Mark I Pu-Al Fuel Elements (Al-2.2 w/o Pu Alloy) and Moxtyl Fuel Elements (UO_2-.47 w/o PuO_2 Mixed Oxide), January 29, 1962.

4 HLO Nuclear Safety Specification No. B-2, Rules for the Storage and Handling of 93% U^{235} Enriched Uranium Metal Foils, January 15, 1962.

5 Letter from R. E. Olsen to C. L. Brown, Critical Mass Computation, Jan. 8, 1962.

6 Letter from C. L. Brown to R. E. Olsen, Critical Mass Computation on 327 Building Inventory, January 15, 1962.

Nuclear Safety in FPD

The nuclear safety of a proposed storage facility for NPR fuel element samples was reviewed and approved for the Engineering Operation.[1,2] The new facility will consist of two groups of three cabinets, spaced ten feet apart; the location will be the 3706 Building.[3] The total capacity of the six cabinets is 16,000 lb. of uranium in the form of rings, cut from NPR inner and outer tubes. The cabinets are of sturdy construction and are securely anchored to the wall. The nuclear safety of this array is assured by the following:

1) The geometry of the array is safe--the horizontal depth of the cabinets is 12 inches, which is 68% less than the minimum critical slab thickness for 0.95% U^{235} enriched uranium.

2) The array is dry and there is a very low probability of flooding with water.

3) If the fully loaded cabinets were to collapse and become flooded, the 8000 lb. of uranium in the collapsed geometry would represent less than a critical mass.

4) The two groups of three cabinets are ten feet apart, and therefore isolated from the standpoint of neutron interaction.

Nuclear Safety in Transportation

Comments concerning the nuclear safety of transporting 1.5% U^{235} enriched fuel elements cross-country were submitted to the Construction Engineering and Utilities Operation.[4,5] This information was needed for a long range study that is being made to estimate the cost of supplying NPR with 1.5% U^{235} enriched, 11-rod cluster fuel elements from an off-site vendor. It was pointed out that nuclear safety in transporting unirradiated fuel elements depends primarily on two factors: the design and integrity of the shipping container, and the degree of control that can be exercised over the transporting vehicle. For example, if the fuel elements are in ordinary boxes and shipped by common carrier, the shipment would be limited to about 0.1

---

[1] Letter from C. L. Brown to W. G. Hudson, Comments on the Nuclear Safety of the Proposed Storage Cabinets for NPR Fuel Tube Samples, January 19, 1962.

[2] Nuclear Safety Specifications for Fuel Element Manufacturing Processes, HW-47013.

[3] Letter from W. G. Hudson to L. L. Samford, Nuclear Safety - 3706 Sample Storage, January 25, 1962.

[4] Personal request from D. A. Knapp to C. L. Brown, January 3, 1962.

[5] Letter from C. L. Brown to D. A. Knapp, Comments on the Nuclear Safety of Transporting 1.5% U^{235} Fuel Elements, January 5, 1962.

of a minimum critical mass. If, however, the fuel elements are in approved birdcages and these are shipped in an escorted or especially built railway car, then the quantity in the shipment would not be limited. Various load limits between these two extremes were quoted for 1.5% U^{235} enriched fuel elements.

Mass Spectrometry

The mass spectrometer for this program provided isotopic analyses of ten plutonium samples for CPD during the month. Operation of the spectrometer has continued to be satisfactory since replacement of the magnet sweep coils in December. Studies which were made of ion source operating conditions revealed that heavy element sample sizes of the order of 10 nanograms were sufficiently large to provide isotopic analyses on most samples. Measurements were also made to attempt to find a background ion spectrum of thallium which had apparently been found on occasion in the other mass spectrometer. No evidence could be found for the existence of thallium ions or complexes in the background of this spectrometer.

Instrumentation

The "C" Column Simulation consists of an attempt to develop a satisfactory mathematical model of a pulse column used in chemical separations. Four possible models of varying complexity have been derived and the analog computer is being used to determine the chemical constants necessary to give the best fit of each of the models to given experimental data. Some test cases were run this month. These were performed in an attempt to analyze some digital computer runs. Work on this study will continue in February.

Maintenance continues to be a problem at the Critical Mass Laboratory. During the month, a routine maintenance procedure was written (SR Memo 62-2). Lack of funds prevented hiring an instrument craftsman to perform the routine procedures. The present work load does not permit the regular instrument craftsman to perform this function. One cause of the maintenance problems seems to be excessive heat in some of the instrument cubicles. An effort is being made by the landlord to increase the ventilation air flow in the control room and through the instrument cubicles. Present temperature in the control room is from 85 to 90 F. Most of this heat is produced by the electronic equipment; consequently, temperatures within some of the cubicles run considerably in excess of 100 F. A scintillation monitor has been installed and is now being used in rod drop tests. The tests are being run to determine control rod worth. The neutron levels before the drop and immediately after the drop are used to calculate the negative reactivity of the rod. The equation $K = \frac{1-R}{R}$ is used where K is rod reactivity in dollars and R is the ratio of the flux after, to the flux before the drop. A fairly fast electrometer is used to measure the scintillation probe photomultiplier tube anode current. A fast recorder then records the electrometer output which is an indication of neutron flux.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Cross Sections

A foil of electrodeposited Am^{243} was received for fission measurements. Malfunctions of electronic equipment which were encountered during the month have caused measurements which were made to be unreliable. Nevertheless, it appears from these preliminary measurements that the neutron-induced fission rates will be too low to obtain useful fission cross sections. In addition, the spontaneous fission rate seems to be lower than has been predicted by phenomenological theory.

Inelastic Neutron Scattering from Water

The series of measurements to determine the correction due to half-order contaminant reflections in the monochromating crystals used in the inelastic scattering measurements has been completed. Analysis of the results has not been completed, but an appreciable correction to the inelastic scattering data appears to be necessary only for the scattering of 0.4 ev neutrons. A series of measurements on a water sample of known thickness is in progress. These measurements are necessary to put the measured scattering cross section of water on an absolute scale. A bronze worm gear in the drive system of the second arm of the three-axis spectrometer has completely failed. A temporary replacement is being procured.

Elastic Scattering of Neutrons from Water

Analysis of the previously obtained data on the quasi-elastic scattering of slow neutrons from water has been continued. Data have been re-analyzed according to a new least-squares fitting program being written at Hanford. The results of fitting to the data of the scattering of 0.147 ev neutrons are essentially complete. The interpretation of the fitted functions is in progress.

Fast Neutron Cross Sections

The analysis of the neutron total cross section data previously obtained on Li, Na, K, Al, Fe, and Cu from 3 to 15 Mev is in progress. Particular attention has been paid to the effects of instabilities of the time-of-flight system during the measurements. Preliminary consideration has been given to the design of a data-reduction program for the computer including the use of a punched-tape output from the data storage analyzer. The precision beam-locating system for the Van de Graaff is being modified to permit use at higher beam currents. Also a new RF deflection system which uses quadrature plates to suppress alternate cycles of the swept beam has been fabricated.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE

Fuel Cycling in Fast-Thermal Reactor Complexes

Work on a fast-thermal reactor complex, briefly alluded to in the previous progress report, has been started. The first complex under investigation consists of an APWR-type thermal machine coupled to a fast oxide breeder.

Changes in the Pu isotopic composition of the APWR are being examined, by means of the MELEAGER code, for a variety of initial Pu enrichments. The thermal reactor input plutonium is derived from a fast reactor breeding blanket.

A simplified model of the Pu buildup in the fast reactor blanket, assuming constant flux, constancy of N^{28} and $N^{49}(0) = N^{40}(0) = 0$ yields the approximate relation, $N^{40}/N^{49} \sim 1/2\ (\sigma_c{}^{49}/\sigma_c{}^{28})\ N^{49}/N^{28}$. For a typical fast oxide blanket $1/2\ (\sigma_c{}^{49}/\sigma_c{}^{28}) \sim 1$, so that N^{49} is approximately the geometric mean between N^{40} and N^{28}. One might note parenthetically here, that for a thermal reactor, the ratio $1/2\ (\sigma_c{}^{49}/\sigma_c{}^{28})$ is of the order of a hundred. This implies much lower burnup in the thermal reactor, for comparable plutonium quality.

An improved matrix diagonalization routine was also used to examine the fast blanket Pu buildup. For constant flux operation, the results show very clearly the great potential of the fast reactor breeding blanket as a producer of high quality plutonium, which can be used as thermal reactor fuel.

Plutonium Values in Fast Spectrum Reactors

The first phase of the plutonium value investigation in fast spectrum reactors has been concluded. An informal report (HW-72304) describing the results of the study has been prepared for publication.

PRTR "Phoenix" Fuel Experiment

A set of preliminary cases was run on the SWAP code to study the effect on the spectral hardening of varying the plutonium concentration and changing the absorption cross section of the process tube in the central cell of the PRTR. Initial results look encouraging in that the required hardening of the spectrum possibly can be obtained with plutonium concentrations and process tube cross sections that are within realm of reality.

At present more cases are being run to acquire data for a greater range of the variables. This study is being performed in order to determine the feasibility of performing a "Phoenix" fuel burnup experiment in the PRTR.

The Critical Facility of the PRP

Specifications and restrictions which will be used when the PRP-CF is being operated are being established. In particular, the procedures which will be used when fuel elements are loaded and unloaded from the reactor and those for core changes other than fuel element changes are being prepared for presentation to the G-E Technological Safeguards Council.

The descriptions of the Physics experiments which will be conducted at the startup of the Critical Facility are being reproduced (HW-71214). The results of the experiments will be used to determine basic loadings, evaluate the hazards involved in operation, and to assure the over-all operability of the facility.

Two modified IBM 704 codes (RE126 and RE135) from Argonne National Laboratory are ready for calculations which involve the kinetics of the PRP-CF. The modifications include an increase in the maximum number of delayed neutron groups from 30 to 50 (because of the photoneutron groups required for the PRP-CF) and the removal of the requirements that all of the input be repeated when more than one case is run. Both programs calculate the behavior of the flux in a reactor following a step change in reactivity by solving the space-independent kinetics equations for one thermal group of neutrons.

It is assumed for RE126 that the reactor is running at a constant power level before any reactivity change is made at either critical or subcritical conditions. In addition, all delayed neutron precursors are assumed to be in equilibrium at the time of the change.

The same assumptions hold for RE135 except cases in which the precursors are not in equilibrium can be calculated.

Code Development

RBU

Several attempts to resolve the discrepancy between empirical and analytic results of the uranyl-nitrate critical mass experiments have had some success. The neutron spectra obtained from the Monte Carlo portion of RBU appears satisfactory in all respects. The previously observed excessive particle leakage was at least partially corrected by a correction in the atom density of hydrogen in the reacting solution. Other improvements were made in the description of the critical assembly as seen by both the Monte Carlo and Diffusion programs. Currently, the reactivity value calculated by the Diffusion code is 0.954 as compared to the empirical value of 1.0011, which indicates errors still existing.

Several portions of the Monte Carlo have been flow-charted, and numerical evaluation of input data, values calculated during the Monte Carlo, and output data continues.

Further communication with J. P. Burr of Atomics International indicates the random number generating techniques used are satisfactory as are the neutron ages in the Monte Carlo.

Program SHUSH

Program SHUSH - Spherical Harmonics Using the Standard HFN--was coded and 50 percent debugged. SHUSH reads basic neutron diffusion parameters and punches cards which, when read by HFN, cause HFN to run multi-energy spherical harmonics calculations in slab geometry. Different energy groups may be analyzed using diffusion theory on the P-3, P-5, P-7, double P-1, double P-2, or double P-3 approximations to the transport equation, with arbitrary isotropic transfer from group to group. Depending upon the angular detail used in each group SHUSH is limited to from five to twenty energy divisions, and uses the same logic as the FLIP[1] code within each group.

[redacted] Anderson, B. L., et al., "FLIP-An IBM-704 Code to Solve the P_L and Double-P_L Equations in Slab Geometry," WAPD-TM-134, March, 1959.

Lattice Parameters for Low Exposure Pu-Al Fuels

A summary report on the experiments using low exposure Pu-Al fuel in graphite lattices is in preparation. Included in this report are descriptions of the lattice components, the masses of copper required to poison the lattices to unit multiplication and tabulations of foil activation data.

Doppler Coefficient of Plutonium Fuels

A report has been prepared which describes the PCTR experiments to measure the fuel temperature coefficient of Pu-Al fuel. The abstract follows: The change in the reactivity of the PCTR was measured as a section of Pu-Al fuel in the center of the core was heated from room temperature to $\sim 400^\circ$ C. Measurements were made with aluminum dummies, with 1.8 w/o low exposure Pu-Al and with 2.1 w/o high exposure Pu-Al in the test cell. The signs and the magnitudes of the fuel temperature coefficients of reactivity were obtained from the data.

Effective Resonance Integral of Pu^{240}

The experiment to measure the effective resonance integral of Pu^{240} relative to the dilute resonance integral as a function of Pu^{240} concentration has been completed. The data collected are not inconsistent with the expected results and are probably satisfactory. There is a marked non-linearity of reactivity change as a function of Pu^{240} addition because of self-shielding effects in the one volt resonance region. Detailed interpretation of the experimental data has been started.

Neutron Spectrum Studies

Neutron Rethermalization

An abstract of a paper entitled "Neutron Rethermalization in Graphite and Water" was submitted to Dr. Corngold of BNL for approval for inclusion in the proceedings of a conference on Neutron Thermalization to be held at BNL from April 30 through May 2, 1962.

An analysis of the differential neutron spectra measured by Coates and Gayther (AERE-R-3839) was completed this month. "Hurwitz Spectra" are in fair agreement with their observed spectra for graphite temperatures of 160, 244, and 321°C. The disagreement at 20°C, reported last month, has not been resolved. The fair agreement found here had led to a new analysis of the graphite thermalization experiments using "Hurwitz Spectra" in place of "Westcott Spectra". The sets of rethermalization cross sections obtained with the two spectra differ by approximately 25%. This difference is considered a measure of the absolute uncertainty in the cross sections since the respective spectra represent extremes of the possible choices of spectra. The results are compared in Tables I and II.

TABLE I

RETHERMALIZATION CROSS SECTIONS OF 300°K GRAPHITE FOR T_n NEUTRONS

T_n	Hurwitz Σ_{reth} cm^{-1}	Westcott Σ_{reth} cm^{-1}	Average Σ_{reth} cm^{-1}
144	0.018	0.016	0.017
523	0.037	0.044	0.040
690	0.034	0.045	0.039
828	0.031	0.041	0.036

TABLE II

RETHERMALIZATION CROSS SECTION OF T_m GRAPHITE FOR NEUTRONS AT APPROXIMATELY 300°K

T_m	Hurwitz Σ_{reth} cm^{-1}	Westcott Σ_{reth} cm^{-1}	Average Σ_{reth} cm^{-1}
144	.0071	.0092	.008
523	.036	.047	.041
690	.053	.066	.060
828	.056	.069	.062

Absorption Rod Experiments

Traverses of the activities of Cu^{64}, Eu^{152} and Lu^{177} were measured (in CY 1961) in and near a 5.31 inch diameter copper rod imbedded in the graphite core of the PCTR. A partial analytic solution of the problem is being used to compute the theoretical traverses rather than numerical methods. The multithermal group model with an "absorption spectrum" is being used to describe the space-energy distributions of neutrons.

Critical Mass Studies for 1.8 w/o Pu-Al Fuel

Experiments to determine nuclear parameters for 1.8 w/o Pu-Al fuel are being conducted in the tank in the TTR reactor room. The experiments consist of approach to critical and exponential measurements with lattice spacings of 0.75, 0.85, 0.90, 0.95, and 1.05 inches.

The approach to critical using the 0.75 inch lattice spacing has been completed. The fuel rods were half-length PRTR rods. A critical loading of 4009 gms Pu was indicated by extrapolation of the inverse multiplication curve which included a loading of 95% of the critical mass.

These measurements will help establish nuclear safety specifications for PRTR fuel processing and will supplement similar measurements which are part of the PRP-CF program.

Anomalous Disadvantage Factors

At the request of Programming Operation an apparent anomaly in the thermal disadvantage factor ($\bar{\phi}_{mod}/\bar{\phi}_{fuel}$), obtained from P_3 calculations in the IDIOT code for a small fuel rod in a water annulus, was investigated. The rod has radius = 0.3065 cm, Σ_a = 0.12038 cm^{-1}, Σ_{s0} = 0.34493 cm^{-1}, Σ_{s1} = 8.517 x 10^{-4} cm^{-1}. The moderator has Σ_a = 0.011946 cm^{-1}, Σ_{s0} = 2.2111 cm^{-1}, Σ_{s1} = 0.9389 cm^{-1}, Σ_{s2} = 0.1891 cm^{-1}. A slowing down source uniform in space and angle of 96.054 was assigned to the moderator region and a corresponding value of 0.103 in the rod. A comparison of the IDIOT P_3, the ANP Program I_2 P_3, and the S-X transport S_4 calculations are shown below:

Cell Radius cm	Disadvantage Factors					Rod Blackness from S-X Current/Flux Rati
	IDIOT	I_2	I_2 Σ_{s2}=0	I_2 With No Source in Rod	S-X	
0.416	1.0510	1.0517	1.0481	1.0482	1.0637	0.06859
0.577	1.0351	1.0352	1.0334	1.0335	1.0418	0.07002
0.701	1.0332	1.0333	1.0321	1.0321	1.0389	0.07027

The reason for the decreasing disadvantage factor with increasing moderator thickness, an anomaly in diffusion theory but consistently displayed in the higher harmonic approximations, can be explained in terms of the change in blackness of the rod which occurs with the change in angular distribution of [redacted] incident on the rod. When the moderator annulus is thin geometrically as well as optically, the neutron source at the rod surface due to uncollided

 [redacted]

plus collided flux in the moderator is smaller normal to the surface than for glancing angles. The effect of this source anisotropy is to produce a flux at the rod surface which is bulged in the tangential directions, as evidenced by the S_4 vector flux printouts (not shown).

Bulging in the longitudinal direction tends to increase the blackness by making longer longitudinal rays in the rod more probable, while bulging in the circumferential direction tends to reduce the blackness by making shorter path lengths more probable. The change in thickness of the moderator annulus had only a small effect on the longitudinal bulge in S_4, and was small to begin with, probably because exponential attenuation of long longitudinal rays in the moderator is limiting on the source strength at the rod surface for large polar angles. The azimuthal rays are short, however, and are proportional to

$\sqrt{r_{mod}^2 - r_{rod}^2}$, while the rays normal to the rod surface increase as $r_{mod}-r_{rod}$. Thus, the ratio of azimuthal to radial source strength goes as

$\dfrac{\sqrt{r_{mod} + r_{rod}}}{\sqrt{r_{mod} - r_{rod}}}$ and is changing very rapidly with moderator radius when the annulus is thin.

The rod blackness, as a result of the fact that fewer paths go through the thicker regions because of the flux anisotropy associated with thin moderator annuli, tends to increase with increasing moderator thickness and approach a limiting value, as indicated by the S_4 results. This change in blackness produces the anomalous behavior of the disadvantage factor, since a smaller blackness forces a larger moderator flux in order to produce the same absorption rate in the rod. Judging from the case in point here, the anomaly disappears when the moderator is about 1 mfp thick. For thicker annuli, one would expect constant blackness and the usual trends of increasing moderator flux with increasing moderator thickness until the moderator absorption rate at large radii equals the source strength.

Homogeneity and Nondestructive Testing of PuO_2-UO_2-PRTR Fuel Rods

A brief review has been made of the problem of PuO_2-UO_2 homogeneity and nondestructive testing of PRTR fuel rods. Attention was given to the heat flux specification for PRTR fuel and the flux distributions for the PRTR. It appears that a tolerance of ± 5% on the homogeneity of PuO_2 is needed only in the vicinity of flux peaks. Hence the fuel rod testing problem can be greatly reduced.

Instrumentation

The feasibility of using a microwave resonant cavity as a sensitive linear displacement transducer for in-reactor metallurgy creep measurements was further investigated. Two identical microwave cavities were used in a new approach; one as the measurement cavity and the other for reference. The reference cavity is tuned so that the resonances of the two coincide as observed on an oscilloscope. With this arrangement, the reference cavity can be reset with reproducibility of two microinches. A conceptual design has been developed for an automatic servo drive on the reference cavity.

The microsecond scaling system for the PRCF has been completed and placed on test.

Documentation regarding the economic and scientific justifications for the proposed experimental digital control computer was prepared at the request of the AEC.

The general design was completed for a scintillation transistorized PRTR liquid effluent monitoring system to be used for containment trip purposes in place of the presently used, unstable ion chamber plus commercial log electrometer system. In addition, an added design was completed, similar to the foregoing except 100 times more sensitive, for a parallel sensitive system to be used for very low-level contamination monitoring of the PRTR effluent. The two parallel systems, including scale overlap, will monitor the effluent for fission product contamination levels from about 10^{-6} $\mu c/cc$ to 1 $\mu c/cc$. Double selectable level trip alarms are included in both basic units. If the prototypes perform satisfactorily, two more parallel containment level trip instruments will be fabricated to provide two-out-of-three redundancy.

HTLTR Studies

The study of ways to minimize the temperature coefficient of reactivity of the proposed HTLTR has continued. The problem is to determine a design such that changes in the leakage rate of neutrons from the reactor and the change in thermal utilization nearly cancel. The effect of varying the size of the reactor is being investigated to see if the temperature coefficient can be reduced by this means without a significant loss of sensitivity of the reactor to changes in the core.

PHOENIX FUEL

ARMF-MTR Experiments with Plutonium Fuel

Samples of Pu-Al which contain boron have been fabricated. The purpose of these samples is to calibrate the ARMF. The samples have been cast satisfactorily by using an aluminum-boron master alloy.

Chemical analyses to determine the boron content and uniformity is very difficult to accomplish because of the small content of boron.

A method of using reactivity measurements to check the amount of boron which was introduced into the melt compared to the amount actually in a sample is being considered.

NEUTRON FLUX MONITORS

Plans were formulated to coordinate the activities of the various groups to be involved in the test irradiation of the experimental breeder foils now being prepared. Successful deposition of uranium solutions onto carbon subtrates was achieved experimentally. The substrates are currently applied to stainless steel holders; however, a special commercial alloy will be used for the actual test samples. Similar work was accomplished with plutonium solutions sintered in carbon. The foil structures are to be analyzed using photomicrography.

A revised draft of the interim report on In-Core Neutron Flux Monitors was written and submitted for typing. This report summarizes all theoretical and experimental work to date for various plutonium and plutonium-uranium composition breeder detectors. The detector parameters of sensitivity, constancy of response, and useful lifetime are discussed in terms of the effects of flux level, flux changes and distribution, and irradiation time.

Further analyses were completed regarding microwave techniques for in-core flux monitoring which would be feasible for use at 600°C in a flux of 10^{13} nv or greater. Microwave noise measurement methods for measuring ionization produced in a cavity appear most attractive for detailed investigation during the next several months. More extensive experimental investigations of microwave spectroscopy methods for detecting neutron-induced nuclear transmutations will be deferred until more suitable equipment is available.

NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

The multiple parameter eddy current test equipment used with a simulated multi-layered test specimen was modified to increase sensitivity and to improve stability. Available drive current for the test coils was increased by a factor of fifty, and resolution of the most sensitive bridge null adjust control was increased by two orders of magnitude. Stability of the input circuits was increased by providing additional shielding and by installation of rigid wiring to reduce variations in stray coupling. Test coil driving current waveform was improved by use of additional filtering in the drive circuits. Measurements of the signal descriptors, or Fourier series coefficients, can now be determined with one percent precision, and can be repeated to this same precision over a period of several days.

The stability and linearity of the amplifiers in the transformation section of the equipment are now being checked. Following any needed changes in this section the evaluation of the method for separation of parameters in the three and four parameter cases will be resumed.

The four parameter summing network fabricated for use with the orthogonal exponential expander and sampling circuits was checked for operation. It was found that individual bias controls must be added in the sampling circuits to reduce undesired transmission of signals through the sampler at times other than during the sampling period. The remainder of the circuit is operational, and detailed stability and linearity checks will next be made.

Heat Transfer Testing

The compact radiometer installed last month was found to perform more satisfactorily than the original radiometer used in these tests. Sensitivity to small heat transfer defects in bonds of aluminum clad uranium fuel elements was improved by moving the radiometer around the fuel element closer to the heated region; the area viewed by the radiometer is now 1/4 revolution away from the plasma flame.

Emissivity differences are still the major limitation in test sensitivity. Partial compensation for emissivity differences was made by using reflected infrared superimposed on that emitted from the hot fuel element surface. This, combined with the other improvements, resulted in the definite detection of a 1/4-inch-diameter bond defect in an aluminum clad fuel element. However, still greater sensitivity will be required to permit detection of slight differences in bond conductivity due to metallurgical composition variations.

Initial tests have established design parameters for a new type of emissivity-independent system. It should be possible to test the concept of this new system using relatively simple equipment.

Savannah River Laboratory has shipped seven nickel bonded, aluminum clad, uranium fuel elements, and Fuels Preparation Department, HAPO, has furnished 130 AlSi bonded, aluminum clad, uranium fuel elements for heat transfer testing.

Zirconium Hydride Detection

Seven hydrided Zircaloy-2 samples containing from less than 50 to 500 ppm, obtained last month, were metallographically analyzed and appeared to be within the expected concentration ranges. Six sections of Zircaloy pipe containing small, highly hydrided spots were also obtained. Ultrasonic tests, made by Testing Methods, FPD, have shown that no strong reflections from the interface between the hydrided and non-hydrided metal occurs in the pipes at frequencies of 2.5, 5, and 10 mc. A request to furnish hydrided Zircaloy-2 samples for ultra low energy neutron radiography has been received from Harold Berger, Argonne National Laboratory. It may be possible to see differences in low energy neutron absorption by samples having different hydrogen concentrations below 1000 ppm.

Theory indicates that under certain circumstances, it may be possible to detect differences in ultrasonic velocity and attenuation in Zircaloy samples containing different amounts of hydrogen. The feasibility of using special ultrasonic effects to detect hydride in Zircaloy will be determined when the recently ordered ultrasonic experimentation system arrives.

In an effort to detect local hydriding in Zircaloy-2, eddy current testing techniques are being applied to measure the Hall coefficient and resistivity of a sample with a single test probe. Work has continued on the preliminary stages of the problem using a bismuth sample and a one-kilogauss magnetic field in an effort to optimize test sensitivity to the point where Hall currents in hydrided Zircaloy are detectable. Presently, signal-to-null ratios of better than 100-to-one are being obtained. This ratio must be increased by at least a factor of 10 before tests with Zircaloy samples can be attempted. Some difficulty has been experienced in obtaining an oscillator with the required purity of 100 KC output signal for driver coil excitation. A crystal-controlled oscillator is being fabricated in an effort to improve the quality of the driving signal. Comparative tests using several different test coil geometries are also in progress.

X-Ray Stress Analysis

X-ray diffraction can be used to nondestructively measure elastic residual stress in metals. However, it cannot be used to measure over-all residual stress after plastic deformation of the region being measured. This is due to non-isotropic straining of the individual crystals seen by the X-rays; some crystals yield and leave their neighbors in a highly elastically stressed condition, regardless of over-all stress levels. Theories applied to determine engineering stresses from X-ray measurements assume a homogeneous, perfectly elastic medium.

Experiments were conducted with the assistance of Chemical Research with available laboratory X-ray diffraction equipment. Measurements on a mild steel bar in tension were within 20% of the actual stress values at 12,000 and 25,000 PSI. This result encouraged an attempt to measure residual stresses in pipes due to welding. Such measurements would be a useful nondestructive test to determine whether stress relief after welding had been adequate. Initial data indicated plastic deformation of the pipes occurred in the region of the weld, and accurate measurement of the stresses before stress relief is not possible. However, two welded pipes were vapor blasted and then heat treated so that one was believed to be fully stress relieved and the other was not. Initial data has shown a striking difference between the broadness of the diffraction lines from the vapor blasted surface of these two pipes. Analysis of the data in an attempt to quantitatively determine [redacted]

Either half of the symmetrical pattern can be viewed independently, which further improves image contrast.

Following these improvements, some initial observations of Lamb wave propagation in flat Zircaloy plates and small diameter tubing were made. Several modes were observed. Photographs of mode propagation and mode conversion at the end of 0.044-inch-thick plates were obtained from what are thought to be the fifth symmetrical, sixth symmetrical, and sixth asymmetrical modes. The modes which were generated due to conversion at the plate edge have not been identified.

Mode propagation in 0.680-inch I.D., 0.035-inch wall Zircaloy tubing and mode conversions due to a 0.010-inch-deep notch machined in the O.D. were also observed and photographed. Mode conversion at the notch was complex, though perhaps not to the extent of that which was observed at plate edges.

By careful optical system adjustment, a single portion of the energy converted at the tubing notch defect was independently observed. Good image contrast was obtained, indicating a supplemental method for ultrasonic defect detection may be feasible.

USAEC-AECL COOPERATIVE PROGRAM

Nondestructive Testing of Sheath Tubing

Studies of comparative ultrasonic signal strengths for various test angles continued. For each ultrasonic mode, a phase velocity exists which is equal to the longitudinal velocity. At the corresponding incident angle, the predominantly horizontal particle motion at the tubing surface should result in a larger signal than at other angles. Studies are in progress to examine these relationships at various frequency-depth (fd) products for plates and tubing.

Before the different modes can be predicted, the incident angle, thickness of plate, and frequency must be known. The incident angle and thickness are readily established but the frequency may not be precisely known, since transducers vary considerably in their central frequency. One way of estimating the frequency is to measure the group velocity and mathematically approximate the fd product and subsequently the frequency. A mathematical expression has been derived for approximating the fd product by use of the group velocity equation and the frequency equation. Measurements of group velocity are in progress.

The ultrasonic responses from three supposedly identical reference notches were measured. Each notch was electro-machined 2.0 ± 0.2 mils deep by 2.25 ± 0.25 mils wide by 250 mils long and was located in the center of a 6-inch diameter Zircaloy-2 plate. The plate thickness in each case was 38.5 mils with a grain size of 15 microns and a surface finish less than 32 rms. A 10-mc, 3/8-inch, spot-focused transducer was set at the angle for maximum response and each notch examined from one side. The plate was then rotated 180 degrees and the notch examined from the other side. The initial gain was arbitrarily established by adjusting the response from Side #1, Plate #1 as 80 percent of full scale. The following results demonstrate the difficulty of obtaining uniform ultrasonic response from supposedly identical fabricated notches:

	Plate #1	Plate #2	Plate #3
Side #1	80.0%	78.0%	70.0%
Side #2	74.4%	100.0+%	80.5%

Designation of Side #1 and Side #2 was arbitrary. The above measurements are uncorrected for possible system non-linearities.

The transducer response measurements using the small ball-bearing technique are about 75% complete. A servo system consisting of an x-y oscilloscope and a polaroid camera was developed to expedite this work. This system can also be used for measurements using small diameter transducers as the beam sampling element. Several transparent photographs of a transducer beam were taken using the schlieren system. One of these was scanned with a commercial densitometer to obtain a plot of beam response which could be compared to the ball-bearing method. The results of the comparison are not yet complete.

The repetition rate of the Immerscope has been increased to 2000 pulses per second by special circuit changes. Faster repetition rates should allow faster and more reliable tube testing.

By tuning the transducer and cable, a signal gain of 50 to 60 times the normal response was achieved with a UR600 Reflectoscope. This compares to a gain increase of 20 to 30 obtained by tuning the Immerscope.

PHYSICAL RESEARCH - 05 PROGRAM

Mechanism of Graphite Damage

Apparatus was designed and fabricated that will be used in the measurement of thermal conductivity of graphite.

BIOLOGY AND MEDICINE - 06 PROGRAM

Atmospheric Physics

Field experiments in atmospheric diffusion and transport were resumed at Cape Canaveral, Florida, on January 11, 1962, under the direction of Atmospheric Physics' personnel. We fully trained Pan American World Airways' field personnel, and by month end, twenty-two experiments were completed despite preemption of considerable suitable range time by other programs at the Missile Test Center. Samples from seven tests were received at HAPO and assayed for tracer dosages by month end. Preliminary examination of the data indicated that all seven of the experiments were successful.

Preparations were made for startup of the second series of experiments at Vandenberg Air Force Base, California, by February 5, 1962. All personnel and essential material to be supplied by Hanford were on-site by month end.

Additional data collected throughout 1961 to confirm earlier estimates of errors in field dosage measurements due to anisokinetic sampling were analyzed. During fifteen experiments, identical sampler assemblies were placed adjacent to each other at various field positions with one sampler drawing air at the normal rate, and the other drawing no air, in order to determine the amount of zinc sulfide impacted on the sampler. The amount impacted was related to the wind speed and the measured dosages corrected for the impaction effect. During neutral and stable atmospheres, a consistent relationship was found over the wind speed range 0.5 to 4.0 meters per second. During unstable conditions, the results were more scattered and the results less definitive due to the higher turbulence levels. At 4.0 meters per second wind speed during stable conditions, the excess dosage due to impaction was determined to be 15, 10 and 4 percent for sampler volumetric flow rates of .25, .5 and 1 cfm, respectively, with a standard error of about 25 percent of the value. These impaction errors were less than expected.

In our rain scavenging work, 200 minutes of good quality records for determining raindrop spectra have been obtained to date, even though the rainfall was much below normal this winter. Several spectra were computed for the light rain of November 30, 1961. There are apparently no published spectra for such low rainfall rates and small droplets as found in that rain.

A prototype particle detector developed by NIO was field tested. The instrument continuously monitors and records the concentration of fluorescent tracer in the atmosphere. On the basis of the field tests, it was estimated that the instrument would detect a tracer concentration of 4×10^{-8} grams per cubic foot. This device promises to fill a much needed anomaly in our sampling capabilities during atmospheric diffusion studies, particularly in determining the effect of wind speed and direction shear with height, the peak to average ratios of concentration and the eddy-flux of material transported through a vertical surface.

Dosimetry

A new standard source was counted with the I-131 counter. The counting rate did not agree with that predicted from the calibration. They differed by a factor of 2.5. We do not yet know if the standardization of the source was in error or if some change has taken place in the counter.

A study of the background of the P-32 counter showed that about half of it was originating in the lucite light pipe--probably from Cerenkov radiation. Operation with an air light pipe was tried. Background was reduced by one-third and the pulse height was slightly increased. Apparently background can be still further reduced by replacing the glass in the crystal mount with quartz.

Two subjects known to have eaten Columbia River whitefish were counted with the P-32 counter. Increases in their counting rates were easily observed. Quantitative evaluation was hindered by increases in their Zn-65 burdens which also took place.

The positive ion accelerator operated satisfactorily during the month. A helium flushing system was completed for the gas target. Preliminary tests with the target show good operation with high emission and negligible contamination.

Tests were made of the LiI scintillation neutron spectrometer. The expected improved resolution at low temperatures was found. The crystal mountings, however, did not survive the temperature cycling and they have been returned to the manufacturer for repair. KI crystals were also tested at low temperature and found to give improved resolution. The KI cracked due to the temperature cycling; however, this does not seem to have affected the resolution. Preliminary studies indicate that pulse shape discrimination may be profitably applied with both LiI and KI.

Development is proceeding of apparatus and techniques for high counting rate experiments with the Van de Graaff. The purpose is to permit some precision long counter experiments to be carried out during a normal working day. Significant deadtime corrections are needed in such work. Attempts are continuing to obtain BF_3 tubes with significantly better resolution, stability, and insensitivity to gamma ray effects together with conformity to the Hanford required design.

As part of the measurement of neutron fluxes at near-background levels, background studies were made of the BF_3 tubes. When wrapped in cadmium, the counting rates are low enough that statistically significant measurements can be made at background neutron flux levels. For tubes wrapped in cadmium, the counting rate is decreased only slightly by placing them inside the large neutron moderator.

A least squares fit by IBM to the calorimetric data for Sb-124 gave a half-life of 60.24 ± 0.02 days. Checks of the calibration and drift rate of the calorimeter showed good stability during the half-life measurements.

<u>Radiation Instruments</u>

The laboratory coincidence-count alpha air particulate monitor continued to perform correctly, and detailed design was completed for fabrication of a field-demonstration instrument. A number of improved circuits will be used in the new instrument to further improve reliability.

Several off-site manufacturers indicated interest in bidding on the fabrication of a number of modified pencil dosimeters. These will be used with the illuminated fiber pre-selectable alarm level personnel dosimeters. Drawings also are being prepared for the modified pencil which is used with the developmental personnel dosimeter with a miniature register readout. It is planned to have six of each of the two types of modified pencil dosimeters fabricated off-site. These will be used in fabrication of personnel dosimeters of the two basic types for field tests. Circuitry fabrication and packaging will be done on-site to meet various plant requirements and to include adaptability to telemetry.

Experiments continued concerning thermoluminescent dosimeters. Commercial LiF_2 was examined at various photon energies from 16 kev to 170 kev with results indicating a marked energy dependence which was more severe than previously noted with CaF_2:Mn. Part of this effect at the lower energies is due to attenuation by the glass capsule. The LiF_2 readout method used only a one-step heating; whereas, the USNRDL have used a two-step method to first move low-energy trapped electrons into higher-energy traps before finally heating for readout. It was determined, in a series of tests, that the LiF_2 sensitivity is only about 2% that of the CaF_2:Mn.

Experiments continued with the experimental field-type continuous airborne luminescent (ZnS) particle monitor being developed for Atmospheric Physics air diffusion studies. Field tests indicate a detection sensitivity of about 4×10^{-8} gm/ft^3; this concentration is obtained at the ARC-4 (two miles) distance about 75% of the time during normal experiments. Tedious 30-minute integrated counting methods, as used with the present fixed-filter system, provide a sensitivity of about 2×10^{-9} gm/ft^3. Sensitivity to dust and pollens was found to be negligible.

Development was started on a new type of automatic sample changer to be used with bottles of liquid low-level radionuclides. The samples are to be counted with a well-type NaI detector. The indexing system, consisting of a hysteresis clutch, two special gears, a ball-bearing lead screw, and a servo system, will be assembled for laboratory tests. All necessary commercial ports were ordered. The completed prototype will be programmed to work directly with a 400-channel analyzer.

Experiments with the developed miniature alpha monitor, which uses a solid state silicon diode detector and transistorized circuitry, detected Pu^{239} with 12% geometry in a 7.8 r/hr Ra gamma field. There was no increase in background above the normal 1 c/m rate. A similar test in a neutron field of about 400 mrem/hr produced similar results with no increase in background. A rough-draft report on the instrument was completed.

An experimental, portable, compact, transistorized G.M. instrument was fabricated. The instrument has a pre-amplifier, count-rate-meter, aurally-indicating tone generator and speaker circuit, and a high voltage supply. In initial laboratory tests, satisfactory operation was obtained for temperatures from 0 F to +130 F. It is being developed as a replacement for the obsolesent HAPO vacuum-tube G.M. portable instruments. The new instrument can also be used for alpha monitoring with the HAPO cast-plastic scintillation probes; thus, only one instrument and two cable-connected detectors will be necessary for dual-purpose alpha and beta-gamma general monitoring.

An invention report was drafted on a single-transistor emitter-follower circuit developed to operate from the current through the dynode resistor divider network used with a multiplier phototube. The circuit provides a low impedance output necessary for driving coaxial cables. Only one cable is required from the detector probe assembly to the main instrument and successful tests were performed with 1000 feet of standard RG-54A/U cable. Initial tests were quite encouraging. The first application planned is for the PRTR liquid effluent monitor system.

The general conceptual design and performance characteristics were determined for electronic instrumentation to be used with the Atmospheric Physics portable mast system. The system incorporates six wind-speed, six wind-direction, and six temperature sensors. Specific detailed circuit design was started for all portions of the required instrumentation.

Shop fabrication was nearly completed on a developmental transistorized alpha monitor specially designed to work with obsolescent air proportional type alpha detectors which are used in large numbers in certain plant locations. Engineering work towards improving the Atmospheric Physics Radio-telemetry System continued. Plans and agreements were reached to improve maintenance attention and records. One complete remote data station was removed from service for redesign and rebuilding as necessary. The Vibrasponder units operated correctly during tests at temperatures from -30 F to +140 F. Attenuators were designed to be used in experiments with the station to simulate poor radio-link reception and transmission. Circuit changes were incorporated to eliminate the present two-volt tap on the battery to permit use of better-quality main power batteries for the data stations. The data station backup time-out circuit was tested and found to be useless below four volts battery voltage. This circuit is scheduled for redesign, since its failure can cause complete discharge of the main power battery.

Experiments continued with a special transistor circuit to be used with an instrument for measuring particle sizes greater than 0.1 micron. Bench tests were completed on one circuit which converts the large, slow (10 to 20 millisecond) pulses from the commercial detection instrument to relatively sharp (20 microsecond) pulses suitable for driving a multi-channel analyzer. The converted pulses retained the required particle-size to pulse-height linear relationship. Further work is scheduled.

Work is proceeding on a 400-channel analyzer to be used in the Positive Ion Generator Facility. Design of the digital logic is essentially complete and the necessary additional equipment and parts are being ordered.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Program

Isotopic analyses were provided on program samples according to schedule during the month. Studies were carried out to determine the possible effects of the acid concentration level of sample solutions on sample sensitivity and ion background spectra. No significant effects were found over a wide range of acid concentrations. Studies were also made of the operating characteristics of several different ion source filament configurations and types of carbonization of the filaments. The most striking result to date has been the apparent success of using a carbonized single trough-shaped filament instead of the triple filament structure for which the ion source of this spectrometer was designed. This type of single filament has operated at least as efficiently with regard to sample size and sample life as any multiple filament type of operation which has been studied. In addition, the background ion spectrum usually encountered with uncarbonized multiple filament operation is reduced to a near unmeasurable level. Comparisons have been made of the operation of this mass spectrometer with that of the other (single filament) spectrometer under nearly identical conditions. These comparisons indicate that the sample sensitivity of the Program spectrometer may be a factor of ten worse than that of the single filament spectrometer. This apparent result demonstrates the need for an accelerated effort in the studies of ion-optical properties of ion source configurations. The assembly of the Ion-Optic Test Facility to carry out these studies is still in progress.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely on a one-shift basis. There were two unscheduled shutdowns due to electronic failure.

The experiments to determine the effective resonance integral for Pu^{240} and to determine the nuclearly safe concentration of uranyl fluoride were completed during the month.

The TTR was not operated during the month except for four nights when it was available to the University of Washington Graduate Center.

The critical approach experiment with a Pu-Al and light water system was continued in the critical approach and exponential tank during the month.

CUSTOMER WORK

Weather Forecasting and Meteorological Service

Consultation service was rendered on meteorological and climatological aspects of NPR safeguards analysis, CPD hazards appraisal, shipment of radioactive cerium and an oxides of nitrogen problem in 300 Area. Off-site consultation was given to APED on VAL meteorological problems. Annual summaries of weather and river data were prepared for 1961. 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	82.2
24-Hour General	62	88.1
Special	166	92.8

Although temperatures during January varied from a high of 63 to a low of -2, the over-all monthly average of 29.8 was practically equal to normal. Precipitation totaling only 0.13 inch equaled the lowest amount ever recorded for January.

Instrumentation

Both the beta-gamma control chassis and the alpha control chassis were fabricated, and system tests were started for the Automatic Conveyor Type Laundry Monitor System. A step-by-step "Alignment Procedure" was written to be incorporated in the operation and maintenance manual. Considerable modification and corrective effort had to be done to many of the transistorized circuit boards fabricated on site to our schematics. Four more alpha detection probes remain to be assembled and tested.

Specifications were written for scalers, a ratemeter, and a recorder to be used for a neutron counting system at 234-5. The work was done for Finished Products Chemical Technology, CPD. Further assistance on the system will be rendered.

Fabrication was started on the new transistorized scintillation Columbia River Monitor for RPO, HLO. The new system, to cover the dose-rate range from 0 to 50 micro r/hr, will be of the pulse counting type to eliminate or severely limit the drift problems which made the original dc system unreliable.

The fuel element dimension readout system recently developed was improved by the addition of power supply delay and arc-suppression circuits. These prevent spurious punching when the program unit and recorder chart drive synchros are turned on.

Calibration of micro-displacement readout systems, to be used by Physical Metallurgy Operation for in-reactor creep measurements, continued. The reference system was set up in the 200-W Metrology Lab and a routine calibration performed. A cursory inspection of the data indicates that the precision of the basic reference system has remained about constant during the past year of operation. The recently installed Boeckler micrometer readout did not perform as anticipated, however, and this readout device will require re-calibration in order to isolate the cause of its extremely poor reproducibility. A rough draft evaluation report for the three-range, second generation transducers has been written, but cannot be completed until Operations Synthesis and Research completes the data analysis. Transducer system calibrations have been temporarily suspended due to a curtailment of the operating funds for this program.

<u>Optics</u>

The groove depth microscope built several months ago for Finished Products Technology was mounted on a manipulator made by them and calibrated. Calibration tests indicated that the microscope would repeat readings to within 100 microinches or less. The microscope has since been installed in its hood where it is being used for measuring product dimensions. The unit has been demonstrated to visitors from two other laboratories where work of the same type is done. They have indicated a desire to have similar units made for them.

Shop sketches have been prepared for a new corner radius microscope to be used by Finished Products Technology.

Another application for the tube distortion Traverse Mechanism has been discussed with several people. A series of four-inch diameter pipes are to be placed under the waste storage tanks in the 200 Areas. The pipes are 100 feet long. Their position must be known over the full length to with ± one foot. We believe that a ten foot long Traverse Mechanism with a TV camera readout can do the job if survey equipment is used to establish the contour for the near end of the pipe.

During the four week period (December 31 to January 28), 344 man-hours of shop work was done. The work load has decreased so that one craftsman has been temporarily released to the 306 Shops.

The work includes:

1. Repair of five borescopes.
2. Repair of two crane periscope heads.
3. Fabrication of two lead glass cylinders.
4. Fabrication and assembly of several shrink fitted ceramic dies.
5. Fabrication of two microwave cavities.
6. Repolishing two lead glass windows.
7. Fabrication of two pyrex brackets for Ceramic Fuels.
8. Repair of film viewer.
9. Servicing of Tech Shops projection comparator.
10. Fabrication of two quartz cylinders for Fuel Testing Operation.

Physical Testing

Service testing work returned to more normal levels as work neared completion on NPR pressure tubes and some of the preliminary problems on NPR primary piping have been resolved. A total of 7,954 tests were made on 5,851 items, representing some 50,028 feet of material, mostly tubular components. Test work included: autoclaving; borescoping; dimensional measurements (micrometric); eddy current; heat transfer (Infrared); magnetic particle; mechanical tests (bend, flare, flattening, hardness, impact, and tensile); metallography (macro and micro examination, and field replication); penetrant (fluorescent O.D. and I.D.); radiography (gamma-ray, and X-ray); stress analysis (electric resistance wire strain gages and X-ray diffraction); surface treatment (alkaline cleaning, conditioning, pickling for autoclaving, steam detergent cleaning, vapor degreasing, and ultrasonic - alcohol cleaning); and ultrasonic (flaw detection and thickness measurements). Work was done for 27 different components representing most of the G-E operating departments and some HAPO contractors. Advice was given on 37 different occasions on general testing theory and applications.

Testing and treatment of the NPR Zircaloy-2 pressure tubes has been essentially completed. A current batch of eleven tubes now being evaluated after autoclaving will complete the work for this month and no testing work is contemplated for the next month. Cleanup tubes will be consoldiated and the final work is expected to be completed at the end of March and the beginning of April. There are now 990 tubes in final storage, ready for reactor installation.

Field testing activities for the month have largely been X-ray and gamma-ray work at 1706-KER, PRTR (Rupture Loop), NPR (Test Coupons), and 100-B Area (Pressure Vessel). The fluorescent penetrant testing of over-bore nozzles is proceeding routinely. The stress analysis of 105-C reactor was completed. Ultrasonic thickness measurements were made on vessels in the 200-West Area. Magnetic particle tests were conducted on the gas seals of 105-N reactor.

Major effort in the 300 Area labs was expended on NPR primary loop piping problems and comprises the following:

Macro examination and bend tests on samples of fusion welded pipe supplied by two manufacturers.

Macro examination and bend tests on seamless pipe from one manufacturer.

Field metallographic examination of weld end preparations on cross-headers. A procedure was developed making it possible to obtain laboratory quality metallographic examination in the field. The weld-end preparations were hand lapped in the field to a metallographic finish, micro-etched, and an electron microscopy replication technique utilized to obtain specimens of the etched surface. The replicas were shadowed with uranium dioxide to reveal the structure and examined with a conventional metallographic microscope at 100X magnification. Excellent results were obtained allowing evaluation of metal for grain structure, oxide inclusions, extrusion effects, and giant grains.

Evaluation of the longitudinal length of fusion-welded pipe discontinuities. Two approaches are being used in this examination. In one, an 18-inch section of the weld is being ground down in 5- and 10-mil increments and examined at each step. In the second, two one-foot sections of weld have been cut into one-inch cubes which are being metallographically evaluated.

Assistance was given in preparing data for a statistical evaluation of the adequacy of the sampling plan used in the bend test examinations.

Ultrasonic testing, penetrant testing, and macro sectioning were performed on both an NPR control rod tip and aluminum bar stock (from which the control rod tip is made) to determine feasibility of testing for minute inclusions in the metal. Ultrasonically the inclusions could not be resolved. In some cases, fluorescent testing did demonstrate the presence of the inclusions. The micro sampling is not yet complete.

X-ray diffraction measurements to evaluate the feasibility of making stress measurements were continued. Considerable experimentation was done in an effort to find a suitable etching procedure to remove disturbed metal surfaces on the weld samples. Measurements made on the sand-blasted surface of the pipe demonstrated X-ray peak sharpening after stress relief treatments demonstrating a differentiation between a temperature of 800°F and 1350°F.

Other work in the 300 Area laboratories comprised the following:

A total of 1,141 Zircaloy-4 fuel element sheath tubes were received from the suppliers during the month. This amount represents about 60% of the tubes on the current tube orders. Fuel element sheath tube testing proceeded routinely.

Infrared heat transfer testing continued with a total of 163 tests completed. Work progressed on calibration of the heat transfer unit utilizing different jet nozzles. Tests were made on space settings, positioning in front and behind the flame using different currents, and gas flow rates. Plans are now underway to build a new radiometer of a different design to overcome several problems that have developed in circuitry.

Fluoroscopy was used in the examination of a temperature control rod. It was desired to view a number of internal components and determine their relation to the aluminum cladding of the rod. Location of the internal components was needed prior to swaging so that proper support areas could be selected.

The ability to locate tungsten wires in high density uranium oxide cylinders was satisfactorily demonstrated utilizing gamma-radiography. An exposure time of one hour was necessary using the 100 curie cobalt-60 source.

Aluminum process tubes in the older production reactors have been cracking. The cracks are predominantly oriented transverse to the tube axis and are originating at the inner wall surface. At the request of IPD, work has been undertaken to determine the feasibility for detecting these cracks ultrasonically. Two approaches were considered: 1) A dry tubing test with a contact probe at one end of the tubing; 2) a test using a movable probe which couples ultrasound through the internal tube surface by filling the tube with water. Both methods involve Lamb wave propagation, since the product of tubing wall thicknesses and available ultrasonic frequencies are in the range for Lamb wave generation. The dry method depends on propagation of Lamb wave energy down the full length of the tube. The water filled case involves propagation of Lamb modes and other possible modes which may be confined to regions of tubing wall very near the transducer, thereby necessitating a movable probe. Initial work has been confined to studies of the dry, contact method.

A variety of contact entry methods were tried. The best results were obtained with a lucite wedge contoured to fit the tubing. By judicious choice of entry angle, a transverse notch about 0.020 inch deep by about 0.125 inch long, located about nine feet from the probe in 0.072 inch wall process tubing was easily detectable. The test response was found to fall off greatly for smaller wall thickness at the same ultrasonic frequency. This drop in response is to be expected for such cases of Lamb wave propagation. Adjustable frequency or broad band systems could extend the range of wall thicknesses to be tested; however, such systems have not been fully developed. In order to obtain less dependence on wall thickness, the alternate method using internal water loading will be studied.

ANALOG COMPUTER FACILITY OPERATION

The major analog computer problems considered during January include:

1. Reactor Transfer Function Description
2. CPD "C" Column
3. Reactor Instrumentation

The computer operations were as follows:

GEDA	EASE	
120	136	Hours up
61	23	Hours scheduled downtime
0	5	Hours unscheduled downtime
4	21	Hours idle
185	185	Hours total

Over-all maintenance of the computers has been good, with the major portion of the scheduled work being completed. An additional eight differential relays have been installed in the EASE bringing the total number of units to

16. Some additional wiring must be done to install the overload and operational lights before the installation is complete. A new eight-channel Brush recorder has been put in operation and has replaced the old eight-channel Sanborn recorder. The Brush recorder uses a pressurized ink system and quick drying ink. The record paper is reproducible on the Photo-Copier in the Analog Computer Lab. The useability of the EASE scanner has not improved in the last month.

INSTRUMENT EVALUATION

Two methods were tested and evaluated for extending the range, from an original 1 mr/hr to 10 r/hr up to six decades of 1 mr/hr to 1000 r/hr, of the Linear and Logarithmic Response Area Monitor we developed. Both methods were successful. The first used two detector probes; one, the original probe which operates to 10 r/hr, and the second which uses a low-gain RCA6342 and a small 0.125 in^3 NE-102 detector to cover the range 1 r/hr to 1000 r/hr. An appropriate circuit was used to switch probes. The second and simplest method used only the original probe assembly with a circuit to switch the high voltage to about -300 VDC, from the normal -850 VDC, for the 1 r/hr to 1000 r/hr region (or to 5,000 r/hr if ever required). The results of the second method were quite satisfactory. It was incorporated into the design of a six decade logarithmic response scintillation area monitor suitable for IPD use in updating the present reactor area monitoring systems.

The experimental transistorized scintillation beta-gamma hand and shoe monitor, which employs gamma-background compensation circuitry, continued to perform correctly without adjustment for the second month at Purex. As a novel auxiliary use, the hand probes were used to detect beta-gamma contamination on shoe covers and gloves which had been laundered but were still contaminated at a level below the detection sensitivity of G.M. type monitors in routine use at the Laundry Operation. HAPO drawings are being prepared for the gamma-compensated monitor.

The experimental scintillation transistorized combined alpha, beta, gamma hand and shoe monitor continued to perform very satisfactorily, after nearly two months' routine use, at Redox. The work on this instrument is done and complete HAPO drawings have been made, checked, and approved. The drawings can be used for off-site procurement by any plant group so interested.

Eight of the original Model II Scintrans ordered by Calibrations Operation were satisfactorily modified for principally beta-gamma use by IPD. The modified units can be used with scintillation beta-gamma probes, both regular and mica-window G.M. tubes, and with both BF_3 and scintillation neutron detection probes. They can still be used with scintillation alpha probes although this was not an IPD requirement. All prints pertaining to the Model II Scintrans were changed to include the necessary minor modifications. There are 65 more Model II Scintrans, principally for alpha monitoring use, now on order by Calibrations Operation, RPO. If desired, these units can be easily modified for combined alpha, beta-gamma, and neutron detection use for less than $25 each.

One ORNL-type "pencil", which indicates changes in dose-rate both aurally and visually, was calibrated and found to show a linear response from 0.5

to 16 mr/hr where 1 mr/hr was found to equate to 14 "pops" per minute. The "pop" rate could not be accurately checked by ear above 16 mr/hr, but pencils did not fail to operate in fields up to 8 r/hr, the highest used in the test.

A Victoreen Company pulsed-G.M. portable instrument was initially tested. Available ranges were marked as 0.5 5, 50, and 500 mr/hr. For the Ra gamma tests, the meter readings, which are shown in mr/hr, were within ± 20% of the true dose rate. The unit, which is a civilian version of a military instrument, uses two regular size D flashlight cells for power.

A highly-directional ("Hevimet" shield-collimator) IPD "Bazooka", which employs a scintillation detector and a vacuum tube dc (electrometer-type) circuit, was tested at the request of IPD. The drift-rate was so extensive that the unit was unusable. It was recommended that the vacuum tube circuit be replaced with a multi-range transistor CRM for pulse counting. The change will be made.

Evaluation tests were started on the transistorized portable scintillation alpha "poppy", which was designed to replace the present obsolescent standard HAPO Portable Alpha Poppy (a vacuum-tubed unit). Battery life is approximately 100 hours. Low temperature performance (due to the mercury batteries) was impaired at about +20 F. For lower temperature use, standard zinc-type batteries will be necessary.

Extensive field tests of the "plug-in" transistorized audio pop unit, designed to be used with all portable HAPO G.M.'s and Alpha Poppies to eliminate the need for headphones, were fully satisfactory and plans were made by Calibrations Operation, RPO, to secure 20 to 25 units from an off-site fabricator.

Paul F. Gast

Manager
PHYSICS AND INSTRUMENT RESEARCH
AND DEVELOPMENT

PF Gast:mcs

CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Reactor Radioisotope Reduction Studies

Addition of sodium silicate at a concentration of 10 ppm (as Si) was started to the cooling water for one reactor tube on January 2, 1962. This concentration increases the pH of the influent water from 6.7 to 7.5 but only a 0.3 pH difference between water from this tube and that from the control tube can be measured after the water passes through the tube. Measurements of the radioisotope content of this water are being made and compared with water from an adjacent tube without silicate addition and at a lower effluent pH by 0.3 pH unit. This tube is used as a control tube for comparison although the pH's are not the same. Although it will take several more weeks to reach a steady state condition, some changes have already been observed in the first three weeks of the test. The As-76 concentration initially increased by a factor of two but now has decreased to about one-half that of the control tube. The Np-239 and Cr-51 have decreased by factors of 2 and 1.5, respectively, while the Cu-64 content increased at first but now has returned to a concentration about equal to the control tube. The P-32 concentration increased by an order of magnitude at the start of the test, indicating a removal from the film, but after two weeks was equal or slightly less than that of the control tube. The Na-24 and Si-31 have increased by factors of 2 and 4, respectively, as might be expected from the sodium silicate addition. Although this initial test is being made under unfavorable conditions, the reductions of concentrations of several of the radioisotopes such as As-76, Np-239 and Cr-51 by factors of about 2 show enough promise to warrant further testing. For these new tests, two new or chemically cleaned tubes with new fuel charges will be made available, one of which will be operated as a control tube at the same pH. Better choice of type, concentration and more complete mixing of the silicate will be made. The sodium silicate added in the preliminary tests is not reagent grade material, but may contain enough arsenic to increase the undesirable parent material content of process water by about 10 percent. Many samples of commercial silicates are being analyzed for their trace element concentrations by neutron activation analysis so that a better source of sodium silicate might be chosen for these tests.

Zeta potential measurements on floc particles and pH measurements of process water are being made at each reactor water treatment plant in an attempt to correlate these measurements with other variables of the water treatment process. Preliminary findings indicate that 18 ppm alum treatment at a pH of 6.7 produces floc with a zeta potential of about + 7 mv. This represents a change in the colloid charge from the -16 to -18 mv found on the river water colloids. With 18 ppm alum and a pH of 7, the zeta potential is around -6. Better anion parent material removal and floc removal is obtained with the latter conditions indicating the possibility that production of water containing only low amounts of arsenic and phosphorus might be aided by treating to an optimum zeta potential. This would indicate an addition of less than 18 ppm alum added at those plants producing water at a pH of 6.7.

Sorption of Nuclides on 100 Area Soil

Soil column adsorption of As-76 and Cr-51 from tap water and reactor effluent water was determined at 60 C and 90 C; these experiments are aimed at demonstrating the validity of the data obtained with tap water as a substitute for reactor effluent water. Adsorption of these isotopes by 100 Area soil was found to be essentially the same for filtered tap water as for reactor effluent water. At 60 C the soil adsorbed 73 percent of the arsenic and 48 percent of the chromium at a rate of water movement equivalent to 83 gal/ft^2/day. At 90 C the arsenic adsorption remained relatively unchanged while chromium adsorption increased from 48 to 57 percent.

Effluent Monitoring

The As-76 monitor has performed satisfactorily for three weeks. The use of a larger ion-exchange column, three times the size of the previous column, has eliminated interference by Na-24 in the As-76 measurement. In fact, Na-24 has not been detected in the column effluent. Cl-38 interference was decreased to 3 percent of the total count in the As-76 channel; this decrease is attributed to the additional hold-up time of the larger column.

Ground Water Temperature Studies

The temperature of the water flowing through each of the 24 pumps located in the 181-B Building pump house was measured. One set of data showed a maximum temperature difference between pumps of about two degrees centigrade, indicating that the thermally-hot spring water entering the 181-B forebay is not completely mixed with the river water before it enters the pumps. An even greater temperature difference may occur during the day as the water flow pattern from the forebay to the suction wells continuously changes with the rise and fall of the river level. Water samples from each of the pumps are being submitted for radioisotopic analysis. These data will be helpful in determining the amount of thermally-hot spring water being taken into the water system at 100-B Area.

Treatment of NPR Decontamination Wastes

Laboratory experiments were conducted to investigate the removal of radionuclides from combined alkaline permanganate process and phosphoric acid decontamination wastes. Completeness of removal was measured as a function of neutralization and neutralization followed by scavenging with salts of calcium, iron, and cobalt.

Neutralization alone removed greater than 98 percent of the cerium, scandium and silver isotopes. Neutralization followed by scavenging removed additional amounts of cerium and scandium but did not increase removal of silver. Of the salts investigated, only iron improved the removal of ruthenium. As observed previously, iron and cobalt scavenging nearly doubles the removal of radiocobalt over neutralization alone, while calcium addition has little or no effect. Less than 5 percent of tin and antimony was removed by neutralization, and none of the scavenging agents examined significantly improved their removal.

Airborne Particulates in Reactor Operations

An investigation was begun to characterize airborne particulates resulting from tube slitting and removal operations. Particulate size, radioactivity, and solubility will be measured. Initial samples showed the presence of Cr-51, Fe-59, Zr-65, Sc-46, Mn-54, and Co-60. Solubility in water, measured in terms of gross beta emitters, ranged from 5 to 20 percent.

SEPARATIONS PROCESSES

Disposal to Ground

Recent tritium analyses of monitoring well samples have helped to clarify the ground water contamination picture southeast of 200 East Area. The contaminated ground water appears to branch into two plumes about 4 to 5 miles southeast of 200 East Area; one plume moves southeast and then east toward the Columbia River, and the other continues in the southeast direction toward the 300 Area. In general, tritium concentrations detected in water samples from wells between four and seven miles distant from the 200 East Area are in the 10^{-4} to 10^{-5} µc/cc range. As additional analytical results are received for wells in this region, a more precise ground water contamination picture should unfold.

Recent tritium results on samples from twelve major separation plants' waste streams indicate a wide range in concentrations from near the detection limit, 1×10^{-5} µc/cc, to the highest detected, 0.44 µc/cc in Redox tank farm condensate. All surface-ponded and steam condensate stream samples were very near the detection limit concentration.

Iodine Sampling in Separations Areas Stacks

Repeated measurements confirmed that a somewhat lower I-131 concentration will be reported for samples drawn from the 50-ft. level sampler than for those drawn from the 20-ft. level sampler in the Redox stack. The average difference is about 20 percent, but in individual samplings it has ranged to over 30 percent. The cause for this disagreement was not determined. Similar samplings are being undertaken at Purex to intercompare the results from the 50-ft. and 196-ft. level samplers.

Efficiencies of iodine adsorption cartridges filled with two different grades of charcoal were measured using I-131 present in the Redox stack. The first of two 1-1/4 inch long cartridges in series adsorbed 90 percent of the I-131 found on the two cartridges. The two charcoals used, BPL* and Whetlerite*, have virtually the same efficiency within the reproducibility of the measurements.

*BPL is a charcoal designation of the Pittsburgh Chemical Company. Whetlerite is charcoal treated with copper, chromium and silver salts.

Purex Water Quality Evaluation

Tests were continued in the experimental C-column to compare solvent extraction performance using Purex demineralized water and 321 Building condensate. The runs were made at the same pulsing frequency while the capacity factor of the facility was automatically adjusted to maintain a constant column density, or column static pressure. In addition, the pulsing frequency and static pressure valves were picked to insure that a high capacity was maintained. Finally, two organic feed solutions were used, both containing approximately the same uranium concentration but one containing 7.2 grams per liter nitric acid and the other only 1.3 grams per liter acid.

Results of the tests showed a slight decrease (approximately 10 percent) in column capacity when the Purex water was substituted for condensate. However, the change from high to low acid concentration produced a significantly larger effect (about 25 percent capacity decrease) than did the change in water quality. These results are being analyzed to elucidate the effects of process stream and water quality variables in the solvent extraction process.

Ion Exchange Contactor Studies

A semi-continuous version of the Jiggler unit (see HW-70658 C, p. C-10), has been subjected to a series of efficiency test runs. The unit has been altered to allow intermittent movement of resin and liquid. This change has resulted in satisfactory and reliable resin movement. Initial tests with feeds containing 3 gms/liter thorium have shown undetectable waste losses from a 4-inch diameter by 2-ft. long absorption section at instantaneous feed rates of 640 mls/min.

Studies of the movement of 50-100 mesh Dowex-1 resin show that the push is controllable to as low as one-half inch movement with a timed pulse of 11 to 40 cycles per minute and an amplitude of 0.75 inches.

Photochemical Reduction of Uranyl Nitrate

Bench-scale studies on the photochemical reduction of uranyl nitrate to uranium(IV) nitrate were continued. In both the bench scale and laboratory work, either formaldehyde or hydrazine was used as the holding reductant and a GE UA-11 photochemical lamp was used as the source of ultraviolet light. The primary goal of recent studies was to resolve the difference in observed reduction rates.

The source of the uranyl nitrate solution appears to be a factor in the reduction rates obtained. In the laboratory studies, the source of uranyl nitrate was the Redox plant product solution. With either Redox or Purex plant product solutions as the uranyl nitrate source, bench scale reduction rates comparable to the laboratory rates were obtained. Conversely, two-fold lower reduction rates were obtained with either dissolved UO_2 or pilot plant uranyl nitrate. The reason for the reduction rate depending on the source of the uranyl nitrate is not known.

WASTE TREATMENT

Clinoptilolite Sorption and Elution

The effect of total cesium concentration on cesium sorption by clinoptilolite from synthetic formaldehyde-treated Purex 1WW has been evaluated. Runs with a feed solution having a total cesium concentration varying from 10^{-5} to 10^{-4} $\underline{M}$ yield a 50 percent breakthrough at about 114 column volumes. With a 2×10^{-3} $\underline{M}$ cesium feed, which is slightly greater than that expected in actual plant wastes, the 50 percent breakthrough decreases to 84 column volumes.

Experiments were performed to determine how completely cesium could be eluted from clinoptilolite with ammonium nitrate. For one experiment, acid-soluble impurities in the clinoptilolite were removed before loading; in all experiments the clinoptilolite was in the sodium form.

Total Cesium Molarity of Loading Solution	Elapsed Time, Days (Loading to Elution)	Percent Cesium Remaining on Clinoptilolite
1×10^{-3}	1	0.4
1×10^{-3}	14	2.0
4×10^{-4}	1	0.9
4×10^{-4}	1	0.5 (acid washed)
Trace Cs-137 only	1	33.0

These data indicate that maximum cesium removal will be achieved with feed containing relatively large amounts of total cesium immediate elution, and acid-washed mineral. The poor elution with trace cesium indicates that there are only a few sites that react with cesium irreversibly.

Packaging Concentrated Purex FTW

Studies were begun to investigate the possibility of packaging projected (1965) Purex formaldehyde-treated waste (FTW) by precipitation and filtration using techniques similar to those planned for bulk fission product packaging. Should this be possible, a multipurpose packaging system might be employed to package either a marketable fission-product or a concentrated waste unit. Slow neutralization with gaseous ammonia (pH 9) of simulated FTW at room temperature produced a precipitate easily filtered on a D porosity (65 micron) sintered stainless steel filter. Filter cake volume was 10 percent of the volume of the unconcentrated FTW. A clear blue filtrate indicated that a nickel ammine complex was formed. The filtrate from such a process would require treatment for cesium removal.

A generalized correlation of high activity waste storage container costs has been developed and is being documented. It is of interest to note that when heat dissipation and vessel construction costs are jointly considered, unit cost of storage volume is almost independent of vessel total volume for constant strength vessels.

Solvent Extraction Treatment of Purex FTW

Further batch contact studies have aimed at defining optimum conditions for extraction of strontium and the rare earths from Purex FTW into a D2EHPA - TBP - Shell Spray Base solvent. Variables studied included dilution of FTW in preparing extraction feed solution, extraction section pH and ratio of feed to extractant volume. The data will be used to select operating conditions for future mini-mixer-settler runs using simulated and plant produced feeds. Other studies examined effects of prolonged (> 10 minutes) contact time between solvent and the use of complexing agents other than HEDTA in the feed. With solvents prepared from unwashed "as received" D2EHPA, distribution ratios for cationic constituents of FTW other than strontium and sodium increased as contact time was increased beyond 10 minutes. Distribution ratios for strontium and cerium decreased when TBP was omitted from the solvent; extraction of europium increased.

A complexing agent which complexes promethium less strongly than does HEDTA at pH about 4 is desired to permit better promethium extraction simultaneously with good cerium and strontium extraction. Citrate and tartrate were examined for this purpose, but no obvious advantage in their use over HEDTA was found.

In-Tank Concentration of Wastes

Laboratory studies with simulated old Purex coating removal waste indicate the waste must be concentrated by a factor of about 5.7 (B.P. 160 C) to produce a slurry which will solidify completely at 80 C. Vapor pressures versus temperature are being determined for these solids, as well as for solids produced at other concentration factors, to evaluate the likelihood of their adsorbing water from tank atmosphere. Vapor pressures for saturated solutions of the solids in water are lower at any given temperature than the vapor pressure of saturated sodium carbonate monohydrate at the same temperature as would be expected due to the presence of other sodium salts.

Waste Sludge Transfer

Process waste sludge in the 241-A-103 underground storage tank was successfully sampled by core drilling. The sample was unloaded in the Radiometallurgical Building for analysis of chemical, mechanical, physical and electrical properties. The core drill penetrated the sludge only two to three inches, at which point the sample apparently blocked in the sample tube, preventing further drilling. The core drilling assembly and cask loading equipment functioned without significant incident during the operation. Efforts to obtain a complete sample (i.e., of full sludge depth--20 to 30 inches) will be continued upon receipt of a new sample barrel and drill bit.

A waste tank sluicer designed to study in-tank sluicing of solidified process wastes, has successfully passed mechanical and hydraulic cold tests and is ready for installation. Tests showed that there are no vibration problems associated with high-velocity discharge (170 ft/sec) of water from the sluicing nozzle. The hole gager (mechanical arm for measuring the sluicing rate) and nozzle control linkage operated satisfactorily. The high sluicer turning torque of 2500 to 5000 foot pounds is due to 8-in. ball joints used in the sluicer assembly.

Cesium Solvent Extraction

Study of dipicrylamine (DPA) and related potential cesium extractants was continued in order to better define the effects of process variables and to elucidate the chemistry of the extraction. New findings and observations include the following:

1. Hot cell extractions were performed with actual full-level 1WW and 103-A supernate. Cesium extraction coefficients (into 0.01 M DPA in nitrobenzene) were identical to those measured with synthetic solutions, and there was no extraction of other fission products. No solvent breakdown was noted after 24 hours of contact, and the cesium was easily and completely stripped with either 0.5 or 1 M HNO_3.

2. Sodium extraction was determined using sodium-22 tracer. Sodium was much less extractable than cesium, the ratio of extraction coefficients (from 1 M NaOH) being ca. 2600. The cesium-sodium separation factors were, of course, a function of both DPA and sodium concentration and ranged from values of the order of 50 to over 800. Cesium extraction was found to have an inverse first power dependence on sodium concentration. Also, the extraction coefficient (E_a^o) for cesium from 103-A supernate or FTW (formaldehyde treated waste) increased with dilution, ten-fold dilution increasing E_a^o about tenfold.

3. A series of diluents, and diluent mixtures, were compared with nitrobenzene. All of those tested to date were inferior to nitrobenzene; however, several (particularly nitroparaffins and nitroaromatics) showed promise and will be tested further. Dinitriles will also be evaluated, and an effort is being made to prepare 2-nitro-tetralin. Addition of benzene, xylene, dibutyl butylphosphonate, or tributyl phosphate to DPA - nitrobenzene solutions caused a spectacular decrease in cesium extraction (a factor of a thousand), suggesting that these molecules react preferentially with DPA and "block" its reaction with cesium.

4. A series of extractants closely related to dipicrylamine were prepared and tested; 2,4 - dinitrodiphenylamine, 2,2', 4-trinitrodiphenylamine, 2,2', 4,4' - tetranitrodiphenylamine, and 2,2', 4,4', 6,6' - hexanitrodiphenylamine (DPA) gave extraction coefficients of 0.002, 0.137, 1.17 and 24.7, respectively, when used at 0.01 M concentration in nitrobenzene to extract an equal volume of 0.001 M CsCl, 1 M NaOH at 25 C. Additional compounds are being prepared for testing.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Bulk Fission Product Packaging

Studies of bulk fission product packaging continued with tests of binding agents for strontium and cerium products. Strontium peroxide with 10 weight percent of lead boro-silicate binder was calcined in a full-scale canister. There was approximately 85 percent shrinkage of the cake volume, but the cake stuck to the canister wall and the filter stick. Strontium peroxide with 3.5 percent of a boro-silicate-phosphate binder containing no lead showed the same shrinkage, but the cake mostly slumped to the bottom of the can. An incompletely calcined portion stuck to the top of the filter stick. Cerous fluoride (62.5 weight percent) fuses with lithium fluoride (37.5 percent) at 750 C. Cerium oxide (probably CeO_2) can be fluxed with acid-fluoride mixes. Mixtures of aluminum, sodium and/or lithium fluoride with P_2O_5 or B_2O_3 react with CeO_2 at 650 C or less to give fluid melts that freeze to crystalline solids, but the fluxing mix must be added to 40 percent of the weight of the cerous oxalate intermediate, $Ce_2(C_2O_4)_3 \cdot 10\ H_2O$.

Tests of the canister loading station indicate that heating of the canister is uneven over its length, there being approximately 300 degrees difference from the mid-length to the bottom of the canister. In addition, high strontium peroxide filter cake permeability has resulted in difficulties in obtaining automatic shutoff of canister filling as demonstrated in earlier designs.

Remote welding studies were commenced with installation of the canister turntable and torch holding and positioning fixture for the inert-gas tungsten-electrode welding station. The system has been run through a shakedown period and works well with the exception of the torch positioning mechanism. Further development will be required to get a torch positioner that meets the requirements of the station.

Ten 304L stainless steel welding samples were welded. To investigate potential problems from a contaminated weld joint area, strontium oxide was placed in the weld joint of three of the samples prior to welding. The strontium oxide prevented metal flow into the weld joint during the first pass of the torch over the area to be joined. There was considerable bubbling and spattering of metal and strontium oxide. Three passes were made on one sample that had strontium oxide in the joint. The entire joint was closed after the third pass and produced a joint with a leak rate of less than 10^{-7} atm. cc/sec of helium with a differential pressure of one atmosphere across the joint. Other samples had leak rates higher than could be measured with a mass spectrometer. Although the test was severe, it indicates that it will be difficult to obtain a satisfactory weld with a contaminated joint.

A one-inch pipe size clamp connector utilizing a belleville spring gasket is under development for use in high radioactive fields. Four tests, using a helium mass spectrometer were performed. In the first three tests, the connector leaked less than 1×10^{-5} atm.cc/sec of helium at temperatures and pressures less than 200 C, 200 psi. The fourth test on the connector showed an excessive leakage. The galling which caused the excessive leakage will be prevented by stopping the relative motion between flanges. More tests will be performed.

Three 2-7/8 inch size belleville spring gaskets were tested in a configuration used as a secondary seal in the HAPO fission product casks. Due to relative motion between the gasket and flange, galling occurred and excessive leakage was observed. Development is still underway to provide a stainless steel gasket, operable by one bolt with high integrity and minute leakage which will fit into the existing HAPO casks.

Second-Cycle Technetium Purification and Concentration

The product fractions from the three A-Cell anion exchange runs on Purex 103-A supernate were combined and processed through a second cycle to obtain ten grams of highly purified technetium-99. The combined feed, which was 8 M in nitric acid, was neutralized with caustic, 100 mg/l ruthenium carrier was added, and then treated with 2 g/l AgO to oxidize ruthenium. After filtering to remove excess silver oxide, the solution was passed through a Dowex-50 column, which absorbed zirconium-niobium and reduced and precipitated the ruthenium (presumably as RuO_2). The technetium was then absorbed on an anion column (IRA-401) and subsequently eluted in a small volume of nitric acid and removed from the cell. Decontamination factors across the decontamination cycle ranged from 1400 for ruthenium to greater than 5000 for zirconium-niobium, for overall decontamination factors (from 103-A supernate to product) of approximately 10^6. Details are given in an invention report (HW-72498).

Promethium-147/Promethium-148 Ratio

At the request of CPD, the Pm-147/Pm-148 ratio was determined on the promethium product from the A-Cell purification run reported in November. Values of 202 and 135 (corrected to 90 days cooling) were obtained by two different radiochemical techniques: (1) total gamma counting, and (2) determination of Pm-148 beta by use of aluminum absorbers. The former is believed to be the more reliable.

These numbers are significantly higher than the value of 70 calculated from irradiation history. The major uncertainties in the experimental values are due to the low Pm-148 specific activity and to possible errors in the accepted Pm-148 decay scheme. The effect of reactor outages would be to increase the observed ratio and might account for some of the difference. It should be noted that a higher than expected ratio in Hanford promethium is favorable from the standpoint of utilization.

EQUIPMENT AND MATERIALS

Remote High Pressure Steam Connectors

Tests evaluating Teflon-impregnated asbestos gasket for superheated steam service were completed. Two tests were performed at 260 C and 440 psig. The first test lasted 137 hours and caused a total leakage of one ml of water. The second test lasted 720 hours and caused a total leakage of 2.5 ml of water. In the second test, the temperature was cycled from 260 C to 20 C nine times. In both tests there was no apparent physical damage to the gasket material.

Hydraulic Equipment

Current Chemical Processing Department plans call for use of waste stream "diverters" to replace the diversion box technique in future high level waste handling facilities. Fabrication and installation of a prototype diverter has been completed and initial tests of hydraulic behavior are encouraging. Modifications for improved behavior are being sought.

A Hastelloy C canned motor pump with 50 mil cans was dismantled for inspection after 5803 hours of operation pumping water at 50 C against a 50-foot discharge head. Recalibration indicated no change in performance during the life test. Wear was noted on the graphite bearings, on the journals and on the impeller keyway. The maximum scoring of the journals and bearings was estimated to be approximately 35 mils. No evidence of contact between the cans was observed. In order to perform hexone pumping tests for a proposed Redox plant application, new bearings were fabricated and the journals were polished. The pump has been installed in a closed circuit test loop provided with flame checks and safety devices intended to halt operation under hazardous conditions. The test stand has been set up in an isolated area and will be placed in operation as soon as possible for an extended period to demonstrate the feasibility of canned motor pumps in handling volatile solvents.

Corrosion in HNO_3-HF Solutions

In connection with a corrosion problem arising from flushing lines in the Recuplex Building, the corrosion of 304-L, 309, 309SCb, 310, 316, 316-L and 347 stainless steels and Hastelloys C and F by HNO_3-HF solutions at room temperature was determined. The solutions tested were 16 M HNO_3-0.025 M HF, 16 M HNO_3-0.25 M HF, 1 M HF, 1 M HNO_3-1 M HF, 1 M HNO_3-5 M HF and 1 M HNO_3-10 M HF. Samples of the various alloys were exposed for a single 96-hour period in these solutions contained in capped plastic bottles. Of the 300 series stainless steels, only 309SCb corroded at less than 50 mils/mo in all six solutions. Hastelloy C corroded at less than 20 mils/mo in all six solutions but is not considered satisfactory for the intended service because of known increase in corrosion by nitric acid at increased temperatures. Hastelloy F corroded at rates of less than 2 mils/mo in all six solutions and, from a corrosion viewpoint, appears satisfactory for the service. Previous experience with Hastelloy F in Niflex solutions showed that weldments of this alloy are subject to preferential weld metal attack in acidic fluoride solutions unless properly annealed.

Non-Metallic Materials

A plastic-coated cotton glove manufactured by Grant Glove Company was tested for possible use at Recuplex. The glove is marketed under the trade name Nigran. Recuplex CAX penetrated in less than 24 hours.

Samples of 85 different pieces of reactor grade carbon were tested for 10 days in boiling 60 percent nitric acid. All 85 samples were judged to be satisfactory for process solution lubricated bearing stock.

PROCESS CONTROL DEVELOPMENT

Recuplex Solvent Extraction Control

Following laboratory evaluation of several alternative control techniques, an automatic control system has been devised for the Recuplex solvent extraction process. Basic elements of the system include ratio controllers for setting flow rates of the feed and extractant streams to achieve maximum column capacity, and plutonium concentration gradient monitors to adjust the flow ratios to result in high column efficiencies, i.e., low plutonium losses in the waste stream. Plans are proceeding for further testing of the system in Recuplex, and procurement of the equipment necessary for the test has been initiated.

Neutron Multiplication Monitor

The neutron detection instruments of the experimental multiplication monitor were relocated in the Purex N-cell to a position providing higher neutron flux. Multiplication factors up to 2.5, corresponding to k_{eff} of 0.6, are expected in the new location adjacent to the N-7 receiver tank.

Counting rates on the BF_3 tube system show variations from 13 percent to 78 percent of chart when filling the receiver tank to a given liquid level, dumping and refilling during the operation of the process. This change in counting rate with the same concentration of plutonium comes primarily from two sources, additional neutrons produced from (α, n) reactions when more solution is added to the tank and from multiplication of these so-called source neutrons by fission.

The diffused junction silicon neutron counter is correctly indicating changes in neutron flux but due to its low geometry and low conversion efficiency, in relation to the BF_3 tube, the resulting counting rate is only about one percent of that of the BF_3 tube. Various methods of increasing conversion efficiency of solid state devices have been reported in the literature; these will be evaluated as quickly as alternate detectors can be obtained.

Redox Dissolver Solution Boiling Point Measurement

A method for determining the boiling point of the Redox dissolver solution is needed to indicate uranium concentration and thus the extent of dissolution. An instrument to indicate the boiling point continuously is under study. The apparatus consists of tube with an electrical heater at one end and a cup-shaped receiver at the other; the heater end of the tube is submerged. Steam generated by the heater is equilibrated with the liquid in the tube, and at some power input steam generation should be sufficient to lift the liquid to the receiving cup where the temperature is measured. A device will be included to indicate if solution is in fact being boiled and pumped by steam lift. Some laboratory testing will be undertaken on solutions of known composition to assure that true boiling points are obtained.

Special pH Electrodes

Investigations were made of gamma dose rate effects on the potential developed by a calomel electrode. A 6 millivolt potential difference was observed between two identical electrodes, during exposure of one electrode to a gamma dose rate of approximately 4×10^6 R/hr. This potential is sufficiently low that a reliable pH reading in high radiation field can be expected. Electrodes using calomel inner electrodes and an inorganic buffer solution have been fabricated and calibrated in the laboratory prior to irradiation testing.

C-Column Mathematical Model Development

The debugging was completed this month on the subroutine to do the non-linear least squares fit of the C-column model to the data. Integration of the two simultaneous differential equations assumed to be the model for the C-column as performed by this subroutine agrees with the analog computer solution to the same equations within the accuracy obtainable by an analog computer. With this subroutine, initial trial runs were made with the Gauss iterative non-linear least squares routine. The parameters for the model determined with the analog computer were used as the initial estimates in the 7090 computations. The Gauss routine effected a ten-fold improvement in the fit to the data, as measured by the standard deviation of the data around the model.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Separation of Plutonium from Uranium in Molten Chloride Systems - The current status of work on the recovery of uranium and plutonium from molten chloride salt solutions of irradiated uranium dioxide fuel elements can be summarized as follows: (a) plutonium dioxide has been precipitated, with good separation from uranium and rare earths and without use of a carrier, by sparging a melt of the proper composition with an oxygen-chlorine gas mixture, (b) UO_2 has been electrodeposited from a melt of the same composition, with good separation from plutonium and the rare earths, but (c) means have not yet been found to achieve good rare earth separation while electrolytically co-depositing UO_2 and PuO_2. Recent developments are cited below.

The precipitation of PuO_2 by reaction of plutonium(III) chloride with an oxygen-chlorine gas sparge has been studied in three molten chloride salt systems at 575 C: 2.6 LiCl-NaCl, 2.6 LiCl-KCl, and LiCl-KCl. Each melt contained 9.2 weight percent (w/o) uranium, and uranium/plutonium and uranium/rare earth ratios of 100 and 1000, respectively. The results achieved were highly dependent upon the compositions of both the melt and the gas sparge. In the 2.6 LiCl-NaCl melt, the most favorable results were obtained with a 28 percent oxygen-72 percent chlorine sparge. Under these conditions, 86 percent of the plutonium was converted to oxide and 82 percent recovered from the melt by settling and decantation.

Promethium-148 and uranium decontamination factors of 370 and 1500 (plutonium basis), respectively, were achieved. Increasing the oxygen concentration also increased the amount of uranium and rare earths carried by the precipitate. In the 2.6 LiCl-KCl melt, a 55 percent oxygen sparge converted 90 percent of the plutonium to the oxide, but the precipitate was much more finely divided than in the 2.6 LiCl-NaCl melt, and only an estimated 50 percent of the plutonium was recovered from the melt. Promethium-148 and uranium decontamination factors (plutonium basis) were 600 and 1100, respectively. No precipitation was observed in a LiCl-KCl melt with 55 percent oxygen or in a 2.6 LiCl-KCl melt with only 28 percent oxygen.

Plutonium and rare earth behavior during the electrolytic reduction of uranyl chloride to UO_2 at 600 C in a 2.6 LiCl-NaCl melt was studied in three experiments. The original melt in each case had the same uranium, plutonium, and rare earth content as described above for the PuO_2 precipitation experiments. A partition-type electrolysis with a 100 percent chlorine sparge gave a 60 percent current efficiency with plutonium and promethium-148 decontamination factors (uranium base) of 85 and 1500, respectively. Attempts were made to co-deposit PuO_2 with the UO_2 by adding 24 and 55 percent oxygen to the sparge gas, conditions which have been found to precipitate PuO_2. The major effect of the oxygen was that, although some PuO_2 was precipitated, very little was incorporated in the UO_2 deposit. At the same time, the promethium separation fell off. For example, in the run with 55 percent oxygen, 30 percent of the plutonium was converted to PuO_2 which agglomerated and settled. Decontamination factors from the melt to the UO_2 deposit were six for plutonium and only 55 for promethium-148 (both on a uranium basis).

<u>UO_2 Crystal Growth Studies: $PbCl_2$-2.5 KCl Salt System</u> - Further studies have been made of the growth of UO_2 crystals by electrodeposition from $PbCl_2$-2.5 KCl solutions of uranyl chloride. Time-lapse photography of growing crystals has shown that the deposits start as needles. These grow rapidly on the 110 or 111 faces, and gradually convert to cubes as 100 faces form on the tips of the needles.

Two observations were made of the effect of introducing air into the melt after a good cubic deposit had been well established. Both deposits, made with UO_2-coated graphite anodes, converted from cubes to needles. In a single previous experiment using an uncoated anode, this conversion had not been observed. The cause of the difference in results is not known.

<u>UO_2 Crystal Growth Studies: 2.6 LiCl-NaCl System</u> - Recent interest in the 2.6 LiCl-NaCl salt system as a medium for achieving good plutonium recovery has prompted an investigation of UO_2 crystal growth characteristics in this system. In general, it has been observed that it is difficult, although possible, to dry the melt sufficiently to produce good, ceramic grade UO_2 with an O/U ratio of less than 2.01. The fact that a temperature of 600 C or greater is necessary with this system also is a disadvantage in growing large crystals.

The potential use of thallium(III) chloride as a catalyst for the dissolution of UO_2 prompted a look at the possible effect of thallium(III) upon the electrodeposition of UO_2. The principal observation was that $TlCl_3$ slowly volatilizes from the melt, in a chlorine sparge at 600 C. In each of two electrolyses, following lengthy chlorine sparges, a dense agglomeration of small cubes of UO_2 was produced, the O/U ratios being 2.022 and 2.014. It was difficult to ascribe any result to the presence of thallium.

UO_2 Crystal Growth Studies: Sulfate, Fluoride, and Fluoride-Chloride Systems - Scouting experiments have been run on the electrodeposition of UO_2 from all-sulfate, all-fluoride, and fluoride-containing chloride melts. It has been possible to obtain UO_2 from all three types of systems, although the deposits from the sulfate and fluoride melts were porous and of low quality. A single run has been made at 750 C with a NaCl-KCl melt containing five w/o NaF, using a silicon carbide crucible. The UO_2 produced in this case was composed of dense crystals which tended toward a cubic orientation and had an O/U ratio of less than 2.01.

Engineering Development - Two pilot plant runs were completed during the month producing a 41-pound batch of powdery UO_2 and a 58-pound batch consisting of 20 pounds of good dense product near the electrode surface and 38 pounds of powdery UO_2 on the outside of the deposit.

Although only a small part of the UO_2 produced in the two runs was of high quality, the run data were informative. The results indicated that:

1. The production of reactor grade, electrolytic UO_2 cannot be assured if U_3O_8 is allowed to remain undissolved in the melt.

2. The use of an HCl sparge (versus chlorine) for drying if used while undissolved U_3O_8 remains in the melt appears to result in further product degradation over that caused by the undissolved U_3O_8 alone.

3. The U_3O_8 sludge accumulated in the crucible from a series of batch cycles can be chlorinated almost indefinitely without complete dissolution. This dictates physical clean-out between cycles or development of a stirrer to augment dissolution.

4. Drying of the melt by intermittent sparging with HCl or chlorine was demonstrated to be much less effective than continuous sparging. The melt regained "moisture" during the non-sparge periods in spite of a dry gas sweep over the melt surface during these periods.

5. The integrity of the crucible container (susceptor) must be maintained and the atmosphere carefully controlled with the drybox lid to insure a dry melt during electrolysis. Leaks in either of these pieces of equipment resulted in increases in the "moisture" content of the melt.

6. Good quality product may be produced with reference electrode to cathode voltages higher than those used in laboratory tests. Part of this effect may be due to the IR drop across the melt.

Materials of Construction for Salt Systems - Samples of Inconel, Inconel X, Inconel 702, Incoloy 802 and tantalum were exposed for single six-hour periods to chlorine-sparged 60 w/o $PbCl_2$-40 w/o KCl at 600 C. Only Inconel 702 corroded at a rate less than 100 mils/mo; its rate was 84 mils/mo. Similarly, Inconel 702, Duranickel, Permanickel, Hastelloy B, C and D, and 406 and 320 stainless steels were exposed for single six-hour periods to chlorine-sparged 60 w/o KCl-40 w/o LiCl at 600 C. Only Duranickel corroded at less than 100 mils/mo; its rate was 58 mils/mo.

Dissolution of PRTR Spike Fuels

Dissolution rates for non-irradiated PRTR spike fuel alloy in 6 M HNO_3-0.03 M NH_4F-0.005 M $Hg(NO_3)_2$ were decreased by a factor of about three when the dissolvent was made 0.02 to 0.03 M in nickel nitrate. The $Ni(NO_3)_2/Hg(NO_3)_2$ ratio appears to control the inhibiting effect and the maximum useful ratio is about five. At ratios above six, activation of the alloy by mercuric nitrate to produce rapid dissolution was not dependable. Two five-inch lengths of Zircaloy-4 clad irradiated PRTR spike fuel have been obtained and stored in the 222-S cubicle to permit I-131 decay. About the first of March these sections will be dissolved to determine plutonium losses during decladding and to compare dissolution rates of irradiated with non-irradiated alloy.

RADIOACTIVE RESIDUE FIXATION

Kinetic Studies of Ion Exchange Materials

Strontium diffusion data were determined for several sodium-based, inorganic zeolites. In the particle diffusion region, activation energies ranging from 8 to 12 kcal/mole were computed for the zeolites erionite, phillipsite, and clinoptilolite, and a gel having a six-to-one, silica-to-alumina ratio. These values are three to five times higher than corresponding cesium values.

An activation energy of 17.4 kcal/mole was calculated for a type A synthetic zeolite, indicative of the formation of bonds stronger than those typical of simple cation exchange reactions. To determine the possibility of a partially irreversible strontium exchange for sodium, a bed of sodium-based type A zeolite was fully loaded with 0.2 N $SrCl_2$ + 1.0×10^{-7} N Sr-85 solution, as indicated by a recording of Sr-85 activity on the zeolite. The bed was then eluted with 0.2 N NaCl solution. Failure to elute some 35 percent of the previously-adsorbed Sr-85 with the NaCl solution indicated that this portion of Sr-85 was "fixed", or had chemically reacted with the type A zeolite.

In the film diffusion region, reaction rate constants for the above same zeolites of 1.0 to 2.0×10^{-3} sec^{-1} were obtained for an influent containing 1.0×10^{-3} N $SrCl_2$ + 1.0×10^{-8} N Sr-85. The reaction rate constants for the same concentration of cesium are about five times faster.

Type A zeolite is the most strontium-selective of the zeolites tested, but elution of the adsorbed strontium is not practical.

Clinoptilolite Quality

Preliminary experiments were carried out in order to improve definition of the quality of clinoptilolite. Cesium distribution coefficients were determined for clinoptilolite obtained from three sources. A mineral from California is green in color, as is one from a Nevada source, but a second from a Nevada source is white with dark bandings. K_d values of 2300, 1200 and 1140 were measured for the clinoptilolite from California, Nevada green and Nevada white, respectively.

Heat treatment of the California and Nevada green minerals raised the K_d values by 25 to 30 percent, but no change was noted for the Nevada white mineral. The calcium carbonate content of the mineral from all three sources was less than 1 percent.

[redacted]

Low- and Intermediate-Level Wastes

Laboratory experiments indicate that ruthenium would not be removed by addition of oxidizing agents to Purex Tank Farm condensate during steam stripping operations. Ozone and hydrogen peroxide were first studied since these oxidants do not introduce cations which might adversely affect the ion exchange removal of cesium and strontium. Laboratory results showed no detectable ruthenium removal during a 15-minute boiling time. Experiments with sodium hypochlorite gave similar results. Longer reaction times were not investigated because of the relatively short hold-up time that is practicable with the 271-CR steam stripper.

Micro Pilot Plant Run 22 which is in progress to evaluate the performance of a 0.25 liter column of Amberlite IR-120 in the sodium form has treated over 2500 liters of Purex Tank Farm condensate. The feed was steam stripped to remove ammonia and organic and adjusted to a pH of 4.2 by nitric acid addition. Cs-137 and Sr-90 concentrations in the effluent have been less than their respective MPC_w values.

Ruthenium Behavior

The measurement of the vapor pressure of RuO_4 fron nitric and sulfuric acid solutions was completed with determination of the temperature coefficient and of the effect of substituting sodium nitrate for nitric acid. In contrast to nitric acid, increasing quantities of sodium nitrate increase the vapor pressure of RuO_4 (from a solution initially one molar in nitric acid).

Measurements of the kinetics of thermal decomposition of RuO_4 (using the specially modified Cary 12 spectrophotometer) have been made with both glass and stainless steel chambers. The initial rate of decomposition in stainless steel was found to be much more rapid than in glass; however, the stainless steel surface gradually became inactivated until the rate was much slower than in the glass system (after ruthenium oxides have built up in both; the glass surface was initially very inactive). Use of the spectrophotometer and continuous flow system has been very satisfactory and has shown reaction details which would have been very difficult to detect or measure by the use of (necessarily integrating) chemical absorbers. It is planned to extend the investigation to include measurements of the influence of nitric acid vapor.

In-Cell Calciner

Assembly of the in-cell calciner equipment in the cold mock-up area is nearing completion, although some electrical, pipe fitting, and instrument work remained at month's end. Testing, calibration and cold shake-down operation should get underway during the coming month.

A two-stage electrostatic bubble scrubber for in-cell use has been designed and is being fabricated. It will employ, besides the bubble stage, an ionization stage with enhanced residence time and a York mesh di-mister following the bubble section. It is hoped to remove 99 percent of the sub-micron particles which have not been removed by prior treatment.

[redacted] [redacted]

BIOLOGY AND MEDICINE - 06 PROGRAM

TERRESTRIAL ECOLOGY - EARTH SCIENCES

Geology and Hydrology

Drilling on Project CAH-921 was completed. Total footage drilled (18 wells) exceeded original estimates of 4,645 feet by about three percent, due largely to the significantly greater depth to basalt than predicted at three sites. In addition, 13 wells (out of service because of silt infiltration or equipment lodged in the casing) were rehabilitated on this contract.

Current exploration by the Corps of Engineers at Columbia River mile 348 was completed. Their well D-11, which is a cased and perforated well completed to a depth of 202 feet, was turned over to Hanford for ground water studies. Integration of geological data from their explorations into the Hanford picture is underway.

A method was studied for overcoming the computational problem associated with a proposed procedure for in-place permeability measurement in heterogeneous soils. The method involves successively improving an initial estimate of the permeability until the potential distribution computed from the estimate agrees with the measured potential. Values obtained by this method were better than those resulting from the earlier finite-difference method which contained 35 percent error. However, the 23 percent error for the successively-improved method is undesirable as compared to the 8 percent error for the linear-approximate method. An important feature noted is that the linear-approximate method tends to smooth peaks excessively and does best in regions of gradual or no permeability change. In contrast, the successive-improvement method shows better agreement in regions of rapid permeability change but does poorly in zones of constant permeability. These findings suggest combining the two approaches to arrive at a better computational scheme.

Two computer programs, "Steady-State Flow in Soils" and "Permeability Improvement" were linked together to calculate permeabilities from potentials and boundary permeabilities. The linking results in a five-fold reduction in computer time since the programs are no longer passed through the computer separately.

Field Apparatus Development and Application

A flux-gate magnetometer was acquired and is being adapted for vehicle mounting. Surveys with this instrument will supplement earlier obtained airborne magnetometer data and will aid in more accurately defining contours of the basalt surface.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Radiation Chemistry

Most protection indices (a measure of the relative ability of a compound to react with free radicals) are determined at 25 C, but protection of animals is measured at the body temperature of 37 C. If the activation energies of the reaction providing protection and the dye reaction used to determine the protection index are different, then good correlation cannot be expected between protection at 37 C and protection index at 25 C. Studies were begun to determine these activation energies. These studies are more conveniently done with the new Gamma Cell 200 Co-60 irradiator recently received and put into operation.

Experimental data on hemolyses of red blood cells protected with various dilute concentrations of valine, histidine, tryptophan and erioglaucine show a fairly good fit to the equation

$$\left[\log \frac{Th^{o}}{Th}\right]^{-1} = a\,(P.I.)\,[P]_{o} + b$$

where: Th = hemolysis time

$(P.I.)$ = protection index

$[P]_{o}$ = initial protective agent concentration

Th^{o}, a, b = constants

Further studies will be made of this correspondence between protection of a living cell and the ability of compounds to inhibit bleaching of erioglaucine dye.

The effect of sample position on ESR signal amplitude has been investigated in our rectangular microwave cavity. The position of a minute sample is rather critical in the vertical direction and in the front to back direction. Moving the sample, which was about 0.3 mm in diameter, 0.8 mm in either of these directions resulted in a 4 percent decrease in peak amplitude of the signal. Moving the sample parallel to the magnetic field from the electromagnet revealed that maximum signal occurred next to the sidewalls of the cavity. At the sidewalls the signal amplitude was 52 percent greater than when midway between the walls. This variation in amplitude is thought to be due to the non-uniformity of modulating magnetic field produced by the coils just outside these sidewalls. At the center of the cavity a 3 mm wide region exists where the signal amplitude stays within 6 percent of its minimum value.

RADIOISOTOPES AS PARTICLES AND VOLATILES

Aerosol Generation and Characterization

Detail specifications were obtained and will be used in assembling a spinning disc aerosol generator. The generator is capable of producing controllable, narrow-particle-size-range aerosols over a wide range of particle sizes.

Particle Deposition in Conduits

The dry particle aspirator was modified to reduce agglomeration and provide better control of particle generation rate. Samples drawn from two identical probes into the settling chamber fed by the dry powder aspirator were less reproducible than required for accurate deposition measurements. The aspirator, chamber and sample measuring techniques are being reviewed for possible deficiencies.

Manager
Chemical Research and Development

WH Reas:cf

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

No significant changes occurred during January.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 02 PROGRAM

Monitoring

Aquatic Biology facilities at 100-K Area are being readied for the start of the annual effluent monitoring tests using young chinook salmon.

Columnaris

Virulence tests using cichlids showed that these fish are highly sensitive to columnaris. Studies on a radiation-induced mutant of columnaris and on sublethally irradiated organisms showed no differences in virulence compared to controls.

Waterfowl

Radioactivity analyses of 263 duck heads during the month completed the study for the 1961-1962 hunting season. A total of 3,443 heads were analyzed.

BIOLOGY AND MEDICINE - 06 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Phosphorus

In the study of the effects of feeding P^{32} on the mortality and spawning success in cichlids, activity levels of 0.16, 0.55, and 2.01 $\mu c/g$ of fish were found in groups fed 0.25, 0.1, and 4.0 $\mu c/g$ of food, respectively.

Strontium

The rearing of 200 trout on a Sr^{90} spiked diet was initiated. When an equilibrated body burden is built up these fish will be used for stress experiments.

The addition of 0.1 mM calcium or more to the external environmental solution in the gill perfusion technique will decrease the active uptake of strontium from 4.0×10^{-7} cm/sec to approximately 2.0×10^{-7} cm/sec.

Data have now been obtained on the absorption of Sr^{85} and Ca^{45} from the perfused small intestine of the rat over a pH range extending from 1 to 12. There was remarkably little effect in the range of pH 5 to 11. In the range of pH 4 to pH 2, there was a marked increase in the absorption of Sr^{85} which was not exhibited by Ca^{45}, suggesting that absorption of the two isotopes was occurring by different mechanisms. A greater variability of results in the acid range may indicate animal variation in reserve buffering capacity. There was a sharp dr in Ca^{45} absorption at the extremes of pH 1 and pH 12. At these extremes the absorption of Ca^{45} and Sr^{85} was quite similar, suggesting that the mechanisms responsible for the usual preferential absorption of calcium over strontium are inactivated under these conditions.

A gilt fed 3.1 mc of Sr^{90}/day for 82 days expired and exhibited pathological lesions associated with bone marrow aplasia. Leukopenia, particularly of the neutrophils, and thrombocytopenia had developed progressively since initiation of feeding. Erythrocyte numbers and hemoglobin concentrations had remained within normal limits until approximately a week before death, at which time both were about half of the normal values. No other significant alterations in clinica condition were noted until two days before death, at which time inappetance and slight respiratory distress developed. Respiratory distress became progressively worse with severe pulmonary edema present 24 hours before death.

On post-mortem, the animal manifested widespread hemorrhages analogous to those seen following acutely lethal whole-body radiation. Free blood was present in most sections of the gastrointestinal tract above the lower bowel. Both lungs were extremely congested and edematous, apparently from an overwhelming bacterial pneumonia. All normal marrow sites were aplastic with active marrow present only in the centers of long bones. This marrow was very hemorrhagic. The vertebral bodies, normally active marrow sites, appeared to be more dense, either with trabecular ossification or fibrosis. Five normal appearing feti (80 days of gestation) were present in the uterus. (Erythrocyte, hemoglobin, and white cell determinations on blood from the feti showed values about 2/3 of normal; however, their significance is of question, because the dam had been dead for over two hours.)

One animal fed 625 µc Sr^{90}/day for over four months gave birth to seven viable offspring. Excepting for reduced size, they appeared normal, with blood determinations on one offspring falling within normal limits.

Comparative Toxicity

A progressive leukopenia has been noted in animals injected intravenously three months ago with either 64 µc Sr^{90}/kg, 6.4 µc Ra^{226}/kg, or 1.3 µc Pu^{239}/kg. Present leukocyte values are approximately 25 per cent below normal.

(One two-year-old control animal died, apparently of rupture of the bladder and associated hemorrhage into the peritoneal cavity.)

Iodine

Three experiments have been completed to test the biological effectiveness of I^{127} as a diluent of I^{131} vapor. Iodine-127 inhaled with I^{131} decreased the amount of I^{131} deposited in the thyroid of rats but the decrease was not as great as was expected. Further experiments are planned using greater quantities of I^{127} vapor.

Neptunium

An experiment was initiated to determine the acute toxicity of intraperitoneally injected Np^{237}. Rats receiving 50 mg/kg died within 5 hours. The acutely toxic level appears to lie between the 30 and 50 mg/kg levels.

Thirty minutes following intracardial injection of Np^{237} samples were taken of liver and kidney for study of neptunium distribution in sub-cellular fractions. These studies are still in progress. Plasma from these animals was dialyzed against either phosphate or citrate buffer for 72 hours. Between 30 and 45 per cent of the Np^{237} in plasma was dialyzable regardless of the buffer employed. Under similar conditions plasma plutonium was 18 per cent dialyzable in phosphate buffer and 92 per cent dialyzable in citrate buffer.

Two young ewes were given 6 mg/kg (4 + μc) of Np^{237} in continuation of the study on the acute chemical toxicity of Np^{237} in sheep. Both ewes were severely ill by the third day post-injection. Liver function was greatly impaired as measured by I^{131} Rose Bengal blood clearance. One ewe died on the fourth day post-injection and at post-mortem showed hemorrhages in the liver, although not to the extent observed in a ewe given 12 mg/kg, reported previously. The remaining ewe (given 6 mg/kg) survived the acute stage and was sacrificed on the twelfth day post-injection, at which time she appeared grossly normal although manifesting impaired liver function.

A further study was performed utilizing I^{131} Rose Bengal blood clearance as a liver function test in sheep by obtaining blood samples at various intervals after injection while simultaneously monitoring a vascular region in the neck. The rate of clearance from the blood as measured by monitoring blood samples was found to be more rapid in sheep than the clearance rate indicated by external monitoring. The differences in the two methods is probably due to the concentration of the I^{131} in the tissue which is detected by external monitoring.

Plutonium

Studies of the intracellular distribution of plutonium and of its state in plasma were initated, as described for neptunium.

Complete data are now available from the experiment to determine the effectiveness of urethane and ultrasonic treatment, in conjunction with DTPA, for therapeutic removal of plutonium. As previously indicated neither urethane nor ultrasonic treatment appear to have significantly beneficial effects. As a pre-treatment urethane decreased the liver uptake of plutonium by about 40 per cent; bone deposition, however, was increased. Urethane administered with DTPA appeared to interfere with the action of DTPA.

Forty per cent of the sites on the last two blond miniature swine injected with 5 μc Pu^{239}(IV) nitrate showed ulceration and exudation by the thirtieth post-injection day. In the sites showing tissue breakdown, only 10 to 40 per cent of the "pre-ulcer" quantity of plutonium was detected by external monitoring, compared with 80 to 99 per cent retention detected in the sites in which no ulcers formed (in a comparable one-week period).

Radioactive Particles

Nine dogs exposed to $Pu^{239}O_2$ and three controls were added to the 27 dogs already on a long-term study of plutonium inhalation. Twelve more will be added in the spring and three, exposed more than two years ago, will be sacrificed for determination of the plutonium content of the tissues, and study of possible pathologic changes. Pulmonary function tests are being developed for detecting plutonium-induced changes in the lungs. These tests are expected to detect changes earlier than roentgenology, since the latter did not show positive changes earlier than about two weeks prior to death in a dog which died five months after pulmonary deposition of 20 to 25 μc.

Milk Transfer of Radionuclides

Plans were formulated for the study of the milk transfer of Sr^{90}, Ru^{106}-Rh^{106}, Pm^{147}, U^{233}, and Cm^{244} following a single intravenous dose. This study will be performed in April or May.

Regenerating Liver Studies

Additional studies on the uptake of C^{14} labeled alpha-amino isobutyric acid (AIB) by the regenerating liver indicate that this uptake is increased approximately twofold in animals given 2,000 r whole-body X-ray and hepatectomized, as compared with animals hepatectomized only, or sham operated.

Ion Uptake by Plants

Chloramphenicol decreased uptake of Cs by low salt-high sugar and high salt-high sugar plants. However, translocation of Cs was not affected. Plants previously injured by Cs recovered when grown in the absence of toxic levels of Cs. Injured roots and leaves did not recover, whereas new growth was normal. Healthy plants (10 days old) did not show symptoms of toxicity when exposed to toxic levels of Cs for four days.

Rattlesnake Springs

Studies of interrelationships between soil characteristics and the natural plant communities on the Hanford Reservation showed a marked pH increase in surface soil from under greasewood plants as compared to soil from barren areas or from under other species from the same community. The higher pH under greasewood is indicative of pronounced mineral cycling by these plants.

A study of the plankton development in a newly formed impoundment was initiated.

Columbia River Limnology

An ecological study of Columbia River plankton was initiated, including establishment of collecting stations and collections of the first series of samples for analyses.

Fallout

Radioiodine concentrations in Hanford and Colorado deer thyroids continued to decrease from December values. Average concentration near the end of January was 3×10^{-4} $\mu c/g$ wet weight. Hanford thyroidal I^{131} concentrations were about 50 per cent greater than Colorado values. All thyroids from Alaskan caribou were below the detection limit of 2×10^{-5} μc I^{131}/g wet weight.

Project Chariot

Over 21 species of freshwater crustaceans were found in plankton from tundra ponds under study in the test site environs. Copepods and Cladocera comprised most of the species. The summer temperatures of the tundra ponds differed noticeably from 1960 to 1961. They were generally lower in 1961 and showed less diurnal variation than those of 1960.

General

Mr. J. Fuquay was a guest of Biology's Internal Emitter Committee meeting. Research on the atmospheric disposition of particles and possible problems of radioactive particle release were discussed.

HA Kornberg
BIOLOGY OPERATION

HA Kornberg:es

C. Lectures

a. Papers Presented at Society Meetings

None

b. Seminars (Off-Site)

Bustad, L. K., "Physiological response to ionizing radiation," Institute of Radiation Biology, University of Washington, Seattle, Wash., January 24,

[redacted]

Van't Hof, J., "Effects of radiation on the biochemistry and morphology of dividing cells," University of Washington Institute of Radiation Biology, Seattle, Washington, January 3, 1962.

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - JANUARY, 1962

ORGANIZATION AND PERSONNEL

J. E. Schlosser was transferred from Physics and Instrument Research and Development to Operations Research and Synthesis effective January 1, 1962. R. H. Rodman accepted a rotational training assignment with the group effective January 1, 1962.

OPERATIONS RESEARCH ACTIVITIES

HAPO Model

The second draft of a report describing the relationship among conversion costs, investment, and production at HAPO is being circulated for review.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Fuel Element Performance

Three separate activities were carried on in connection with the general problem of improving measurements performed on the unirradiated fuel elements. The analysis of UT-2 data for twelve standards encompassing the range of production data was completed. On the basis of this analysis, values were assigned to the standards against which testers can be calibrated in the future. In another area, the capability of the bond tester was evaluated in an experiment in which new crystals were used and great care taken to calibrate the testers prior to collecting the experimental data. Finally, assistance was provided in the analysis of data collected to determine the adequacy of dimensional measurements on the pre-irradiated fuel element.

Further assistance was provided in the analysis of data describing chemistry and grain size segregation along an ingot and the resulting rolled rod.

An analysis is being made of break strength data from some 500 fuel elements encompassing a range of residence times. Break strength is being correlated with fuel element power and residence time.

Because of the inability to detect ingot impurities existing in minor amounts, many values are reported as being $< x_0$ppm. As a result, there is some question as to how best to summarize the resulting data. Work is being done in this area. It has been shown for one impurity selected at random that the censored log-normal distribution provides a good description of the data. An attempt will be made to develop some sort of censored distribution for each impurity.

Assistance was provided in the design of a production test to evaluate the in-reactor corrosion behavior of fuel elements given a water autoclave followed by a chromic acid autoclave treatment. In preparing fuel elements for this test, it was found that a chromate-dichromate autoclave treatment after the water autoclave may give better results than the chromic acid autoclave. A laboratory experiment was designed to pursue this further.

General

An analysis was made of warp data from some 80 NPR fuel element extrusions in order to evaluate the effects of identified process variables. It was impossible to estimate these effects clearly because of the large amount of confounding in these production data. Certain qualified conclusions were reached, and an experiment proposed to identify more effectively the effects of these process variables on warp.

Some NPR fuel element wall thickness data were examined to determine how best to characterize average wall thickness and the variation in wall thickness along the extrusion. A method was developed and suggested which gives estimates of the minimum, maximum, and average thickness, plus the orientation of the maximum (or minimum). This method requires the use of computer techniques to be of practical use.

Assistance was given in the design of an experiment to evaluate certain duplex bath variables as they affect the bonding properties in the Alsi process.

Some assistance was provided in analyzing bumper rail heights before and after welding, and in designing experimentation to more fully evaluate sources leading to variation in rail heights.

A review was made of the acceptance specifications for U-235 content in ingots and/or dingots. Specifically, the effect of compositing samples on acceptance criteria was investigated.

A test was made of a theoretically deduced hypothesis pertaining to the relationship between certain warp vectors in NPR fuels.

Quench media effects on the type and magnitude of dimensional distortion of heat treated bare cores were evaluated.

The requested critique of fuel element failure surveys performed by FPD personnel was completed.

The mathematical analysis for the propagation of Lamb waves in cylindrical shells continues. Although the analysis is considerably more complex than that for slabs, results so far have shown the existence of entirely new phenomena unique to this geometry.

<u>Irradiation Processing Department</u>

Reactor Optimization Studies

As suggested previously in connection with the study of work rates within IPD (specifically, charge-discharge rates), data were broken down by outages rather than by months. On this basis, it was found that work rates were about the same for all reactors on the average when adjusted for the number charged. These results were then used to prepare control charts monitoring the performance at each outage, and the accumulated performance. This will be discussed with area analysts in the near future.

A method of processing and analyzing overtime data was proposed. One year's data will be processed, as they are made available, in order to obtain a rough idea of the effect of reassignments of personnel, and changes in the number of personnel, on total labor costs. A much better estimate of these effects should result from the computer simulation study currently underway.

Work is proceeding in the computer simulation study of reactor operations. Difficulties have been experienced in processing personnel records for analysis, largely due to corrections and adjustments which were made for individual payment records. Concurrently with the work being done to provide correct data, analytical programs are being written to provide the basic distributions of craft efforts to the reactor functions.

Process Tube Leaks

Work is continuing on the development of a model for predicting the probability of a process tube leak due to internal corrosion. Since the corrosion rate of aluminum is an important aspect of this, interest has been revived in a comparison of existing corrosion models, and possibly, in the development of an empirical model should existing models prove to be inadequate.

General

An electronic random number selector was developed by IPD personnel for use in sampling of incoming reactor components. The results of 2700 selections were analyzed as requested to determine if the frequencies of numbers generated were from a truly random device. The device is designed to randomly select numbers from one to eight.

Using previously developed results, the probability that a given reactor would operate D days without incurring an unscheduled outage was calculated as requested.

Work continued on the problem of estimating the probability of detecting cracks in welded primary piping.

Work continued on the provision of a reliability analysis of various reactor safety systems employing a "k out of n" type of trip logic. Current effort is directed toward incorporating into the analysis a consideration of routine periodic trip checking of devices. Figures of merit are being calculated for specific cases.

<u>Chemical Processing Department</u>

Machining Development

Major progress has been made on the EDPM program to produce magnetic control tape for the Gorton lathe. A series of tests designed to examine the program's reliability in distributing the proper signals along the tape have all been successful.

General

Primary attention during the month was directed at many problems associated with meeting specifications on the final product, and demonstrating conformity to them. The recently installed use of process control techniques to assure that the process average purity remains above a certain level while the product and measurement variations remain below given levels has operated satisfactorily in demonstrating conformity to purity specifications now that part-by-part acceptance had to be stopped due to the excessive amount of analytical work required. Statistical assistance was also provided in connection with problems arising from Pu-240 and density specifications.

Detailed calculations concerning the surface geometry of a specific item of manufacture were prepared.

Relations Operation

The study concerning the effect of different variables on blood count was continued. To improve the sample used for study, the effects of age, date of examination, and radiation were studied on a population of males in the 100 Area. Further work is planned in connection with this study.

Contract and Accounting Operation

A sample was prepared for the review of file records and filing systems.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Pulse Column Facility

Further statistical analysis was done on absorptiometer calibration data from the backup set of four test cells. These calibration functions and cells will be used for future experiments if the original test cells are damaged. Work continued on the revision of NELLY, the nonlinear least squares routine, to handle a two component dependent variable vector. The revision will be used to fit simultaneously the aqueous and organic concentration models.

Statistical evaluation was initiated of the twenty pilot study experiments run on the pulse column last summer. The first stage of the evaluation is a correlation study to determine the gross dependence of several average value mass transfer indices on the five independent variables, aqueous flow rate, organic flow rate, feed concentration, pulse amplitude and pulse frequency, which were used as the physical factors in the pilot study experiment design. Two indices, the fraction of total uranium throughput transferred and the absolute transfer rate, are currently being correlated with these independent variables.

Nondestructive Testing

A FORTRAN program was written to estimate the average strain in a given direction in metal piping using X-ray diffraction data. This nondestructive testing procedure is being evaluated as a potential method for assaying the strain relief characteristics of annealing on NPR piping welds.

Materials Development

A discussion was held with personnel of Structural Materials Development to consider the possibility of IBM machine processing of creep data. The basic strain-time data for each creep test will be recorded on IBM cards. FORTRAN programs are being written which will analyze these data using any one of a number of theoretical creep mechanism models with graphical as well as numerical output.

Reactor Effluents

An evaluation is under way jointly with Chemical Research to determine the representativeness of effluent samples taken from the sampling ports of the KE test loops. A recent experiment was performed where a number of duplicate water samples were collected, each sample split and duplicate analyses for Na-24 and Cu-64 done. Appropriate analysis of variance calculations have been carried out on these data and recommendations made concerning the need for further investigation to pin down the magnitude of the sampling variance.

General

A graphical procedure based on the theory of propagation of Lamb waves was devised which will enable the experimenter to more correctly identify which of the many possible vibrational modes are actually present during the ultrasonic inspection of a thin plate.

Closed form general solutions were obtained for a set of three ordinary nonlinear differential equations. These equations arose during the course of reactor shielding studies.

Assistance was given in the establishment of an empirical relationship among certain parameters in a buckling equation in connection with criticality studies.

4000 Program

Swelling Studies

Statistical analysis was completed of etch study data supplied by Physical Metallurgy Operation. Four pore size distributions were obtained from a replica of a sample of irradiated uranium following a twenty-minute ion bombardment etch. Later, a second set of four distributions were obtained from the sample following an additional seventy-minute etch. The sample was carefully marked so that distributions were obtained from paired twenty- to ninety-minute etch locations. These eight pore size distributions were processed to determine the effect of the additional etch on void density and void fraction estimates. Further work was done on programming of statistical procedures for detailed analysis of the micrograph pore size distributions. Currently, a method is being programmed for the estimation of the functional form of a theoretical pore size distribution in the matrix from moment information assuming that the theoretical distribution is of the log-normal type.

Aluminum Corrosion

A second order, second degree differential equation, relating penetration rate to time for a particular postulated mechanism of aluminum corrosion, was integrated. The parameters in the function were estimated using data from a recent autoclave corrosion experiment with 360°C deionized water.

Test Reactor Operations

A meeting was held with the manager of PRTR to discuss the D_2O inventory problem. Several suggestions were made concerning the recording of inventory data so that it will be possible in the future to estimate the bias in recording instruments due to the buildup of water vapor in pressure tubes. Additional hot inventories records were obtained, and these data are currently being analyzed.

5000 Program

The problem of optimal search patterns was expanded to include possible arrangements of detection devices compatible with selected search procedures. Some results were obtained with work continuing on this problem.

A Monte Carlo evaluation was started of several estimation methods for quantitative resolution of a mixture of pure death processes. The program, presently being debugged, computes random counting data which simulates the decay of a multicomponent death process and then feeds these data into several resolution techniques which estimate the time zero size of each component of the pure death process.

A new search technique using the NELLY program was tried on equal ignorance type data. Wind rose data are being fitted to circular normal distributions. The search procedure will be reprogrammed making use of this prior information.

6000 Program

Atmospheric Diffusion Studies

Work continued on tentative diffusion curves, using NELLY and the APE data.

7-E

Biology and Medicine

Work continued on testing mathematical models for the control groups of the Mice Inhalation Study. A program is currently being written to determine parameters of a trial model.

Statistical analysis of data from an experiment involving rats subjected to a partial hepatectomy has been completed and a report is in preparation.

Other

Radiation Protection Operation

Curves were fitted to calibration data using a digital computer program. A copy of the program was provided for use with future data.

Results of the study to determine the correlation between badge and pencil readings were reviewed with the customer. As a result, further, more definitive studies are planned.

A discussion was held with Programming and Radiation Protection personnel concerning the recent CPD request for further hazards analysis study of the shipment of large quantities of radioactive material. Methods of estimating the expected consequences of accidental release during shipment of these radioactive materials and the probability of such release as a function of certain controllable variables were considered. A pilot study approach to these problems was decided upon and certain calculations are now being performed.

Robert Y. Dean
Acting for
Manager
Operations Research and Synthesis

CA Bennett:dgl

PROGRAMMING OPERATION

JANUARY, 1962

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Fuel Geometry and MELEAGER Codes

One phase of a study has been completed with the Hanford computer codes, IDIOT and MELEAGER, for U-235 in UO_2, which will assist in studying the effects of fuel element geometry on fuel cycle costs.

MELEAGER, a burn-up code, does not directly recognize fuel element geometry but certain parameters do reflect geometrical effects. The input parameters SDPV and SCA reflect lattice spacing and fuel element diameter, respectively. These MELEAGER terms were calibrated for geometrical SDPV's and SCA's with the IDIOT code. The IDIOT code (based on transport theory which uses the P_3 approximation to solve the Boltzmann equation) recognizes fuel element geometry directly and has been calibrated against criticality experiments.

The calibrating method being used is based on the primary importance of varying SDPV and SCA in determining the resonance escape probability (p) and the ratio of neutrons released in the fuel per neutron absorbed in the fuel (η). These are key parts in the four-factor formula for reactivity, $K = \eta \epsilon pf$. Comparison of the ηp response surfaces can be used to compare MELEAGER with the IDIOT code.

The following table shows the necessary value of SDPV in MELEAGER to achieve the same value of ηp as that achieved by the reference code, IDIOT, for a given value of geometrical SDPV inserted into IDIOT. Graphite, H_2O, and D_2O moderators are considered for the case of 3 percent U-235 in UO_2 at 95 percent of theoretical density.

TABLE I

NECESSARY MELEAGER CODE INPUT SDPV's TO ADJUST REACTIVITIES TO MATCH IDIOT CODE RESULTS

Geometrical SDPV into IDIOT	1	2	3	4	5
Reactor Type	SDPV in MELEAGER for Equivalent ηp				
Graphite Moderator	1.3	2.0	3.0	4.0	5.0
H_2O Moderator	1.3	2.45	3.35	4.25	5.5
D_2O Moderator	1.3	2.3	3.5	4.65	5.75

Agreement is remarkably good for Graphite, except at low values of SDPW, corresponding to closely spaced lattices. Here MELEAGER appears, by comparison, to be more conservative as it yields lower values of reactivity for a given SDPW and enrichment. The net effect is to cause an increase in fuel costs based on MELEAGER because higher enrichments are required for given exposures which means that the interest charges on the fuel will be increased. Work is planned to check the codes with plutonium enriched UO_2 to demonstrate the applicability of the above results.

Zoned Spectrum Reactor

The zoned spectrum reactor concept was demonstrated with seven fueling schemes to give reasonable fuel costs, as shown in Table II. These seven fueling schemes, the reactor type, and the economic climate were all chosen to allow comparison of the results with those of the broader combined cycles study. The parameters unique to the zoned spectrum type of operation were selected to ascertain the maximum possible merit of this concept and include:

1. No penalty for the change in thermal utilization factor which normally occurs when the relative amount of moderator is altered; this change is minimal with the D_2O moderation assumed.

2. No penalties for the extra start-up and shutdown costs involved in getting onto an equilibrium cycle.

3. No loss in operating efficiency, which is equivalent to assuming that fuel shuffling takes place without shutting down the reactor.

TABLE II

FUEL COSTS FOR ZONED SPECTRUM REACTORS USING VARIOUS FUELING SCHEMES

(Plutonium Price = $11.64/gm (fissile))

Fueling Scheme	Combined Cycles Series No.	Assumed Cost of U-233	Minimized Total Fuel Cost (mills/kwh)
U-235 in UO_2	1000		1.45
Cascade Tails UO_2 (0.4% U-235) Enriched with U-233	2000	$15/gram $ 5/gram	1.55 0.74
Cascade Tails UO_2 Enriched with Pu, 70% 239, 18% 240, 11% 241, 1% 242.	3000		1.45
Cascade Tails UO_2 (0.4% U-235) Enriched with Pu of composition 95% U-239, 5% 240.	4000		1.51

1250199

TABLE II (cont'd.)

Fueling Scheme	Combined Cycles Series No.	Assumed Cost of U-233	Minimized Total Fuel Cost (mills/kwh)
ThO_2 Enriched with U-235	6000	$15/gram	1.82
ThO_2 Enriched with U-233	7000	$15/gram	1.44
ThO_2 Enriched with Pu of composition 95% 239, 5% 240.	9000	$15/gram $10/gram	1.85 2.02

Fissile enrichments ranged from 3.0 to 3.5 percent and exposures ranged from 23,000 to 57,000 MWD/T.

The zoned spectrum reactor concept appears to have potential merit in a variety of reactor fueling schemes. Further study would be required to demonstrate its desirability in a given reactor with its specific limitations.

Code Development

The PROTEUS code was developed to economize on MELEAGER computation time by making data for the graded fuel cycle from the data of a MELEAGER batch cycle run. For the normal case, this works very well but in certain extreme cases such as fuels with low density, this has led to serious inaccuracies in the batch results. An option was put in PROTEUS to allow calculation of batch results separately so that optimum results are obtained.

A merging routine to allow the addition of needed cases to obtain minimized fuel costs was added to PROTEUS code. The code was revised so that a tape of polynomial coefficients was produced so that additional end points can be produced. This necessitated a new merge logic. It is now designed to merge an old and a new MELEAGER source tape to produce merged QUICK input and a merged polynomial tape which can be used to produce additional QUICK input data. It can also merge a polynomial tape with a MELEAGER output tape or with a polynomial tape. The code has been made self-auditing by the addition of an error analysis and case summary.

The PUVE code originally written as a subroutine of QUICK code has been rewritten as a separate code to permit experiments with various definitions of Plutonium Value, as the method used by the Hanford Laboratories is different from those used by others.

The plotter routine which is a part of the QUICK code has been revised to increase its usefulness. Specifically its accuracy has been improved and the various parameters are plotted against exposure instead of arbitrary time periods. The MINIMIZER PLOTTER code has also had its accuracy increased and the formats and parameter identification improved for easier use. A summary tape is now printed as desired for concise presentation of data in future fuel cycle documents and for exceedingly compact tape storage. The normal printout will be kept for a more complete reference record but is not suitable for direct reproduction in surveys. An error tape is also printed at the command of the QUICK code when certain error limits of the curve fits are exceeded. The tape contains information which helps the user to determine if the error is serious enough to invalidate the results.

MELEPRO has been completed and debugged and has performed satisfactorily. This code edits MELEAGER A-3 Standard output tapes, prints out the results in table form, and deletes redundant information also stored on the B-8 tape.

Salt Cycle Reprocessing

Work on the computer program designed to evaluate Salt Cycle reprocessing economics has progressed to the extent that three of the four material balance subroutines have been tested and debugging is nearly completed on these. Only a few check calculations remain to be done and no serious problems are foreseen. The fourth subroutine is well under way. After these subroutines are completed they will be tied into the general economics program.

High Exposure Plutonium for PRTR

A shipment of separated and decontaminated high exposure plutonium was received early in the month. This shipment, portions of which ranged up to about 30 percent Pu-240, completed the procurement program originally initiated by HLO for the Plutonium Recycle Program.

SPECIFIC FUEL CYCLES

Density and Cross Section Evaluation Study

Plutonium values obtained with the MELEAGER CHAIN code appear to be conservative for reactors optimized for U-235 enrichment with closely spaced lattices that produce hard neutron spectra. Plutonium enrichment of fuel elements produces an even harder neutron spectrum than U-235 enrichment would because of the higher neutron cross section of the plutonium. For hard spectra the Westcott cross section model used in MELEAGER CHAIN code over-emphasizes the epithermal flux near the Pu-239 absorption resonance which increases alpha and thereby reduces eta. This was demonstrated with the MELEAGER physics code using an adjusted Westcott system by comparing it with other codes including a multi-group code named SPECTRUM developed by General Dynamics with the result that the MELEAGER code reactivities for given enrichments are lower than reactivities produced by other codes.

The influence on plutonium value results from the higher plutonium inventory required for operating a given reactor and the decrease in neutron production. This increased inventory increases the interest charges on the fuel; thus, the costs of the plutonium enriched cycle are increased accordingly. The allowable price of the plutonium must be lowered in the plutonium enriched cycle to equalize the costs with the uranium enriched cycle.

It has been demonstrated that reduced UO_2 spatial concentration lowers the fuel cycle costs for plutonium enriched reactors with hard neutron spectra. This improved fuel cost at lower density may be due, in part, to the conservatism of the present model. A new physics model designed with less conservatism for hard neutron spectra would result in minimum fuel costs occurring at densities higher than those with the present model but still below the theoretical density of UO_2 for many cases.

Combined Cycles

Additional higher exposure cases needed in order to obtain minimized total fuel costs were run in MELEAGER codes for the following series:

Series	Compositions
1000	U-235 enriched UO_2
2000	U-233 enriched UO_2 tails
3000	Medium exposure Pu in UO_2 tails.

Careful analysis reveals that for some systems, minimized total fuel costs will not be attained at reasonable exposures. Therefore, the QUICK economics code will need modification so that fuel costs are printed for several technological exposure goals or limits. Thus, in a specific study with UO_2 one might define the minimized total fuel cost as that computed for exposures less than 50,000 MWD/T.

Plutonium Value Computations

A report describing a method of calculating plutonium values was issued. The report, "PUVE - A Computer Code for Calculating Plutonium Values," HW-71811, is the first in a series of formal reports describing work on fuel cycle analysis. The second report, "QUICK - A Simplified Fuel Cost Code," HW-71812, has been completed and is in the process of publication. "Fuel Cycle Analysis for Successive Plutonium Recycle - I. Results for Five Reactor Concepts," HW-72217, has been written and will be ready for distribution within a short time. The report on MINIMIZER code, HW-71813, has not been completed.

At the request of the Commission, a large number of supplemental plutonium value determinations are being processed and will be issued in Part II of MELEAGER CHAIN studies. A preliminary exploration of plutonium value in thorium is included in this series.

OTHER ACTIVITIES

Hazards Analysis

Findings of the Chemical Effluents Technology studies on volatilization of radionuclides from cerium-sodium sulphate indicate that Sr-90 release is of approximately equal radiological significance to Ce-144 release. The preliminary draft report "The Consequences of Accidental Releases During Shipment of Radioactive Cerium," HW-72163, was recalled for revision.

W. K. Woods
Manager,
Programming

WK Woods:jm

RADIATION PROTECTION OPERATION
REPORT FOR THE MONTH OF JANUARY 1962

A. ORGANIZATION AND PERSONNEL

Joyce W. Clay transferred from Construction Engineering and Utilities to the Environmental Studies and Evaluation Operation effective January 8. Rosa S. Hoffman resigned from the Company on January 12. Darlene P. Moore transferred from Chemical Research and Development to the Environmental Studies and Evaluation Operation effective January 22. Louella M. Robb was deactivated due to personal illness on January 23. The work force now totals 133.

B. ACTIVITIES

Occupational Exposure Experience

No new cases of plutonium deposition were confirmed by bioassay analyses during the month. The total number of plutonium deposition cases that have occurred at Hanford remains at 283 of which 205 are currently employed.

A CPD maintenance employee received a superficial puncture wound to his index finger while working in a hood at the 234-5 Building. Examination of the injury at the Whole Body Counter indicated about 7×10^{-4} μc of plutonium. After removal of a small speck of foreign material by an Industrial Physician, no contamination was detected.

The hands of a CPD technician were grossly contaminated with plutonium while attempting to remove the cork from a plutonium sample bottle at the 234-5 Building. The acidic nature of the plutonium nitrate solution made decontamination difficult. After four hours of decontamination effort with standard reagents and techniques, the contamination level was about 1000 d/m plutonium. Followup surveys the next day showed that no contamination remained on the skin. Followup bioassay samples were scheduled to determine the extent if any of absorption through the skin.

A survey of an IPD maintenance employee revealed skin contamination up to 20,000 c/m and nasal contamination up to 2000 c/m after working in the vertical rod enclosure at 105-F. Examination in the Whole Body Counter four hours after the incident indicated a body burden of about 0.5 μc Na^{24} (approximately 7 percent of the maximum permissible body burden for Na^{24}). A followup examination in the Whole Body Counter five days after the incident indicated the body burden had decreased to less than one percent of the permissible limit.

A pressure build-up in a storage vessel in the tank farm of the 321 Building forced about 600 gallons of uranyl nitrate solution through openings in the top of the tank. Uranium contamination was detected on piping, wall and the roof of the 321 Building and on several hundred square feet of ground nearby. Minor contamination was detected on the clothing of two firemen and the fire truck which responded to the incident. No significant personnel exposures resulted.

Autoradiographic evaluation of contaminated protective clothing showed that four employees could have received excessive radiation exposure to small skin areas. Dose estimates for the one IPD employee and three CPD employees involved ranged from 110 rads to the wrist of one employee to 4 rads to a small skin area on the midsection of another employee.

Typical radiation conditions encountered at the PRTR included: gamma radiation beams up to 50 r/hour and general radiation levels up to 0.1 r/hour during process tube inspection; momentary exposure rates up to 0.8 r/hour in the reactor hall during discharge of fuel elements; hand exposure rates up to 3.5 rads/hour and whole body dose rates up to 275 mr/hour during maintenance on the primary system check valves; dose rates up to 35 r/hour were measured through the service building basement wall during fuel element inspection in the storage basin. The maximum exposure to tritium as measured by Bioassay was 12.8 μc T/liter which corresponds to a crude dose of about 80 mrem in the following 28 days.

The discharge of irradiated fuel from the PRTR into the storage basin has caused the contamination level of the water to build up to about 7×10^{-6} μc Sr^{89}/cc. Sr^{90}, I^{131}, and Zr^{95} were found in trace quantities. It appears that the increase in storage basin activity is proportional to the discharge of fuel into the storage basin. The storage basin activity increases to a maximum following a discharge operation and decreases during the period when no fuel is discharged.

Three major pieces of equipment used in processing of personnel dosimeters failed during the New Year's holiday week end. A fourth piece of equipment that failed two weeks later is suspected of also being involved. These included the X-ray tube in the automatic badge processing machine, a sola transformer supplying the manual densitometers, the six volt power supply on the automatic densitometer, and a resistor in the electric relay on the automatic film processing equipment temperature control. An investigation is underway to determine the possible malfunction of the electrical distribution system outside the building.

Environmental Experience

Average fallout concentration at various localities in the Pacific Northwest ranged from 2.7 to 9.0 μμc/m^3 during January. This range is slightly less than last month but the average is higher than last month.

Measurements of P^{32} in whitefish caught between Ringold and Richland in January indicated that the 1961 seasonal maximum occurred in late November or early December 1961 and amounted to about 1.3×10^{-3} μc P^{32}/g. This concentration was less than half of the 1960 seasonal maximum. Including duck and goose heads received this month from various locations in Washington, Idaho, Oregon and California, the total this season is 3443. This completes the acquisition phase of this special water fowl study. The maximum concentration in 1550 samples radioassayed to date from Southeastern Washington hunters was 2.6×10^{-3} μc P^{32}/g. Other pertinent biological samples received this month include oysters, local meat and beef thyroids. Analytical results are to be reported separately.

Columbia River water radionuclides of HAPO origin averaged concentrations equivalent to < 2 percent of the MPC_w-GI. The 12-month calculated dose trend continues downward primarily due to effects of continued special reactor influent water treatment.

At the Hot Semi-Works special filter samples of the off-gas line from A cell process vessels were taken. Results indicated negligible particulate activity venting to the stack from this source. Still unexplained are emissions higher than presumed normal for current work activities, based on previous experience. Current emissions of Sr^{90} while abnormal are not of great concern being in the order of nanocuries per day.

Studies and Improvements

An aerial reconnaissance of the local environs was made to determine the minimum acceptable routine aerial monitoring effort. The flight, passing over several large bodies of water, also provided information on the datum level of the aircraft and instrumentation.

A third dye test to determine dispersion from PRTR aqueous effluents in the Columbia River was completed. The river flow during the test was low and represented adverse effluent dispersal conditions. Initial review of the data indicates that the local operating limits for orderly shutdown will probably be reduced by a factor of approximately ten.

The CPD Hazards Analysis work continued. A re-evaluation of the waste storage tank incident was made based upon the assumption that the supernatant layer is removed. The time required to remove this layer is critical. Rapid removal generates extremely high (i.e., > 10,000°F) temperature in the sludge. Such temperature would result in the release of very large quantities of long-lived radionuclides. However, it appears that the prompt loss assumption is valid only in the event of some major outside influence such as an earthquake or an act of war.

A hazards analysis of a Ce^{144} shipment was completed and a comment draft issued. Since these shipments were postponed, further work on this problem was deferred.

Stack monitoring equipment at Redox was repiped to provide separate collection of strip filter and I^{131} monitor data. Agreement of I^{131} results from the I^{131} monitor and the static scrubber is averaging within 20 percent.

The routine autoradiographing of particles on filters from air samples was discontinued. Studies indicated that this activity was no longer deemed necessary to the environmental monitoring program.

Columbia River water samples from Portland will hereafter be collected by, and forwarded to HAPO by, the U. S. Public Health Service. This will eliminate the need for bi-weekly trips to secure these samples.

Three extrapolation chambers were fabricated for use in measuring surface dose rates and dose at various tissue depths for plutonium metal. A dry box to provide facilities for making these extrapolation chamber measurements was designed and fabrication ordered from the Technical Shops. This study will yield data to compare with calculated plutonium surface dose rates and to provide an improved basis for calibration of the personnel film dosimeter and the finger ring dosimeter for plutonium metal exposures.

Construction prints for the new personnel film dosimeter were completed and fabrication of the dosimeter processing machine was begun in the Technical Shops. The alarm system, used to indicate that the X-ray tube on this machine is functioning properly, was altered to provide a clear signal to the operator when no current or very little current is applied to the tube head.

The K-fluorescent X-ray source was recalibrated with the free air ion chamber. A routine recalibration of this calibration source was established.

Several neutron irradiations of prototype solid state dosimeters were planned but only partially completed due to the operating difficulties with the positive ion accelerator and limited time available. Some apparent annealing of neutron damage was observed when the forward resistance of the irradiated diodes was measured promptly following irradiation. Annealing appears to take place within the first 30 minutes after irradiation.

The forward resistance of a 0.075 inch diode was measured on several successive days. The resistance values measured were within 0.2 percent of each other while the room temperature varies by about 1°C. These preliminary measurements indicate that an accurately controlled temperature environment may not be necessary for routine dose evaluation with these diodes. A brief survey was initiated to define other properties that might be useful for measurement of neutron dose.

A contract for 65 Scintrans at $617 each and 30 BF_3's at $294.45 each was awared on December 28, 1962. The vendor visited at the Hanford plant on Jaunary 2 and inspected the prototypes of these models.

C. VISITORS AND VISITS

The following visitors met with various members of the Radiation Protection Operation staff during the month:

E. G. Dunford)
H. G. Herring) - U. S. Forestry Service, Wenatchee, Washington

C. Henderson)
M. Lammering) - U. S. Public Health Service, Portland and Cincinnati
D. Hoffman)

H. M. Griffin - General Nuclear Corporation, Anaheim, California

D. Wagstaff - Oregon Board of Health, Salem, Oregon

D. Weeks - Nuclear Industries, Seattle, Washington

Members of the Radiation Protection Operation visiting off-site during the month included:

J. K. Soldat - AEC, Germantown, Maryland, to attend meeting on fallout.

R. D. Tillson - University of Washington and Seattle University, Seattle, Washington, technical recruiting.

A. R. Keene - Olympia, Washington, to attend conference on water pollution control.
- Washington, D.C., to attend NCRP Subcommittee 7 meeting.

D. RELATIONS

Ten suggestions were submitted by the personnel of the Radiation Protection Operation and one was re-opened during the month of January. One suggestion was adopted and four were rejected. Fifteen suggestions submitted by RPO personnel are pending evaluation.

Radiation protection orientation included lectures to: new employees; members of the Analytical Laboratories Operation and Coolant Systems Development; and firemen.

K. R. Heid presented a talk to the Richland Exchange Club on fallout and civil defense.

Safety meetings were held throughout the various components during the month. "Signal 30", a film of highway fatalities, was also shown.

E. SIGNIFICANT REPORTS

HW-69368 - "A Compilation of Basic Data Relating to the Columbia River - Sections 6 and 7", by J. K. Soldat.

HW-71710 - "Hanford Criticality Dosimeter", by P. E. Bramson.

HW-72337 - "Consequences of a Radiological Accident in Fuels Preparation Department", by G. E. Backman.

HW-72338 - "Summary of Radiological Data for the Month of December, 1961", by R. F. Foster.

HW-72543 - "Monthly Report - January 1962, Radiation Monitoring Operation", by A. J. Stevens.

"Review of Current Air Sample Collection and Evaluation Procedures", by J. M. Selby.

PERSONNEL DOSIMETRY AND RADIOLOGICAL RECORDS

External Exposure Above Permissible Limits	January	1962 to Date
Whole Body Penetrating	0	0
Whole Body Skin	0	0
Extremity	0	0
Hanford Pocket Dosimeters		
Dosimeters Processed	2,464	2,464
Paired Results - 100-280 mr	9	9
Paired Results - Over 280 mr	1	1
Lost Results	0	0
Hanford Beta-Gamma Film Badge Dosimeters		
Film Processed	9,721	9,721
Results - 100-300 mrads	866	866
Results - 300-500 mrads	94	94
Results - Over 500 mrads	36	36
Lost Results	20	20
Average Dose Per Film Packet - mrad (ow)	9.83	9.83
- mr (s)	15.67	15.67
Hanford Neutron Film Badge Dosimeters		
Slow Neutron		
Film Processed	2,112	2,112
Results - 50-100 mrem	0	0
Results - 100-300 mrem	0	0
Results - Over 300 mrem	0	0
Lost Results	10	10
Fast Neutron		
Film Processed	521	521
Results - 50-100 mrem	97	97
Results - 100-300 mrem	114	114
Results - Over 300 mrem	1	1
Lost Results	10	10
Hand Checks		
Checks Taken - Alpha	38,637	38,637
- Beta-Gamma	55,862	55,862
Skin Contamination		
Plutonium	3	3
Fission Products	72	72
Uranium	3	3
Tritium	0	0

Whole Body Counter	Male	Female	January	1962 to Date
GE Employees				
Routine	25	0	25	25
Special	4	0	4	4
Rechecks	3	0	3	3
Terminal	14	2	16	16
Non-routine	26	5	31	31
Non-employees	0	0	0	0
Pre-employment	0	0	0	0
	72	7	79	79

Bioassay

	January	1962 to Date
Confirmed Plutonium Deposition Cases	0	0*
Plutonium - Samples Assayed	469	469
- Results Above 2.2×10^{-8} μc Pu/Sample	20	20
Fission Products - Samples Assayed	573	573
- Results Above 3.1×10^{-5} μc FP/Sample	4	4
Uranium - Samples Assayed	169	169
Biological - Samples Assayed	22	22

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} μc U/cc			Following Period of No Exposure Units of 10^{-9} μc U/cc		
	Maximum	Average	Number Samples	Maximum	Average	Number Samples
Fuels Preparation	13.2	3.4	39	13.1	2.6	35
Fuels Preparation**	0	0	0	0	0	0
Hanford Laboratories	5.9	3.1	24	10.2	3.4	14
Hanford Laboratories**	0	0	0	0	0	0
Chemical Processing	91.6	7.7	29	8.8	3.8	25
Chemical Processing**	0	0	0	0	0	0
Special Incidents	3.2	3.2	1	0	0	0
Random	2.3	1.8	2	0	0	0

Tritium Samples	Maximum	Minimum	Count	January Total
Urine Samples				
Routine	4.9 μc/l	< 1.0 μc/l	228	
Samples Above 5.0 μc/l	12.8 μc/l	5.0 μc/l	86	
				314
D_2O Samples				
Moderator	529.0 μc/ml	290.5 μc/ml	6	
Primary	82.6 μc/ml	58.5 μc/ml	6	
Reflector	435.0 μc/ml	276.5 μc/ml	6	
				18
Water Samples	0.59 μc/ml		134	134
				466

* The total number of plutonium deposition cases which have occurred at Hanford is now 283, of which 205 are currently employed.
**Samples taken prior to and after a specific job during work week.

Calibrations	Number of Units Calibrated January	1962 to Date
Portable Instruments		
CP Meter	1,031	1,031
Juno	262	262
GM	554	554
Other	190	190
Audits	97	97
	2,134	2,134
Personnel Meters		
Badge Film	1,716	1,716
Pencils	4,780	4,780
Other	486	486
	6,982	6,982
Miscellaneous Special Services	322	322
Total Number of Calibrations	9,438	9,438

AR Keene

Manager
RADIATION PROTECTION

AR Keene:ljw

1250211

GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 3.54 for the month and 3.54 for the year-to-date.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 18,938 hours. This includes 13,759 hours performed in the Technical Shops, 3,824 hours assigned to Minor Construction, 142 hours to Other Project Shops, and 1,213 hours assigned to off-site vendors. Total shop backlog is 20,930 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 2.8 per cent (496 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	3,585	18.93%
Irradiation Processing Department	2,288	12.08%
Chemical Processing Department	409	2.16%
Hanford Laboratories Operation	12,656	66.83%
Construction Engineering & Utilities	Zero	Zero

Requests for emergency service decreased requiring a 2.8 per cent overtime ratio compared to a 3.8 per cent ratio for the previous period.

At the close of the reporting period, there were no open personnel requisitions.

Security performance was considered satisfactory with no violations. There were eight medical treatment injuries which is within the forecasted parameters established for this operation.

CONSTRUCTION OPERATION

There were 94 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $135,670. Ninety six new orders, five supplements and adjustments for underruns amounted to $9,850. Expenditures during the month on HLO work were $87,504. Total J. A. Jones backlog at month's end was $133,017.

Summary

	HL No.	HL Unexpended Balance	CE&U No.	CE&U Unexpended Balance
Orders outstanding beginning of month	93	$ 133,199	1	$ 2,471
Issued during the month (Inc.Sup.& Adj.)	96	84,851	-	--
J. A. Jones Expenditures during month (Inc. C.O. Costs)		87,504		
Balance at month's end	64	130,546	1	2,471
Orders closed during month	125	95,888*	-	--

Maintenance Work Orders active - 4 Face Value - $8,700.

* Face Value of Orders Closed

Project CAH-902 - 303-L Building - Uranium Scrap Burner Facility - Final punch list items have been established and the necessary design change and supplement to J. A. Jones has been approved by the AEC. These six items should be complete by 2-14-62.

Project CGH-924 - 306 Building - 200-KW Induction Heating Stations - All materials are here for the added station and the electricians will start work on it about 2-12-62. This station will complete the work on this project.

Project CGH-937 - 231-Z Building - Safety Improvements - All duct work will be complete 2-9-62. Start-up of the second exhaust fan is scheduled for 2-8-62. This project should be complete by 2-15-62.

100 Areas

141-C - Build Entrance Enclosure - All material is on hand and work started 2-6-62.

141-H - Build Concrete Block Wall Enclosure - The old fence has been removed and concrete block walls are installed. The new ceiling is complete. The new light fixtures are due to arrive next week.

141-C - Build Concrete Pads and Install Feeding Stations - Electric fence modifications are complete. Concrete pads were poured 2-2-62. Fence panels are being installed.

1706-KE - Install Water Supply to Fish Tanks - Job is complete.

200 Areas

Remove Equipment from 234-5 Building and Install in 231-Z - Painting will be complete this week and this job will be closed out.

Install Arc Melt Hood and Furnace - Job is complete.

300 Area

Install Special Alloy Storage Facility and Racks - 306 Building - We are waiting delivery of the metal doors. All other work is complete.

Install Exhaust System in Arc Melt Room - 306 Building - Job is complete.

Install Continuous Sampler Facility - 307 Building - The lump sum sub-contractor to J. A. Jones has completed the concrete block work. Roofing and electrical work has started.

Modify Blue Change Room - 309 Building - All work is complete except some touch-up painting.

Install Office Partitions in Rooms # 1,101,103,105,111 & 112 - 309 Building Job is complete.

Install Shielding Wall - 309 Building - This work is being lump sum sub-contracted.

Move Dynapack from 306 Building and Install in Basement of 325 Building The 4" concrete block wall is complete and accepted from the lump sum sub-contractor. We are waiting delivery of tempered glass for windows and metal doors.

Install Office and Foyer Partitions - 325 Building - The office partitions is complete. The janitor closet is 50% relocated. Pipefitters are relocating the sink.

FACILITIES ENGINEERING OPERATION

Project Activity

At month's end Facilities Engineering Operation was responsible for 11 projects having total authorized funds in the amount of $2,698,600. The total estimated cost of these projects is expected to be $7,512,000. Expenditures on these projects through December 31, 1961 were $707,000.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end	11
Number of new projects authorized in January CGH-951 - A-C Column Facility - 321 Building	1
Projects completed in January CAH-921 - Geological & Hydrological Wells FY 1961	1
New project proposals submitted to AEC in January	0

New projects awaiting AEC approval 2
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
Graphite Shop Addition - 300 Area
Second Floor Modifications - 308 Building

Engineering Services

Title	Status
Pressure Vessel and Piping Systems - Engineering & Inspection Service	Vessels in 308, 231-Z, 222-U and 292-U were inspected during the month. Also work continued on the Rupture Loop in 3 09 Building towards [redacted] static test.
"Split-Half" Machine for Critical Mass Studies	Fabrication is continuing and material is being ordered.
Room Air Conditioner - Room 27-A 326 Building	Work completed.
Salt Bath Furnace Alarms - 306 Bldg.	Field work has progressed so that the large furnace could be successfully operated.
Ceramic Fuels Space - 325 Bldg. Basement	An electrical power distribution plan was developed for future

Title	Status
Laboratory Addition - 321 Building	Plans are being developed and estimates obtained for additional laboratory space in 321 Building.

Drafting and Design Services

The work load in the 3706 Building drafting room and in 327, 306, 308 and 1707-D Buildings is steady with a minor amount of overtime required.

The equivalent of 140 design drawings were completed this month as compared to 126 last month.

Major design and drafting work in progress during the month includes the following:

1. Shim Rod Drive Mechanism - PRTR - 7 scope drawings completed.
2. Hood for Furnace - 5 drawings required - 80% complete.
3. TF-23 Test Loop - 10 drawings required - 75% complete.
4. Transistorized Scintillation Monitor - 6 drawings - work complete.
5. Relocation of 280 Ton Pressure - 12 drawings required - 75% complete.
6. Welding Equipment for 8 foot Element - 12 drawings required - 80% complete.

In addition to the above, several design jobs of one to two sheet magnitude were completed during the month.

Plant Maintenance Operation

Total costs for December were $179,704. Fiscal year to date expenditures are 100.3% of forecast.

Analysis of Costs

At the midpoint of the year, the expenditures exceeded the forecast by $10,000, or 0.3%. Maintenance cost continues below the anticipated level, utilities charges are clost to predicitions, but the costs of janitor and operators exceed the forecast by 5% and 10%, respectively.

Analysis of Improvement Maintenance

Item	December
Relocation and Alteration	$ 8,092
Repainting	1,602
Heat & Vent Modifications	6,745
Electrical Modifications	174
Piping Modifications	28
	$16,641

Significant Activities

1. Painting continued inside 231-Z Building.
2. The floor of the basement corridor in 326 Building was tiled.
3. An order was issued to install refrigerated air conditioning in the ceramic laboratories in the basement of 325 Building.
4. The contractor is preparing the site for the TC-1 relocation. The entire job is about 15% complete.
5. An order was issued to modify office 109, and erect a sound barrier in the corridor leading to the outer conference room, in 325 Building.
6. An order was issued to partition the control room in 309 Building.
7. An order was issued to provide an additional sump pump in the basement of 325 Building to reduce the likelihood of floods.
8. An order was issued to replace a corroded stainless steel filter box with one of PVC under hood #5, Room 309, in 325 Building.
9. Work is progressing with the installation of insulated trolley conductors on the monorail in Room 16A, 326 Building.
10. Two of the air conditioning units in 326 Building have been sandblasted and repainted.
11. Additional lighting was provided in Rooms 2, 2A and 10 in 3702 Building.

Waste Disposal and Decontamination Service

Quantities of Waste Removed

	December	November
Concrete Barrels	12	23
Loadluggers-Hot Waste	4	4
Milk Pails	22	41
Gattling Gun	3	1
Crib Waste	260,000 gal.	400,000 gal.

The amount of crib waste remained at about the average level for CY 1961.

The new 300 North Area disposal garden has been completed, and will be put into service by mid February.

The design of the new equipment for the decontamination facility in 325 Building is almost complete.

The analysis of retention basin #1 sample taken at 12:30 pm, 1-16-62, showed a concentration of 6.03×10^{-6} $\mu c/ml$. of total beta activity. This was six times the allowable limit. A resample showed 1.58×10^{-6}. The basin was released and subsequent analysis confirmed the total strontium at less than 1.47×10^{-7} $\mu c/ml$.

The waste disposal and decontamination facility went on a work order basis this month, to provide better cost control. At the same time, T. W. Thomas was assigned to work about 80% of his time in this operation. This additional manpower will broaden the group's capacity to handle special work.

1250217

Plant Engineering and Miscellaneous

Approximately 24,000 square feet of prints were reproduced during the month.

The total estimated value of the sixteen requisitions issued during the month was $35,000. This procurement is primarily for approved HL projects.

Plans are being prepared to improve heating and cooling system in 3707-C Building.

Metal doors are being installed in 325 Building laboratories presently having gates.

Engineering work is nearly complete on Budget Studies.

A temperature-humidity recorder for recording conditions at 4 of 8 stations simultaneously is being designed for installation in 144-F Building.

Central criticality annuciation - The 16 pair telephone cable between 3506-A and 3706 is installed as is the telephone cabinet in 3706. Plant telephone will tie-in all buildings to be annuciated when conduit runs to boxes have been completed. Work in the 306 Building is complete, underway in 308 and 309, and will be in 325 and 326 after February 1. The annuciator has been shipped from the factory.

Fire alarm and civil defense standardization - Thirteen of 17 HLO buildings have been completed to date on this program. One electrician is working full time to completion.

A design of lighting and heating was completed for two proposed rest rooms and an office in the 3718 Equipment Storage Facility. Elementary control diagrams and equipment layout was completed for the proposed 340 storage basin motorized valves. The installation is to automatically control the influent valves and automatically close the effluent valves. Floatless liquid level controls, stepping switch, and auxiliary relays are proposed. Drafting is preparing a drawing at the present.

JL Boyd
Manager
Laboratory Auxiliaries

JL Boyd:ml

1250218

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CAH-822	Pressurized Gas Cooled Facility	4141 Operat

AUTHORIZED FUNDS			COST & COMM. TO 1-14-62	ESTIMATED TOTAL COST
$ 1,120,000	DESIGN $ 43,000 CONST. $1,077,000	AEC $ 0 GE $ 1,120,000	$ 1,103,447	$ 1,170,000

STARTING DATES	DATE AUTHORIZED	EST'D. COMPL. DATES
DESIGN 8-19-59 CONST. 10-17-60	2-3-61 DIR. COMP. DATE 9-30-61	DESIGN 4-29-60 CONST. 5-1-62

ENGINEER: TR&AO-MEEO - 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.	ACT
DESIGN	100	100	10
TITLE I	100	100	10
GE-TIT. II			
AE-TIT. II			
CONST.	100	100	9
PF			
CPFF	17	100	9
FP	7	100	1[illegible]
Govt.Eq.	76	100	9

SCOPE, PURPOSE, STATUS & PROGRESS

*A project proposal revision has been submitted which requests an increase of authori funds of $50,000 and extension of the project completion date to 6-30-62. A revised schedule will be issued when the project revision is approved.

Construction forces have completed installation of the in-reactor test section prototype in "B" cell.

Bristol-Siddeley reports a successful run of one blower at design point speed and density but at ambient temperature; high temperature runs are scheduled for February

PROJ. NO.	TITLE	FUNDING
CAH-842	Critical Reactivity Measuring Facility	58-e-15

AUTHORIZED FUNDS			COST & COMM. TO 1-14-62	ESTIMATED TOTAL COST
$ 400,000	DESIGN $ 45,000 CONST. $ 355,000	AEC $ GE $	$ 180,169 (G	$ 400,000

STARTING DATES	DATE AUTHORIZED	EST'D. COMPL. DATES
DESIGN 11-17-59 CONST. 10-3-60	DIR. COMP. DATE 3-15-62	DESIGN 2-1-61 CONST. 3-15-62

ENGINEER: TR&AO-MEEO - 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.	ACT
DESIGN	100	100	1[illegible]
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	93	[illegible]
PF			
CPFF	60	88	[illegible]
FP	40	100	1[illegible]

SCOPE, PURPOSE, STATUS & PROGRESS

The revised project proposal requesting additional funds and an extension of the scheduled completion date has been approved by the AEC. A tentative schedule has been prepared which reflects the changes in percent complete.

CPFF percentages includes Government Furnished equipment. Authorization to spend the funds required for the additional work were received by the CPFF field forces the week of January 7.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-72590

DATE 1-31-62

PROJ. NO. CGH-857	TITLE Physical & Mechanical Properties Testing Cell - 327 Bldg.		FUNDING 0290
AUTHORIZED FUNDS $ 460,000	DESIGN $ 45,000 / CONST. $ 415,000	AEC $ - / GE $ 460,000	COST & COMM. TO 1-14-62 $ 90,226 / ESTIMATED TOTAL COST $ 460,000
STARTING DATES	DESIGN 11-2-59 / CONST. 5-15-62	DATE AUTHORIZED 9-22-61 / DIR. COMP. DATE 12-15-62	EST'D. COMPL. DATES: DESIGN 3-15-61 / CONST. 12-15-62

ENGINEER: FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	2	740
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 resistivity furnace envisioned for the project has been cancelled because of development problems encountered. These measurements will be taken with existing equipment in so far as practicable.

New bids have been received for the cell assembly with a quoted delivery of 17 weeks after receipt of order. The apparent low bidder was $6,000 below estimate.

PROJ. NO. CGH-858	TITLE High Level Utility Cell - 327 Building		FUNDING 0290
AUTHORIZED FUNDS $ 400,000	DESIGN $ 50,000 / CONST. $ 350,000	AEC $ / GE $ 400,000	COST & COMM. TO 1-14-62 $ 343,777 / ESTIMATED TOTAL COST $ 400,000
STARTING DATES	DESIGN 11-1-59 / CONST. 5-15-61	DATE AUTHORIZED 4-6-61 / DIR. COMP. DATE 2-28-62	EST'D. COMPL. DATES: DESIGN 2-15-61 / CONST. 3-31-62

ENGINEER: FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	4	220
PLANT FORCES		
ARCHITECT - ENGINEER		35
DESIGN ENGINEERING OPERATION		930
GE FIELD ENGINEERING	1	22

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	78	34
PF			
CPFF	100	78	34
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.

Cell assembly delivery on site still appears possible by February 5th.

Difficulty was encountered because of north cell door being 1" shorter than intended. Modification should not delay delivery beyond the above date.

Installation of electrical conduit and piping is continuing.

1250220

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-72590

DATE 1-31-62

PROJ. NO. CAH-866	TITLE Shielded Analytical Laboratory - 325-B Building	FUNDING 61-a-1

AUTHORIZED FUNDS $ 700,000	DESIGN $ 60,000 / CONST. $ 640,000	AEC $ 546,500 / GE $ 153,500	COST & COMM. TO 1-14-62 $ 99,200 (GE) / ESTIMATED TOTAL COST $ 700,000

STARTING DATES	DESIGN 9-5-59 / CONST. 6-28-61	DATE AUTHORIZED 5-31-60 / DIR. COMP. DATE 6-30-62	EST'D. COMPL. DATES: DESIGN 11-14-60 / CONST. 6-30-62

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	8	1116
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	32*	26
PF	3	1	1
CPFF	2	0	0
FP	95	63**	25

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.

Half of the siding was erected and the subcontractor quit because of the cold weather.

The sheet metal subcontractor has nearly completed his fabrication. The painting subcontractor will be called back to finish the painting.

S&E Contractors, Inc. had a representative in L&F Machine Company's shop checking on production and delivery status of cell materials that are holding up job progress. Shipping dates have been moved back from December 15, 1961 to February 19th for cell castings and March 2nd for concrete wall embedded items.

The electrical subcontractor has resumed work in the basement.

*Official project construction schedule.

**Contractor's construction schedule does not reflect actual conditions.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CAH-867	Fuel Element Rupture Test Loop	58-e-15

AUTHORIZED FUNDS			COST & COMM. TO 12-31-61	ESTIMATED TOTAL COST
$ 1,500,000	DESIGN $ 130,000 / CONST. $ 1,370,000	AEC $ 770,000 / GE $ 730,000	$ 518,266 (GE	$ 1,500,000

STARTING DATES	DATE AUTHORIZED	EST'D. COMPL. DATES
DESIGN 8-1-60 / CONST. 11-2-60	DIR. COMP. DATE 6-30-62	DESIGN 3-15-61 / CONST 6-30-62

ENGINEER: TR&AO-MEEO - PC Walkup

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	20	1640
COST PLUS FIXED FEE	11	1703
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	100	100
TITLE I			
GE-TIT. II	91	100	100
AE-TIT. II	9	100	100
CONST.	100	84	75
PF	2	100	20
CPFF	57	100	92
FP (1)	10	100	100
(2)	31	50	39

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Company
(2) Lewis Hopkins Construction Company

This facility is to be used for fuel rupture behavior studies with respect to physical distortion and rate of fission product release.

Project is behind official schedule because the FP contractors' schedule is not consistent with the official schedule and because of delays in delivery of material being procured by J. A. Jones Construction Company.

PROJ. NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-h-1

AUTHORIZED FUNDS			COST & COMM. TO 12-31-61	ESTIMATED TOTAL COST
$ 420,000	DESIGN $ 44,000 / CONST. $ 376,000	AEC $ 400,000 / GE $ 20,000	$ 397,000	$ 420,000

STARTING DATES	DATE AUTHORIZED	EST'D. COMPL. DATES
DESIGN 8-8-60 / CONST. 7-10-61	9-2-60 / DIR. COMP. DATE 3-31-62	DESIGN 3-31-61 / CONST. 6-15-62

ENGINEER: FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	18	1760
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	NS	100
TITLE I			
GE-TIT. II	17	NS	100
AE-TIT. II	83	NS	100
CONST.	100	94	61
PF	1	60	60
CPFF			
FP	99	93	60

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides additional space for biological research supporting services, and involves an addition to the 108-F Building.

Roof over main building has been completed.

New transformers were installed on January 13, 1962. Most major pieces of heating and ventilating equipment have been received. Number 1 and 2 washer sections were installed on pads. All partition and drop ceiling framework has been completed and gypsom board is being installed on first floor. Conduit is complete on first floor and well advanced on second floor. Duct work on first and second floor has been installed. Most of the plumbing is complete. Allied Engineering has changed their shipping date of the Handling Facility to March 15, 1962.

1250222

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-72593

DATE 1-31-62

PROJ. NO. CAH-916	TITLE Fuels Recycle Pilot Plant		FUNDING 4-62-d-3
AUTHORIZED FUNDS $ 385,000	DESIGN $ 385,000 / CONST. $ -0-	AEC $ / GE $ 385,000	COST & COMM. TO 1-14-62 $ 321,952 / ESTIMATED TOTAL COST $ 5,000,000
STARTING DATES DESIGN 3-1-61 / CONST. 9-1-62	DATE AUTHORIZED 10-27-61 / DIR. COMP. DATE --	EST'D. COMPL. DATES DESIGN 6-15-62 / CONST. 7-1-64	

ENGINEER: FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	23	
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	46	42
TITLE I	11	100	100
GE-TIT. II	89	40	35
AE-TIT. II			
CONST.	100	NS	
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

Design has fallen behind schedule in spite of the Design Operation working overtime.

The AEC was notified that design is proceeding on a chilled air ventilation system in the administrative area of FRPP as the result of a study made by CE&UO. Copies of this study and the back-up calculation were furnished to AEC.

Approximately 22 drawings were issued for comment this month for a total of 86 for comment and two for approval.

PROJ. NO. CAH-917	TITLE Field Service Center - Atmospheric Physics		FUNDING 61-j
AUTHORIZED FUNDS $	DESIGN $ / CONST. $	AEC $ / GE $	COST & COMM. TO $ / ESTIMATED TOTAL COST $ 154,000
STARTING DATES DESIGN 4-15-62* / CONST. 10-1-62*	DATE AUTHORIZED / DIR. COMP. DATE	EST'D. COMPL. DATES DESIGN 8-15-62* / CONST. 6-15-63*	

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 3-15-62.

The project proposal was submitted to the AEC on January 23, 1961.

There has been no change in the status of this project for some time.

1250223

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CAH-921	Geological & Hydrological Wells - FY 1961	61-j

AUTHORIZED FUNDS			
$ 79,000	DESIGN $ 1,000	AEC $ 69,500	COST & COMM. TO 12-31-61 $ 65,799
	CONST. $ 78,000	GE $ 9,500	ESTIMATED TOTAL COST $ 79,000

STARTING DATES			EST'D. COMPL. DATES
DESIGN 4-15-61	DATE AUTHORIZED 3-24-61		DESIGN 5-15-61
CONST. 5-22-61	DIR. COMP. DATE 2-5-62		CONST. 1-24-62

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	2	1032
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	100
PF	0		
CPFF	3	100	100
FP	97	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

All construction work including modification #3 was completed 1-24-62. The Physical Completion Notice is being prepared.

PROJ. NO.	TITLE	FUNDING

AUTHORIZED FUNDS			
$	DESIGN $	AEC $	COST & COMM. TO $
	CONST. $	GE $	ESTIMATED TOTAL COST $

STARTING DATES		EST'D. COMPL. DATES
DESIGN	DATE AUTHORIZED	DESIGN
CONST.	DIR. COMP. DATE	CONST.

ENGINEER

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

1250224

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CAE-922	Burst Test Facility for Irradiated Zirconium Tubes	62-k

AUTHORIZED FUNDS			
$ 29,600	DESIGN $ 29,600	AEC $	COST & COMM. TO 1-14-62 $ 29,600
	CONST. $	GE $ 29,600	ESTIMATED TOTAL COST $ 228,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	11-7-61	DATE AUTHORIZED 10-23-61	DESIGN	5-15-62
CONST.	6-15-62	DIR. COMP. DATE	CONST.	12-1-62

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER	1	50
DESIGN ENGINEERING OPERATION	1	50
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	13	15
TITLE I			
GE-TIT. II	38.5	2	2
AE-TIT. II	61.5	20	23
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to permit deliberate destructive testing of irradiated zirconium tubing. This will provide operating and tube life data not now available because of the limited operating history of Zircaloy-2 pressure tubing in reactors.

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.

General Electric portion of design started 12-12-61.

Design progress has been curtailed, pending approval of the Design Criteria by the Commission.

1250225

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CAH-924	200-KW Induction Heating System - 306 Building	0290

AUTHORIZED FUNDS			COST & COMM. TO 1-14-62	
$ 31,000	DESIGN $ 3,200	AEC $ 24,650	COST & COMM. TO 1-14-62	$ 4,983 (GE)
	CONST. $ 27,800	GE $ 6,350	ESTIMATED TOTAL COST	$ 31,000

STARTING DATES			EST'D. COMPL. DATES
DESIGN 5-1-61	DATE AUTHORIZED 3-27-61		DESIGN 10-15-61
CONST. 12-4-61	DIR. COMP. DATE 2-28-62		CONST. 2-28-62

ENGINEER

FEO - LF Higginson

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		72
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		38
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	100
TITLE I			
GE-TIT. II		NS	100
AE-TIT. II			
CONST.	100	80	80
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a source of power for induction heating for R&D work in the 306 Building.

Installation of the power distribution system and remote switching stations is progressing on schedule.

Per cent actual completion unchanged from previous report because the sixth remote switching station previously deleted from the project is now to be installed in another location.

PROJ. NO.	TITLE	FUNDING
CAH-927	Additions to the 271-CR Building Waste Treatment Demonstration Facility	61-j

AUTHORIZED FUNDS			COST & COMM. TO 1-14-62	
$ 80,000	DESIGN $ 11,000	AEC $ 64,300	COST & COMM. TO 1-14-62	$ 14,697 (GE)
	CONST. $ 69,000	GE $ 15,700	ESTIMATED TOTAL COST	$ 80,000

STARTING DATES			EST'D. COMPL. DATES
DESIGN 6-15-61	DATE AUTHORIZED 5-16-61		DESIGN 2-29-62
CONST. 3-29-62	DIR. COMP. DATE 6-30-62		CONST. 7-1-62

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER - Bovay Engineers		141
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	93	93
TITLE I			
GE-TIT. II			
AE-TIT. II	100	93	93
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.

Plans for procurement of long delivery items are proceeding.

A meeting between AEC, GE and the J. A. Jones Company representatives was held 1-26-62 to plan the project construction phase.

1250226

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CAH-932	300 Area Retention Waste System Expansion	62-k

AUTHORIZED FUNDS			COST & COMM TO	
$	DESIGN $	AEC $		$
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 70,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	4-1-62*	DATE AUTHORIZED	DESIGN	5-15-62*
CONST.	7-15-62*	DIR. COMP. DATE	CONST.	11-15-62*

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will increase the basin capacity commensurate with the increased volumes handled. This will permit transfer to crib waste of contaminated waste if required and still permit adequate sampling time for the normal flow.

The project proposal was submitted to HOO-AEC for authorization on 5-5-61.

The proposal was returned unapproved on September 12, 1961, with a letter suggesting alternate solutions. These were reviewed for feasibility and practicability. The project proposal was returned to the Commission for further review and approval; it was reviewed at the Review Board Meeting January 4, 1962 and deferred for further study. The next Review Board Meeting is scheduled for February 1, 1962.

*Based on AEC authorization by 3-1-62.

1250221

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CAH-936	Coolant Systems Development Laboratory	62-k

AUTHORIZED FUNDS			COST & COMM. TO 1-14-62	ESTIMATED TOTAL COST
$ 93,000	DESIGN $ 12,000 / CONST. $ 81,000	AEC $ 78,000 / GE $ 15,000	$ 14,486	$ 93,000

STARTING DATES	DATE AUTHORIZED	EST'D. COMPL. DATES
DESIGN 9-8-61	8-9-61	DESIGN 1-1-62
CONST. 4-9-62	DIR. COMP. DATE 10-31-62	CONST. 10-31-62

ENGINEER: FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER - Bovay Engineers		166
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	100	100
TITLE I			
GE-TIT. II			
AE-TIT. II	100	100	100
CONST.	100	NS	NS
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides facilities for the conduct of corrosion and decontamination studies for nuclear reactor coolant systems, by the addition of 2,700 sq. ft. laboratory facility on the west side of the 1706-KE Building.

A request for contract services has been prepared for submission to the HOO-AEC.

PROJ. NO.	TITLE	FUNDING
CGH-937	Safety Improvements to 231-Z Building	61-j

AUTHORIZED FUNDS			COST & COMM. TO 1-14-62	ESTIMATED TOTAL COST
$ 45,000	DESIGN $ 5,500 / CONST. $ 39,500	AEC $ / GE $ 45,000	$ 44,220	$ 45,000

STARTING DATES	DATE AUTHORIZED	EST'D. COMPL. DATES
DESIGN 7-12-61	6-29-61	DESIGN 9-29-61
CONST. 7-10-61	DIR. COMP. DATE 5-15-62	CONST. 2-20-62

ENGINEER: FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	6	450
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	NS	100
TITLE I			
GE-TIT. II		NS	100
AE-TIT. II			
CONST.	100	100	95
PF			
CPFF	100	100	95
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides supplemental ventilation and installation of a fire detection system in the 231-Z Building.

Fire detection system is complete except testing.

The two exhaust fans have been installed. The duct work is about 90% complete. The roof ventilators will be removed when weather permits the patching of the roof.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-72590

DATE 1-31-62

PROJ. NO.	TITLE	FUNDING
CGE-951	A-C Column Facility - 321 Building	0290

AUTHORIZED FUNDS			COST & COMM. TO 1-31-62
$ 55,000	DESIGN $ 5,000	AEC $ -0-	$ -0-
	CONST. $ 50,000	GE $ 55,000	ESTIMATED TOTAL COST $ 55,000

STARTING DATES			EST'D. COMPL. DATES
DESIGN 1-30-62	DATE AUTHORIZED 1-12-62		DESIGN 4-1-62
CONST. 3-15-62	DIR. COMP. DATE 10-31-62		CONST. 10-31-62

ENGINEER

FEO - E. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a closely integrated "A" column in series with the relocated "C" column to permit the development of a mathematical model for the mass transfer of uranium, as well as the exploration of the possibilities of computer optimization of a combined "A-C" extraction battery.

Directive HW-55 dated 1-12-62 authorized work on this project. A design W. O. has been issued and work is in progress.

PROJ. NO.	TITLE	FUNDING

AUTHORIZED FUNDS			COST & COMM. TO
$	DESIGN $	AEC $	$
	CONST. $	GE $	ESTIMATED TOTAL COST $

STARTING DATES			EST'D. COMPL. DATES
DESIGN	DATE AUTHORIZED		DESIGN
CONST.	DIR. COMP. DATE		CONST.

ENGINEER

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

TECHNICAL ADMINISTRATION OPERATION

MONTHLY REPORT

EMPLOYEE RELATIONS

Twenty-eight non-exempt employment requisitions were filled during January with eleven remaining to be filled.

Thirteen participants completed the Creative Approach Seminar.

PROFESSIONAL PLACEMENT

Advanced Degree - Nine Ph.D. applicants visited HAPO for employment interviews. Four offers were extended; one acceptance and three rejections were received. Current open offers total four.

BS/MS - Three program offers and two direct placement offers were extended; one program offer was accepted. Offers open total six. Eleven schools were visited for recruiting purposes.

Technical Graduate Program - Eight Technical Graduates were placed on permanent assignment, one E&SP member transferred to the Industry Control Department and one Technical Graduate terminated. Current program members total sixty-three.

TECHNICAL INFORMATION

The backlog of technical reports was reduced to eight from last month's total of thirty-one.

O E Boston

O. E. Boston, Manager
Technical Administration

FINANCIAL OPERATION MONTHLY REPORT
JANUARY 1962

GENERAL ACCOUNTING OPERATION

Travel activity is still running below the level of the past two fiscal years as shown below:

Trips Started - Year to Date	
FY 1960	700
FY 1961	727
FY 1962	626

Following is a summary of the status of letters or agreements covering specific actions requiring AEC concurrence:

No.	Title	Status
AT-52	Expanded Use of Whole Body Counter	Still pending
AT-104	Fission Products Dispersal Handbook	Still in AEC hands
AT-105	Symposium on the Biology of Transuranic Elements	Approved February 6, 1962
AT-198	Miniature Swine for Hammer-smith Hospital	In process
AT-205	Sanitary Engineering Advisory Committee-Washington State University	In process
AT-212	Delay in Disposition of Residence of Transferred Employee	Approved December 21, 1961
AT-215	Delay in Disposition of Residence of Transferred Employee	Approved January 11, 1962
AT-220	Delay in Disposition of Residence of Transferred Employee	In process
AT-222	Delay in Disposition of Residence of Transferred Employee	In process

An Assistance to Hanford authorization was issued to the General Engineering Labs covering analysis of tubing by the electron probe technique.

The following OPGs were revised during January:

22.3.1	Approval Authorizations
3.1.11	Benefits for Employees Entering and Re-Employment of Veterans Leaving the Armed Forces
3.4.16	Continuity of Service and Leaves of Absence
3.4.14	Removal from Payroll

One contract, SA-196 with the Franklin County Public Utility District, was processed during the month.

A substantial increase in Forms Control activity was noted. This increase was primarily attributable to changes in printing requirements and reorganizations.

Forty-four revisions to the AEC Manual were received. A summary of these revisions is covered in a separate report to the Section Managers.

During calendar year 1961 eight suggestions were submitted by eligible financial employees. All suggestions were from General Accounting personnel who represent 62.5% of those eligible under the suggestion system.

A comparison of calendar years 1960 and 1961 for Finance is shown below:

	1960	1961
Suggestions Received	3	8
Rejected	2	6
Adopted	0	3
Amount of Awards	0	$45
Tangible Savings	0	$190

Suggestions adopted included two safety suggestions and one procedural change.

Hanford Laboratories' investment in Plant and Equipment at December 31, 1961, totaled $65.9 million, reflecting a net increase for CY 1961 of $10.7 million.

During the month $48,888 of equipment was transferred to classified plant account from Equipment Work in Progress and $17,467 from Construction Work in Progress.

Considerable effort is being spent in assisting Contract and Accounting Operation in the preparation of a revised HAPO Movable Property Catalog. Upon completion of the revision the new catalog will be issued by Contract and Accounting Operation.

The physical inventory of movable catalogued equipment in the custody of Chemical Research and Development Operation is progressing on schedule. The inventory count started on January 8, 1962, and will continue through February 1962.

A report of results was issued for the quarterly inventory of Other Special Materials in custody of 95 HLO material holders as of December 31, 1961. The inventory revealed a net shortage of $172.37 due primarily to a shortage of 66 grams of platinum.

The shortage was traced back to the September 30, 1961 inventory where the material was inventoried in the count of two different holders. The books have been adjusted to compensate for these differences.

An audit of blank One Trip Property Passes in the possession of 60 Hanford Laboratories' authorized holders was made during the month. All passes were accounted for except for nine missing passes of which five had been issued to individuals, surrendered at a check point and apparently misplaced by Security. In our opinion the holders' pass accountability was satisfactory.

Nuclear Materials Operation advised us that the USAEC had entered into a contract with the Stanford Research Institute for a review of practices and procedures in Nuclear Materials Management. In connection with this review Hanford Laboratories was requested to provide information as to the numbers of employees devoting time to NMM functions and to describe their duties. Upon receipt of the requested information from the field, a report will be completed for Hanford Laboratories and submitted to Nuclear Materials Operation.

At the request of Nuclear Materials Operation a call letter was issued to the field for a special ten-year SS Material forecast covering plutonium, enriched uranium and U-233 in connection with the 04 Program. Upon receipt of the requested information, a report will be prepared and submitted to Nuclear Materials Operation.

The Hanford Laboratories' SS Material balance at December 31, 1961 totaled $20.9 million, indicating a net reduction for the month of $.4 million. This reduction can be summarized as follows:

(Amounts in Thousands)

Receipt from Off-Site	$ 24
Transfer to Other Departments	(210)
Material Consumed in Research	(258)
	$ (444)

Total HAPO Consumed in Research at December 31, 1961 is $1.3 million of which $1 million is applicable to Hanford Laboratories and $.3 million to Fuels Preparation Department.

Heavy Water losses chargeable to operating cost for the month of January amounted to $18,463 representing $3,319 scrap material and $15,144 BPID loss. At January 31, 1962, accumulated scrap for return to Savannah River totaled 17,172.49 lbs. valued at $209,200.81.

Fifty-six items valued at $96,865 were received at the Laboratory Equipment and Material Pool during the month of January. Thirty-three items valued at $10,418 were loaned or transferred in lieu of placement of requisitions, two items valued at $355 were temporarily withdrawn by custodians and ten items valued at $4,513 were withdrawn permanently by custodians. There are currently 957 equipment items valued at $501,296 physically located in the storage pool of which 32 items valued at $54,198 are held for the convenience of others. Reactor and Other Special Materials on hand at the pool at month end totaled $207,258 and materials held for the convenience of others totaled $173,152.

Action as indicated occurred on the following projects during the month:

New Money Authorized HLO

CAH-867 Fuel Element Rupture Test Facility	$(50 000) -1)
CGH-951 A-C Column Facility	55 000

Physical Completion Notices Issued

CAH-681 Hanford Equipment in the ETR
CAH-896* Stress Rupture Testing Facility

* AEM Services Only

Construction Completion and Cost Closing Statements Issued

CAH-681 Hanford Equipment in the ETR
CAH-919* Air Conditioning 314 Building

* AEM Services Only

(1- HOO-AEC reduced General Electric Company contingency funds by $50,000 and gave to CPFF Service Contractor to complete construction. Contractor's original estimate was $18,000 under project proposal estimate, other additional costs resulted from Design changes $18,000, SWP Conditions and Gas Activity $11,000.

COST ACCOUNTING OPERATION

During January, one exempt employee, W. R. Portch, was transferred to the Cost Accounting Operation from the Research Administration function. J. G. Plese, a Business Training Recruit, was transferred to Construction Engineering and Utilities Operation and D. H. Johnston, a Business Training Recruit, was transferred from the Irradiation Processing Department to the Cost Accounting Operation.

Financial data concerning Hanford Laboratories' requirements for the remainder of FY 1962 on programs sponsored by the Division of Reactor Development were prepared for review by DRD representatives at Hanford on January 3, 1962. Also prepared in cooperation with the HLO research components were preliminary budget assumptions, proposed program levels and associated dollar requirements for fiscal years 1963 through 1967 for current and proposed DRD programs. These assumptions were submitted to HOO-AEC on January 12, 1962.

Preparation of the Budget for FY 1964 and Revision of Budget for FY 1963 has been initiated. Personnel requirements were received from the sections and are ready for internal review within Hanford Laboratories. Special equipment requirements of Hanford Laboratories have been transmitted to the appropriate HAPO components for inclusion in the special equipment budgets.

The current quarterly forecast of FY 1962 equipment expenditures was prepared and submitted to Contract Accounting for HAPO consolidation. The forecast contains estimated expenditures on a quarterly basis for each major AEC program.

An authorization for $58,000 was received in January from the U. S. Air Force to continue the current Plutonium Inhalation Studies until August 1, 1962. An authorization was also received from UCLRL in the amount of $20,000 to perform additional services for Project Whitney.

Special requests established during the month were as follows:

Accounting Code	Identification
.4R	Pennsalt Chemicals Corporation - Cost of packaging and shipping coupons to Pennsalt Chemicals Corporation for use in testing decontamination processes and agents in accordance with Special Agreement SA-192.
.4T	APED - Cost of packaging and shipping coupons to APED for use in testing decontamination processes and agents in accordance with Approval No. AT-8.

The establishment and cancellation of program codes in Hanford Laboratories during the month were as follows:

Program Code	Title	Comments
.20	In-Reactor Measurements	Title cancellation, program becomes part of new code .20.
.20	Irradiation Damage on Reactor Metals	New title, combining old codes .20 and .33.
.33	Irradiation Effects on Structural Materials	Cancelled, program becomes part of new code .20.
.92	Project Whitney Fabrication	To record special fabrications.

Effective February 1, 1962, a more detailed reporting of operating costs of the Chemical Effluents Technology Operation will take place. Previously, costs were distinguished between the 300 Area function and the 200 Area function; whereas, in the future costs will be reported by technological functions which conform with the organizational structure of the Chemical Effluents Technology Operation as follows:

Organization Code	Title
7650	Chemical Effluents Technology-General
7651	Geochemical and Geophysical Research
7652	Process Research and Development
7653	Particulate and Gaseous Waste Research
7654	Process Demonstration and Analysis

The credits received in the continuity of service account and from other HAPO components due to the adjustment to CY 1961 Pension Plan costs were booked in January and effected a net reduction in costs of the research and development components, the servicing components and the general overhead account as follows:

	(In thousands)
Physics and Instrument R & D	$ 63
Reactor and Fuels R & D	151
Chemical R & D	91
Biology	26
Test Reactor and Auxiliaries	38
Servicing Components	128
General Overhead	77
Total	$574

The effect of these credits on Hanford Laboratories' programs is shown below:

	(In thousands)
Research and Development	
HLO Programs - 02 Program	$ 12
04 Program	215
05 Program	20
06 Program	54
FPD Programs	31
IPD Programs	29
CPD Programs	32
Process Technology	23
Project Whitney	8
Charges to Service Assessment Pool	58
Other Services to HAPO Components	49
Miscellaneous	43
Total	$574

A new Time Distribution Report (TDR) was developed for use by Hanford Laboratories and instructions for implementation were transmitted to the components. The new TDR is designed around a group submission rather than an individual card for each person. The new format will require less time to prepare and will be more convenient for the components to utilize in other phases of business planning and cost control.

PERSONNEL ACCOUNTING

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 447	688	759
Additions and Transfers In	22	3	19
Removals and Transfers Out	29	17	12
Employees on Payroll at End of Month	1 440	674	766

Overtime Payments During Month	January	December
Exempt	$ 3 771	$ 3 937
Nonexempt	15 548	19 789
Total	$ 19 319	$ 23 726

Gross Payroll Paid During Month		
Exempt	$ 629 761	$ 630 537
Nonexempt	395 292	485 982
Total	$1 025 053	$1 116 519

Participation in Employee Benefit Plans at Month End	January		December	
	Number	Percent	Number	Percent
Pension Plan	1 280	99.4	1 282	99.4
Insurance Plan				
Personal Coverage	371		376	
Dependent Coverage	1 055	99.9	1 058	99.9
U.S. Savings Bonds				
Stock Bonus Plan	93	39.9	91	39.7
Savings Plan	77	5.4	80	5.5
Savings and Security Plan	1 081	89.8	1 087	89.3
Good Neighbor Fund	967	67.3	978	67.6

Insurance Claims	January		December	
	Number	Amount	Number	Amount
Employee Benefits				
Life Insurance	0	$ 0	0	$ 0
Weekly Sickness and Accident	16	987	15	875
Comprehensive Medical	90	5 833	82	5 637
Dependent Benefits				
Comprehensive Medical	14	13 725	130	12 099
Total	254	$20 545	227	$18 611

W Sale
Manager
Finance and Administration

W Sale:whm

1250237

TEST REACTOR AND AUXILIARIES MONTHLY REPORT - JANUARY 1962

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Plutonium Recycle Test Reactor

Operation

Reactor output was 955.11 MWD plus 36 hours of shutdown experimental time, resulting in a plant efficiency of 44% and a total experimental time efficiency of 48%. Total exposure to date is 4593 MWD. Exposure for maximum UO_2 fuel element is 1360 MWD/T and for maximum Pu-Al is 62.7 MWD or 37.4% burnup. The sixth refueling was accomplished 1-17-62. Total elements remain at 39 Pu-Al and 46 UO_2. Three new Pu-Al test elements were charged and the nested tubular UO_2 element was moved into a higher flux zone.

D_2O and helium losses were 1,261 pounds and 187,600 scf, respectively.

There were 13 reactor scrams during the month, six of which occurred at high power levels. Seven of these scrams were caused by spurious flow monitor trips, four were caused by pressurizer level or pressure problems, one was caused by a spurious flux monitor trip, and one was caused by a spurious seismoscope trip.

A UO_2 fuel element was damaged preventing further re-use during discharge when the fueling vehicle was moved while the tip of the element remained below the rotating shield. Design for an additional fueling vehicle interlock system was started to prevent such an incident in the future. A separate report has been written on the incident.

Equipment Experience

Oil leaks on both the high pressure helium compressors were repaired this month. Leaks were through a threaded, gasketed joint between the second stage head and the cylinder housing. Permanent repairs were made to the Number 1 unit by welding the head to the cylinder housing. Some shrinkage occurred (about 0.006") on the cylinder housing, but it was easily "rehoned" to correct size. Repairs to the Number 2 unit are considered temporary.

Seals were replaced on Boiler Feed Pump #1.

The HM chamber was replaced on effluent activity channel "C". Moisture had entered the chamber causing erratic operation.

Valves S-60, S-66 and S-67 were repaired. The clamping bolts which bind the split adjustment nut and the actuator shaft and valve stem together had "stripped" on all three valves.

Startup Channel #2 has been given a complete PM and recalibration. Two significant items were found: (1) The counterbalance weight on the count rate meter had shifted such that the meter was reading approximately 30% low on the first three decades, correct in the next two decades, and 10% low in the sixth decade. Subsequent balancing of the meter eliminated these errors. (2) Extreme chassis heating had caused several 1% resistors to change outside of allowable tolerances. A cooling fan was installed on the instrument rack to hold the temperature at an acceptable point.

Preventive maintenance required 344 manhours or $6\frac{1}{2}$% of total craft effort.

Improvement Work

Work completed:

Fuel Transfer System Limit and Tension Switches
Moderator and Reflector Pump Seal Modification
Indicating Light for Ring Header Level Controller
Moderator Level Servomanometer Modifications

Work partially completed:

Shield Pump Seal Modification
Automatic D_2O Condensate Return from HX-7

Design work completed:

Primary Oxygen Analyzer
In-line Gas Sampling
Series Block Valves in Helium Lines to Stack
Primary Pump Bowl Venting
Additional Bracing for Boiler Blow-down Line
Fuel Handling Vehicle Attachment to permit assembled removal of tube, element and nozzle.
New Head Bolts for High Pressure Helium Compressor

Design work partially completed:

Safety Circuit Ground and Low Voltage Detector

Process Engineering and Reactor Physics

Analysis of previous startup data resulted in substantial improvements in startup predictions and determination of reactivity balances.

A major portion of a preliminary issue of Critical Test Results is ready for printing. Additional analysis was necessary before completion and this work is essentially complete now. A review of the beta value for the reactor kinetics led to the need for additional work. The conclusion made was that the beta value used in previous calculations was high because of the transmission effect of high energy gammas from the core causing less of a photoneutron effect than previously assumed.

Work on PRTR tests during the month included:

PRTR Test Number 12	(Measurement of Effective Delay Neutron Fraction) Final report was prepared.
PRTR Test Number 17	(Primary Pump Vapor Binding) Supplement No. 1 was prepared and approved.
PRTR Test Number 18	(Charge-Discharge Flow Versus Pressurizer Level) Performance was completed. Final report was prepared.
PRTR Test Number 19	(Degasser Efficiency) Performance was completed.
PRTR Test Number 20	(Test of Reactor Cooldown and Depressurization in the Event of an Evacuation) Performance was completed. Final report was prepared.
PRTR Test Number 23	(Total Primary System Leakage Between Angle Valves and Primary Pump Inlet Valves) Final report was prepared.
PRTR Test Number 24	(Temperature Coefficient Tests) Performance was completed.
PRTR Test Number 25	(Calandria Temperatures after a Reactor Scram) Test was prepared and approved.

Procedures

Thirteen Operating Procedures were revised and issued - 16 additional were in the process of revision.

Twenty-three Operating Standards were revised and issued.

Two revised Process Specifications were accepted for use.

One Maintenance Manual was issued and two others were issued for comment.

Three Maintenance Procedures were issued for comment and one was issued for approval.

Inspection sheets, designed to improve preventive maintenance performance, were issued, covering a total of 49 instruments.

Drawings approved for as-built conditions total 171 - an increase of 70 during January.

Personnel training was as follows:

Charge-Discharge and Load-Out	36	Man-hours
Qualification and test subjects	193	
Procedures, Standards and Specifications	54	
Total PRTRO	283	Man-hours
Transistors (two men completed 25 hour course)	16	Man-hours
Total Maintenance	16	Man-hours

Three written qualification examinations were given to PRTRO Reactor Engineers and one was given to a Technologist.

Personnel qualifications at month-end.

Qualified Reactor Engineers - 7
Provisionally Qualified Reactor Engineers - 2
Qualified Technicians - 4
Provisionally Qualified Technicians - 2
Qualified Technologists - 18

Project Status

Fuel Element Examination Facility - The manipulator was damaged when an interlock to prevent collisions between the carriages failed while PRTRO personnel were training on the equipment. A gear drive and bearings in the main gear box were damaged.

PRTR Water Control Laboratory - Detailed equipment installation drawings for t PRTR water control laboratory were completed and issued for comments. The laboratory equipment, except for two hoods, exhaust fan, and vacuum pump, have been received.

Additional Shielding Storage Basin Wall at -12'-0" Level - Drawings H-3-13996, Sheets 1 and 2, showing detailed places for constructing additional concrete block and lead shielding along the storage basin wall at the -12' -0" level together with a work order, was issued to J. A. Jones Construction Company.

Relocation of the sulphite hold-up tank was completed by Maintenance during the reactor shutdown in mid-January.

Plutonium Recycle Program Critical Facility

Project Status (Project CAH-842)

The design was completed and work started during this period on the items authorized in Revision 3 of the Project Proposal. Fabrication of the Auxiliary Moderator Storage Tank was completed, and installation of the intertie piping started.

The reactor tank was clad with 20 mils of cadmium poison to eliminate the possibility of a nuclear incident caused by cell flooding.

The control rods have been completed and are ready for installation.

Fabrication and calibration of a criticality alarm has been completed.