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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT

NOVEMBER, 1960

DECEMBER 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

GENERAL ELECTRIC

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
NOVEMBER, 1960

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By Authority of PR-24
DS Lewis 8-4-92
By J. Jang 8-18-92
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Compiled by
Operation Managers

December 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE November 30,1960

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	128	124	252	129	116	245	0	9	1	1
Reactor & Fuels Research & Development	200	181	381	200	182	382	0	2	0	3
Physics & Instrument Research & Development	82	39	121	82	38	120	0	1	0	0
Biology Operation	35	48	83	36	48	84	0	0	1	0
Operation Res. & Syn.	16	4	20	16	4	20	0	0	0	0
Radiation Protection	39	96	135	38	98	136	1	0	0	2
Laboratory Auxiliaries	52	198	250	53	199	252	0	1	1	2
Financial	14	16	30	14	15	29	0	1	0	0
Prof. Placmt & R.P.	76	11	87	79	11	90	2	0	5	0
Programming	13	3	16	14	4	18	0	0	1	1
General	1	3	4	1	3	4	0	0	0	0
Totals	656	723	1379	662	718	1380	3	14	9	9
Totals excluding internal Transfers.	656	723	1379	662	718	1380	2	13	8	8

BUDGETS AND COSTS

November operating costs totaled $2,160,000; fiscal year-to-date costs are $10,369,000 or 39% of the $26,594,000 control budget.

Hanford Laboratories research and development costs for November compared with last month and the control budget follow:

(Dollars in Thousands)	Cost				
	Current Month	Last Month	FY To Date	Budget	% Spent
HLO Programs					
02 Program	$ 26	$ (11)	$ 224	$ 661	34
04 Program	873	763	3 814	9 622	40
05 Program	63	61	316	796	40
06 Program	185	208	992	2 372	42
	1 147	1 021	5 346	13 451	40
IPD Sponsored	272	281	1 338	3 170	42
CPD Sponsored (Excluding Strontium-90 Program)	167	218	817	1 693	48
Total	$ 1 586	$ 1 520	$ 7 501	$ 18 314	41%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

PRTR Phase III-A construction is estimated to be 68% complete. Construction was completed on those systems required for critical testing and the reactor was brought to critical on November 21, 1960. Design testing is estimated to be 50% complete.

No major PRTR design deficiencies have been encountered. However, sporadic level oscillations of several tenths of an inch were noted at moderator levels in the range of about 50 to 85 inches. These were suppressed by increasing the volume of helium in the gasholder. Hilium entrainment in the moderator and moderator entrainment in the helium gas balance system caused temporary difficulties which are being corrected.

Construction of the PRTR Maintenance and Mockup Facility, which includes the Rupture Loop Annex and Critical Facility Building, is estimated to be 15% complete. Designs of the Critical Facility and the Rupture Loop are estimated at 96% and 81% complete, respectively.

The spare PRTR primary process pump was disassembled after 2827 hours when excessive noise and vibration were observed. One of the two motor thrust bearings was defective. The thrust bearings were replaced by a single combination thrust-radial bearing suitable for the low thrust load. The mechanical seal showed no evidence of excessive wear and was re-installed without servicing. The pump has now operated for a total of 3217 hours with the same mechanical seal assembly.

A comprehensive review of PRTR primary coolant leak studies was completed. It was concluded that the emergency light water injection system can provide an adequate supply of backup coolant to prevent fuel melting for leaks of all sizes and locations.

The consequences of various nuclear accidents in the PRP Critical Facility are being studied on the analog computer. Preliminary results indicate that the rod safety system should limit fuel element temperature increases to a few degrees for any credible reactivity insertions.

Zircaloy ribs were successfully welded to eight-foot long fuel rods containing either sintered UO_2 pellets or swaged UO_2. The modified high frequency resistance seam welding process was used. Five rods were fabricated for evaluation at Westinghouse.

A three-foot long fuel assembly consisting of seven 0.91" OD stainless steel clad, swaged UO_2 fuel rods failed in a high temperature loop in the ETR. The cause has not yet been determined.

Irradiating UO_2 having 8.40% and 11.25% of total uranium atoms fissioned has been found to have melting points of 2760 C and 2660 C, respectively, as compared to 2790 C for nonirradiated UO_2 studied by the same method.

A purposely defected Zr-2 clad, four-rod cluster UO_2 fuel element containing sintered pellets was irradiated in a KER hole for nearly three weeks. During the irradiation, essentially no activity was detected in the effluent coolant by the gross gamma monitor system.

UO_2 powders were sealed in stainless steel capsules with porous end caps and high energy impacted at 1100 and 1200 C. At these temperatures and attained pressures in the 500,000 psi range, densities of 99% of theoretical were obtained. This high density was due in part to the porous end caps, which allowed evolved gases to escape.

Study of PuO_2-UO_2 fuels continued with determination of the distribution of PuO_2 in cold swaged UO_2-PuO_2 rods, determination of the absorbed gas content of various samples of UO_2 in preparation for hot swage fabrication and sintering experiments. In the latter, PuO_2 sintered in hydrogen containing more than 2 w/o H_2O had an O/Pu ratio of 1.98, but lower moisture content resulted in O/Pu ratios as low as 1.81. A number of high and low density UO_2-PuO_2 capsules have been discharged from the MTR after completing irradiation to 5000 MWD/T.

A seven-rod Zr-clad Pu-Al cluster has successfully completed 65 thermal cycles and five to seven reactor scrams in the ETR under conditions approximating PRTR pressure and temperature.

Initial experiments to develop a Zr-clad, extended surface plutonium-bearing fuel element fabricated by roll cladding have begun. The method is potentially inexpensive.

Experiments with PuC and UC-PuC are continuing. Under high vacuum and below the peritectic temperature PuC appears to break down by plutonium volatilization and formation of Pu_2C_3.

Phase diagram studies of the PuO_2-ZrO_2 system showed that at room temperature about 0.5 w/o PuO_2 is soluble in ZrO_2, from 0.5 to about 40 w/o PuO_2 monoclinic ZrO_2 and FCC PuO_2-ZrO_2 solid solution are in equilibrium, and above about 40 w/o PuO_2 the FCC solid solution exists.

Mild fretting corrosion penetrating up to five mils in a vertical zircaloy process tube has been observed under semi-prototypical PRTR conditions at 316 C. The attack does not occur at 20 C, suggesting that true fretting rather than simple mechanical wear is operative at the high temperature.

Recent tests suggest that the oxygen content in hot water may be an important factor in controlling hydrogen pickup by Zircaloy, higher oxygen concentration reducing the hydrogen pickup.

The first evidence of local heavy hydriding has been found in one short section of Zircaloy-2 process tube removed from the center-flux region of KER Loop 1. The hydrided region was beneath a localized heavy corrosion scale, the origin of which is under investigation. This tube section leaked when pressurized to 5000 psi internal pressure, compared with bursting pressures of 16,000 psi or more for other irradiated portions of the same tube, and 14,000 psi for unirradiated controls.

A new closure for NPR tubular fuel elements has been developed in which a partially copper plated Zircaloy ring is placed in the recessed end of the tube, the tube end heated to 730 C, and the fully bonded closure formed by back extrusion of the ring and projected cladding stock.

In tests which were run to determine the probable damage to NPR elements during charging, all specimens withstood 40,000 pounds load without failure. The closures tested were brazed and welded, flush fitted and welded, and recessed caps with welded closure.

To gain knowledge of the failure mechanism operative in coextruded Zircaloy-2 jacket material, tube burst tests under various states of biaxial stress were made on 3/4" OD Zircaloy-2 tubing. Variation of the axial to tangential stress ratio from 0.5 to 0.66 reduced the fracture strain at failure from 10% to 3.5%.

A fifth in-reactor rupture test has been successfully performed at the ETR. A previously unirradiated NPR inner tube component, defected on the outer cladding surface, was ruptured and subsequently operated at full reactor power for two hours and 25 minutes before activity in the pump cubicle required termination of the test.

Eight KER-size NPR type tube/tube fuel elements, with the inner tubes closed by hot heading and projection welding, and the outer tubes by an unbonded TIG welded closure, have been successfully irradiated and discharged after an exposure of 2000 MWD/T.

Two hot-pressed, aluminum-clad I&E fuel elements, irradiated in the MTR to 1400 MWD/T, were destructively examined. The aluminum-nickel-uranium bond was intact in regions of relatively low flux but had failed at some points in the high flux region.

Laboratory thermal hydraulic tests indicate that in the event of complete rupture of a front hydraulic fitting of a K Reactor process tube the reverse flow of hot water from the rear header would not be sufficient to prevent melting of the fuel element cladding on high power central zone tubes with present rear header pressures.

Calculations were made to predict the times associated with melting a fuel element should one become lodged in the rear face piping following its discharge from a K Reactor. It was found that unless the reactor had been shut down for several hours prior to discharge, the fuel element would melt in a very short time.

An improved type of fast neutron spectrometer is being developed for shielding studies. The proposed change in the basic Perlow counter will extend the range of this instrument by at least a factor of five in the high neutron energy region.

Samples of EGCR graphite have been measured after four GETR cycles and recharged into the GETR for additional irradiation at high temperature.

Addition of 10% partial pressure of CO to helium containing 0.1 mm of water vapor effectively inhibits the graphite-H_2O reaction at 825 C.

2. Chemical Research and Development

Purex head-end production runs to produce crude Strontium-90 have been followed closely with laboratory and hot cell experiments to improve recovery and purity of the crude. Overall recovery in the last six of the 14 production runs was brought to about 60 percent.

Installation of the larger scale Strontium purification equipment in A Cell of the High Level Radiochemistry Facility was completed and cold runs were begun. Experiments in a small column in this cell have shown that with use of ethylenediamine tetracetic acid (EDTA), iron loading of the ion exchange resin can be eliminated and the strontium capacity of the resin increased significantly. In other work, the flowsheet conditions to be used in the Hot Semiworks Strontium-90 purification program are being further refined. Present concept includes an extraction column, a partition-stripping column and an ion exchange column.

Optical microscope observations were made of the millipore filters used to collect particles in the studies of fission product release from air oxidation of heated fuel element material. These observations indicate that the majority of particles generated are of submicron size.

The pilot scale facility for investigating the removal of reactor effluent radioisotopes by means of aluminum turnings absorption was operated at a 6 linear ft/min flowrate as compared to 3.8 ft/min in earlier runs. Decontamination factors achieved at the higher flow were comparable except for As-76 removal which dropped from 60-70% to 52%. Studies of mineral bed absorption of specific isotopes from reactor effluent show promise for pyrite, pyrrhotite, calcite, and scapolite for P-32 absorption. Pyrite appears promising for As-76 absorption, but not for Zn-65.

Removal of solids from calciner off-gas has continued to be a problem in radioactive waste calcination. Recent tests with Fiberflax aluminum-silicate cloth filter elements gave low pressure drop and ready solids removal as compared to the sintered stainless steel or ceramic filters previously used in the test installations.

The first tests with irradiated feed were made of the Salt Cycle Process concept of plutonium recycle fuel reprocessing. Feed for this High Level Radiochemistry experiment consisted of 440 grams of enriched UO_2 (1.6 percent U-235) which had been irradiated to 1000 MWD/T and cooled approximately 18 months. Analytical data on the run products are not yet available. Qualitative observations indicate that the irradiated material oxidized more slowly than unirradiated material in the stainless cladding removal step, and that Sb-125 deposited in the off-gas scrubbing equipment in the dissolution step. Otherwise the process experience appeared to duplicate the performance obtained in cold runs.

Laboratory experiments were completed to measure the absorption by soil of radioisotopes contained in organic liquids. In tests with 30 percent TBP in a petroleum solvent, the absorption coefficients were found to be similar to those measured for aqueous systems.

3. Physics and Instrument Research and Development

In the NPR program, analysis of recent experiments continued to obtain information on the conversion ratio and preparations for temperature coefficient measurements were initiated. Development of radiation monitors for the building encountered difficulties when the customer indicated that the equipment would have to survive higher radiation levels than previously contemplated. The basic approach to the automatic control problem progressed with inclusion of additional complications in the computation methods following completion of a study of the properties of the simpler equations.

For the present production reactors, preparations were begun to assist IPD in the physics portion of the planning for enlargement of process channels and fuel elements in C Reactor. Procurement of materials for exponential experiments started.

In the Plutonium Recycle Program, the Section participated in the critical tests at the PRTR through supplying technical manpower and special instrumentation. Meanwhile, work continued on improved understanding of the behaviour of plutonium in graphite-moderated lattices and in the debugging of the RBU computer code. Also, development of instruments for in-reactor examination of PRTR process tubes progressed with calibration of

the gas gap gauge and improvement of the diameter probe.

Difficulties have been encountered in adapting existing computer codes to the IBM 7090 in some cases involving timing of print-outs to internal machine operation and some rewriting will be required.

Major modifications to the PCTR were initiated to allow improved performance of measurements of moderator temperature effects. Primary work was the drilling of ninety-nine new driver rod channels in the graphite stack. This work has been satisfactorily completed.

Shakedown work continued at the Critical Mass Laboratory prior to start-up. Potential points for leakage of plutonium are either being welded closed or placed within hoods. The tamper tank and control rod assembly for the reactor vessels are being installed.

Precision counting of neutrons for dosimetry work took a step forward with the completion of three long counters which gave results agreeing among themselves to 0.3%.

The accuracy of our mass spectrometry work was demonstrated by the excellent agreement of our results with the stated composition of a series of standard samples from the National Bureau of Standards.

Unexpectedly large deposition rates for airborne contamination during very stable atmospheric conditions is indicated by the first analysis of data from the experimental dispersion program. In the single case analyzed to date, 96% of the material was deposited in the first 2 miles of travel.

Orderly progress was made in instrument development programs, including: computations indicating that neutron flux monitors containing U-238 in addition to a mixture of plutonium isotopes would give nearly constant response over periods exceeding a year and for a wide range of postulated operating conditions; development of an ultrasonic transducer which may eliminate the need for immersing test pieces in water; improvements in the Whole Body Counter analyzer; miniaturization of experimental thermoluminescent dosimeters; improvements in experimental in-reactor creep measurements.

4. Biology

The expanded collection program to help assess Columbia River Hazards provided extensive data on fish and waterfowl. Fish flesh appears to contain in the order of 10^{-3} to 10^{-4} $\mu c/g$. (Significant variations were found

and appear in the monthly report, which should be used for hazard evaluation in place of numbers given here.)

The waterfowl sampling program using duck heads appears a successful technique. The average level of beta contamination was 6×10^{-4} μc/g and 15 percent of the heads were above 10^{-4} μc/g.

Columnaris recovery from salmon and scrap fish fell off with the advent of lower river water temperatures.

Intravenous doses of Sr-90, Ra-226, or Pu-239 in pigs at levels similar to those which caused death in dogs at Utah, caused only bone changes in pigs, as revealed by radiography.

Some rather important results were obtained that eventually should affect permissible limits for radioactive particles in air and the interpretation of bioassay data. Pulmonary retention of plutonium oxide particles appears to be greater at sizes of 1 μ diameter than at 0.4 or 0.2 μ. Partition of plutonium between the urine and feces following inhalation is also dependent on particle size.

5. Programming

The "Uranium Cascade Cost" computer program was completed during November. The new code calculates the cost of uranium per gram of U-235 and, in addition, prints out the enrichment cost and feed cost portion of the total expense and the ratio of these quantities. A feature of the program is that the value of the tails may be non zero. To operate the code, three of the four cascade constants (i.e., price of natural uranium, cost of separative duty, the tails composition, the value of the tails) must be specified. The fourth will be calculated and the cost schedule generated.

The PUCK code was extensively debugged and updated. This code computes the apparent worth of plutonium in a specific reactor and economic environment. The minimum total fuel cost, including out-of-reactor and in-reactor inventory charge, direct burnout charge and fuel fabrication and jacketing cost, is calculated for both once-through and recycle conditions. Fuel costs as a function of assigned plutonium price are also determined. The intersection of the recycle and once-through curves indicates the apparent worth of plutonium under the given conditions.

Substantial progress was made on calculating the value of "idealized" plutonium--plutonium having the properties of U-235 except that it is produced by absorption in U-238 and can be chemically separated from U-238.

This study examines the fact that the value of "idealized" plutonium can be based on the price of pure U-235 as determined by the cascade process, rather than the price of U-235 at enrichments equivalent to the plutonium enrichment under study.

Assistance was provided in arranging 30 visits to HLO by 180 persons, including representatives from 7 foreign countries. Of special interest was a team of Euratom Research and Development board members, here to review progress in the Plutonium Recycle Program. Programming also coordinated HLO's activities in achieving public recognition of PRTR initial criticality.

TECHNICAL AND OTHER SERVICES

There are 18 currently active projects having combined authorized funds in the amount of $19,169,000. The total estimated cost of these projects is $21,013,000. Of the eight that are behind schedule, seven are more than three percent behind schedule.

Three new projects for the construction of much needed facilities are moving toward authorization. These are (1) Biology Facility Additions, (2) Atmospheric Physics Facilities, and (3) Plutonium Metallurgy Facilities - 231-Z Building.

The microfilming program is proceeding steadily, with 3906 documents microfilmed during the month. A second auto-scan microfilm reader has been ordered and should be on hand shortly. This is badly needed in the 300 Area Files for the use of technical people who must now use the microfilmed reports in their work.

There were no unusual radiation protection problems during the critical testing of the Plutonium Recycle Test Reactor.

Two cases of plutonium deposition were confirmed in November. Four other cases of potential plutonium deposition occurred involving high-level skin contamination to a J. A. Jones employee and exposure of three CPD employees as a result of (1) head and hand contamination from a leaking process line, (2) head and hair contamination during changing of a ruptured glove, and (3) a plutonium contaminated minor injury resulting from a hand tool puncturing a hood glove.

Computer coding for the Z Plant Information Study is approximately 50 per cent complete. Unless unforeseen difficulties arise, this programming should be completed by the end of the year as scheduled.

A series of response surface experiments designed to locate optimum conditions for the canning of four inch I&E enriched fuel elements was successfully completed.

Solutions to the neutron diffusion equation in several simple geometries were supplied as an aid in shielding calculations.

Closed form solutions were obtained to a mathematical model used to describe the time and spatial behavior of concentrations in a long filter column in which diffusion, transport, and absorption mechanisms were present.

A document was issued giving a method of obtaining joint confidence intervals in connection with estimates obtained from a multiple gamma-ray spectrum.

SUPPORTING FUNCTIONS

Financial restrictions were placed on Miscellaneous Capital Work Orders under $20,000 due to a limitation of authorized funds for FY-1961. Several jobs have been cancelled and several more are being held up pending a review of HAPO requirements.

Two special requests were received during the month: (1) engineering services at Dugway Proving Ground for the Defense Systems Department, General Electric Company, and (2) provide four pieces of zircaloy tubing to Savannah River Plant, E.I. duPont. Estimated billing price of each was $500.

As of November 30, 1960, the staff of the Hanford Laboratories totalled 1379 employees, including 656 exempt and 723 weekly salaried. Of the total, 562 possess technical degrees, including 335 BS, 123 MS and 104 PhD.

The medical treatment frequency for November was 1.56 as compared with 1.80 for the preceding month. There were no disabling injuries or serious accidents during the month. There were 4 security violations, bringing the total for the year to date to 31, as compared with 42 for the corresponding period last year.

During November there was one visit by a PhD candidate seeking employment and an HLO offer was accepted by an experienced PhD physicist. Two offers were rejected during November, an HLO offer to an experienced PhD chemist and a CPD offer to an inexperienced PhD chemical engineer. Current open offers include an FPD offer to an inexperienced PhD physicist and two IPD offers to inexperienced chemical engineers.

During November thirteen HAPO scientists and engineers participated in Company PhD recruiting, and seven BS/MS recruiters visited twenty schools.

Two Technical Graduates were added to the rolls and five accepted permanent assignments during the month. At month's end there were 67 Technical Graduates on the roll including six members of the Engineering and Science Program.

A story on Hanford research requested by the Spokesman-Review for their annual progress edition was edited and released. The Washington State Department of Commerce and Industrial Development has requested several minutes of film on HLO activities to be included in a new motion picture aimed at bringing new industry to the state.

Assistance was provided for the publicity of the PRTR criticality. A TV news film prepared by Relations with HLO assistance was shown on the Cascade Network.

There were 14 requisitions received during the month, 14 vacancies were filled, 1 was cancelled, and 20 remain to be filled.

Seminars in BOCE, Creative Approach and Understanding People continued with a total enrollment of 40 Laboratories employees. A proposed Columbia Basin College "Engineering Aid" night class curriculum was reviewed by selected Laboratories managers and comments forwarded to Relations Operation, Education and Training.

W. Sale

for Manager
Hanford Laboratories

HM Parker:WS:dg

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Nickel-Plated Fuel Elements. Investigation is under way to determine a suitable aluminum pretreatment and plating bath composition to yield an adherent non-porous nickel plate on aluminum. Plate adhesion is measured by a cathodic testing device which electrolytically generates hydrogen on the nickel surface. For a given rate of hydrogen generation, the adhesion can be measured by the time and extent of blistering. Different pre treatments and plating baths have produced plates which have been 85% blistered after 3-1/2 hours to plates which show no blistering after 24 hours.

A bath composition of 0.1 molar nickel sulfate, 0.3 molar sodium hypophosphate, and 0.3 molar lactic acid has been selected on the basis of the cathodic testing results for further investigation.

Effect of Oxygen on Corrosion Product Hydrogen Pickup in Zircaloy. A statistical analysis was performed on the percent of corrosion product hydrogen pickup data presented in the October monthly report. The analysis shows there is no significant time effect for either static or refreshed systems. The best values for percent hydrogen pickup in static and refreshed systems are 25.8% and 13.0%, respectively. Preliminary data indicate that the oxygen content of the water may be the controlling factor for hydrogen pickup. The hypothesis is based on the fact that, although the percent of hydrogen pickup remains constant, the concentration of hydrogen in either the static or refreshed autoclave system diminishes with time. During the period of the test the oxygen concentration remains constant (3-4 ppm in the refreshed system and negligibly low (less than 0.1 ppm) in the static systems). It appears, therefore, that the oxygen rather than the hydrogen concentration is the controlling variable for hydrogen pickup by Zircaloys during autoclaving. Additional work is planned to substantiate this hypothesis.

Hydriding of Zircaloy-2 in a Simulated NPR Gas Atmosphere. An experiment was started in May 1960, to expose Zircaloy-2 coupons (size 1" x 1/2" x 0.030") with various surface conditions to a simulated reactor atmosphere produced by passing tank helium over 800 C NPR graphite and then over the Zircaloy samples. Traces of water in the helium react with the graphite to give small amounts of carbon monoxide and hydrogen. Gas analyses (volume percent) averaged about 99.8% He, 0.02% H_2, and 0.01% CO. H_2O content was about 30 ppm by volume (0.003 vol. %). From the low percent hydrogen pickup results listed in the table below, it is concluded that

little or none of the hydrogen in the environment was absorbed by the samples. The corrosion weight gain values are lower than would have been expected for an equivalent exposure in water or high pressure steam.

Previous data from this experiment appeared in the August 1960 monthly report. This experiment has been concluded.

Surface		300 C	350 C	400 C
		Time, 112 Days		
Vapor blasted	Wt. Gain (mg/dm^2)	23	40, 45	84,82
	H(ppm)	5	10, 20	0, 40
	% Th.	3	5, 9	0, 9
	TIME:	176 days	176 days	102 Days
Etched & autoclaved in 400 C, 1500 psi steam	Wt. Gain	15	7	39, 36
	H(ppm)	15	5	15, 20
	% Th.	15	10	6, 8
Scratched	Wt. Gain	11	9	35, 38
	H (ppm)	5	10	20, 15
	% Th.	7	18	6, 9
Etched only	Wt. Gain	8	17	60, 55
	H(ppm)	10	5	5, 0
	% Th.	18	5	1, 0

Effect of H_2 Pressure on Hydriding of Zircaloy-2. A series of etched, vacuum-annealed Zircaloy-2 coupons was exposed at 400 C to mixtures of water vapor and hydrogen to determine what effect, if any, hydrogen pressure has on the rate of hydriding at constant water vapor pressure. Tests were conducted at 0.1 and 0.5 mm H_2O vapor partial pressure, and 10, 25, and 400 mm of H_2 pressure. Examination of the data at 0.5 mm H_2O indicates that about five ppm hydrogen was picked up in the first two to six hours, but then hydriding essentially stopped. The weights continued to increase as the samples oxidized and the resulting decrease in percent theoretical hydrogen absorbed indicates that not even much corrosion product hydrogen was picked up by the samples after the initial period.

The data from systems containing 0.1 mm of water vapor indicate somewhat higher initial hydrogen pickup (about 15-20 ppm) during the first few hours of test. Analyses of samples with longer exposures indicate no appreciable further hydrogen pickup up to 115 hours. Oxidation rates at both 0.1 and 0.5 mm are similar to those observed in 1500 psi steam at 400 C.

Radiometallurgy Laboratory Studies

Elevated temperature tensile tests were completed on four irradiated and two unirradiated thorium specimens. Considerable difficulty was experienced in welding platinum strips to the specimens and deformation was

finally measured by means of cross-head travel (RM-501). Two, 18-inch long, enriched tube-and-tube elements were visually examined; the unalloyed uranium was slightly bumped while the two w/o zirconium alloy samples were smooth. No evidence of clad necking has been found on either piece (RM-572). An aluminum-clad irradiated I&E element was exposed to out-of-reactor loop water to determine the crud film buildup in an intense gamma field. Samples of the crud film were removed for analysis. The thickness of the film was measured and determined to be 0.0004 inch (RM-335). Four annealing runs on uranium samples with high and low irradiation exposures were made during the month as a part of the swelling program. Annealing times of one hour and 100 hours were used at both 400 C and 500 C (RM-265).

Metallographic examination of the KER Loop 1 tube section (No. 9), which had burst at less than 5000 psi, revealed severe hydriding of the Zircaloy-2 had occurred under a thick layer of the zirconium oxide on the inside surface of the tube. The eight-mil thick oxide layer extended for two inches longitudinally and one and one-quarter inches circumferentially at one end of the tube section. The maximum hydride concentration was found near the inside surface of the tube under the oxide layer and was estimated to be in excess of 1000 parts per million hydrogen (RM-330).

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

Basic Metallurgy Studies

Mechanical and Physical Properties of Materials. The evaluation of zirconium - 2 a/o niobium - 2 a/o tin alloy for fuel element cladding applications has continued. Heat treatments designed to simulate the material condition expected in the cladding of beta treated fuel elements have been applied to zirconium - 2 a/o niobium - 2 a/o tin alloy specimens. The heat treatments given consisted of oil quenching from 660 C, 700 C, 740 C, and 780 C after a suitable holding time at temperature. Tensile tests conducted at 450 C show ultimate strengths of 62,800 psi to 54,000 psi and 0.2% yield strengths of 38,900 to 34,000 psi. The high strength value corresponds to material quenched from 780 C; the low value corresponds to material quenched from 660 C.

Corrosion studies in 600 F water and 750 F steam have continued. Thirty-day weight gains in 680 F water range from 78.5 mg/dm^2 to 116.8 mg/dm^2; 14-day weight gains in 750 F steam range from 107.1 mg/dm^2 to 147.2 mg/dm^2. The largest weight gains correspond to the highest solution temperature; the lower weight gains correspond to lowest solution temperature. The surface layer which forms in these corrosion tests is grey in the early part of the corrosion tests and lightens as the test proceeds.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material before and after irradiation is a direct way of detecting radiation induced damage in these materials. Thin films and foils suitable for electron microscopy offer advantages, since radioactivity hazards are minimized. The rirst three capsules from a series

of eighteen, irradiated to an exposure of 1 x 10^{19} nvt in a Snout Facility, have been received. The thin foil specimens will be studied by transmission electron microscopy to establish changes in microstructure. Fission fragment damage in metallic and non-metallic thin films has been observed by transmission electron microscopy techniques. A series of irradiations designed to establish similar information on bulk specimens has begun. A transverse face of an aluminum cylinder 0.25" in diameter by 0.25" in length, was polished to yield a smooth surface. Various thin coatings of plastic and of carbon were applied to the specimens, and a thin coating of UO_2 was evaporated on the plastic layers. After irradiation, the plastic layer will be dissolved from the aluminum to free the UO_2. The aluminum pins will then be monitored by gamma ray spectrometry for identification of fission products, and then the surface of the aluminum plug will be examined by replica techniques for fission tracks similar to the previous work on thin films. In addition to these experiments, foils of aluminum were thinned to approximately 1000 A thickness. Carbon black particles were deposited on the aluminum, and the foil was then shadowed with a thin film of UO_2. These specimens will be examined after irradiation for evidence of fission fragment damage in areas devoid of the UO_2, and possible perturbation of dislocation motions due to damage associated with the fission fragment bombardment.

Development of a standard, routine method for thinning zirconium and Zircaloy-2 foils to approximately 100-2000 A thicknesses has continued, but the results are non-reproducible and erratic. Oxide formation on the foils or inherently high oxide content in the foils poses a problem. As reported previously, Zircaloy-2 foils thinned electrolytically have revealed what appeared to be a fine distribution of second phase constituent, which formed repeatedly on all specimens. Strangely enough, zirconium foils, thinned in the same manner, also show the same type of second constituent dispersion. The conclusion, therefore, follows that the second phase constituent is produced during specimen preparation and that it is not, as first surmised, a peculiarity of Zircaloy-2.

X-Ray Diffraction Studies. Orientation of extruded uranium tubes and rods with various heat treatment histories is being determined by several x-ray methods. Nine pole figures for the planes (023), (112), (110), (200), (131), (021), (002), (113), and (111) have been obtained from a 0.2" diameter hemisphere machined from a segment of NPR coextruded tube. These pole figures provide a self-consistent picture of the orientation in that sample. This method of pole figures based on use of one sample represents an advance over past techniques. Other techniques require anywhere from 7-11 samples. The technique is being used to study the variations in the orientation of as-extruded and heat treated uranium. Circumferential variation along a ring cut from an extruded tube is presently being examined. Preliminary evidence based upon data taken from three samples 120, 150, and 90° around the circumference of an as-extruded tube (FPD Extrusion No. 7, 108' from end) shows that the sharpness of the 110 axial texture does vary. This variation is being checked and is believed to result from (1) variations in starting texture of the billet, or (2) anisotropic heat transfer conditions during fabrication.

Solid State Reactions. X-ray diffraction is being used to study the effects of irradiation on non-fissionable materials. Annealing studies of irradiated molybdenum are being carried out in order to investigate the nature of the damage and to obtain information on the behavior of various types of lattice disorder. An effect of total neutron exposure on the annealing kinetics of irradiated molybdenum has been observed, using x-ray diffraction. An annealing process was actually suppressed by increased neutron dose. In the case of molybdenum irradiated to exposures of 10^{18} and 10^{19} nvt, a large decrease in lattice parameter occurs on annealing between 50 and 200 C. No decrease is observed in this temperature range upon annealing molybdenum previously irradiated to exposures of 5×10^{19} nvt or greater. This behavior is explained by the formation of interstitial clusters during irradiation. The irradiation to higher exposures has tied up a fundamental defect (interstitial) produced during initial stages of irradiation. This results in a type of damage that is stable and does not anneal out until high temperatures are reached.

Metallic Fuel Development

Tubular Fuel Elements. A production test of eight, 20-inch long, Zr-2 clad, natural uranium elements made up of hot headed projection welded KER inner size and unbonded TIG welded KER outer size tubes has been discharged after an average exposure of 2030 MWD/T. The average specific power was 68 kw/ft, and the maximum was 78 kw/ft. Bulk coolant temperatures were 288 C outlet and 233 C inlet. The estimated maximum uranium temperature was 500 C.

This represants the first irradiation of the hot headed projection welded closure of a tubular geometry and the first in which the projection weld has not been backed up by a fusion weld. It also represents the first irradiation of an unbonded TIG welded closure on Zircaloy clad elements. Preliminary inspection in the KE basin shows no corrosion of either the projection welds or the TIG weld. The projection weld crevice, a point of concern, appears as clean and black as at charging. Some bumping of the clad surface is evident, and at least one element appears to have minor pitting corrosion.

The inner component of NPR prototype fuel elements has been under test in KER Loop 3. The test includes four inner components of 16-inch length. The total exposure will have reached 1600 MWD/T by month-end. The elements are coextruded, clad with 0.020-inch thick Zircaloy-2, and have a 1.430-inch OD and 0.520 inch ID. The power output from these elements is about 80 kw/ft, with maximum fuel temperature slightly in excess of 500 C.

An additional 18 NPR inner tube fuel elements were completed during the month. Nine of the elements have 0.030 inch thick outer clad and nine have 0.020 inch thick clad. All have chem-milled and welded end closures. The fuel element supports are made of steel and are stud-welded to the clad with Zircaloy-2. The autoclave surface film on the fuel clad and on the end closure welds is of extremely high quality.

During the second week of November, two KER loops were charged with KER single tube size fuel elements. These fuel elements are 1.6% enriched, clad with 0.027 inch of Zr-2, closed with Zr-Be eutectic brazes, and supported by mild steel supports attached with Zr-2 studs. Operating conditions of these elements will be prototypical of NPR tube-tube fuel elements. Goal exposures are 1000 and 3500 MWD/T.

Completed elements for PT-IP-364A were shipped to the KER facility to await tube loading. This test is a brazed closure on KER size tube-tube elements with a 2 w/o zirconium - 1.6% enriched uranium core. The braze alloy is 84 Zr-2 + 12 Fe + 4 Be. Five tube-tube elements were shipped with two tube-tube assemblies retained as spares. In addition, four outer tubes were made available as heater elements for PT-IP-316A, Supp. E, a test intended to detect possible crud formation.

Two brazed closure NPR inner elements were placed in the MTR on November 14, 1960, for a single cycle of irradiation. This test was to operate at a specific power of 104 kw/ft and would test the stability of an element with a brazed closure using an 84 Zr-2 + 12 Fe + 4 Be braze alloy. Shortly after startup, high activity was observed in the loop and the test was removed from the reactor. It is possible that this high activity was due to carry-over from a previous rupture experiment which used the same in-reactor tube. Basin examination of the elements through the periscope did not show any sign of element failure. The tube will be replaced in the reactor at mid-cycle shutdown to determine definitely if the high activity was due to carry-over from the previous rupture.

A fifth in-reactor rupture test has been performed at the ETR under conditions closely approximating NPR conditions. In this test a previously un-irradiated NPR inner tube fuel element, defected on the outer cladding surface, was used. Three minutes after the defect cap was sheared off, the gross gamma monitor began to rise gradually. After forty-six minutes, the delayed neutron monitor and the gamma scintillation counters began to rise slowly. The gamma scintillation counter continued to rise slowly but at an ever increasing rate, until two hours and twenty-five minutes had elapsed. At this time the activity in the heat exchanger piping in the loop cubicle had reached the level at which the test was to be terminated. The time of operation of this element after the defect cap was sheared off was considerably longer than in the fourth rupture test. In the fourth rupture test a previously un-irradiated KER-size outer tube was irradiated for thirty-three minutes after the defect cap was sheared off. The activity in the heat exchanger piping in the loop cubicle was allowed to reach the same level in each test before the reactor was scrammed to terminate the test.

Fuel for Present Reactors. Radiometallurgical examination has been essentially completed on two hot-pressed, aluminum clad fuel elements. These elements were irradiated in the MTR as test GEH-4-57; 58. The specific power was 142 kw/ft and the exposure 1400 MWD/T. Examination upon discharge showed no visual evidence of damage. Metallurgical examination showed several important irradiation behavior characteristics of the nickel bond. First, in the high flux region some diffusion of the aluminum into the

nickel diffusion barrier occurred, resulting in a thickening of the Ni_2Al_3 layer. Second, in the high flux region the clad separated from the uranium in several spots. These areas were associated with areas of a high concentration of pits in the uranium. Third, the end caps had pulled away from the uranium. However, there was no indication of hot spot behavior even where the two elements were butted together. Fourth, the double worked diffusion closure showed no sign of failure or unusual behavior. The uranium core was in excellent shape with only one area of cracking. This occurred on the internal bore of the hottest element but ended at the nickel diffusion barrier. The cracks did not penetrate the nickel layer. Some transverse cracks were observed in the Ni_2Al_3 layer of the diffusion barrier.

Component Fabrication. Test elements of NPR inner tube stock 1.263 OD x 0.430 ID with 0.040 inch outer clad and 0.030 inch inner clad were processed for a variable heat treatment test to be irradiated in the KER Loops. The sections were heat treated with varying quench and cooling rates. After heat treatment the elements were cropped to 15-inch length with the balance of each section used for characterization of the heat treatment. The elements were sealed with unbonded end closures. The fourteen elements were nondestructively tested for unbond and clad thickness before autoclaving and were OD and ID autoradiographed to show clad thinning. No unusual defects were noticed in these tests. Zircaloy-2 supports (four at 90°) were welded on and the elements were autoclaved 72 hours in 400 C, 1500 psi steam. Zircaloy-2 sleeves have been prepared for adjusting water velocity for some irradiations in the KER Loops. These will have Zircaloy-2 supports with steel shims. Calculations are being made for irradiations of some of these elements in the ETR 3x3 Loop in the event that charging in the KER Loops cannot be accomplished.

The crimped steel shoe over a Zircaloy-2 support has been selected as the candidate support for the outer tubes of the first NPR loading. Testing of this support shows the steel to be very tightly attached to the Zircaloy-2 shape. Static loading indicates the supports will carry from 300 to 400 pounds per support. After failure by buckling in the first mode (center of support touches the element), the collapsed height of the support is approximately 0.075 inch. A dummy fuel element, bearing this type of support, was drawn through a tapered tube to collapse the supports under dynamic conditions. The supports were fully buckled in the first mode, but none of the steel shoes were dislodged. The shoes that were in dry contact with the tube shifted rearward about 1/8 inch. Those that had water lubrication did not shift. Approximately 2000 pounds force was necessary to pull the dummy element through the tapered section of tube. The non-scratching properties of the support were good. Testing was done on Weber's apparatus, and none of the samples scratched during normal testing on runs of 217 feet. On run to failure tests, the samples ran 1540 feet before wearing through the iron shoe. Further testing is planned to determine effects of radiation, decontamination, and storage.

Steel self-supports were installed on two types of KER Loop charges. The first was NPR inner with welded closures and the second type element was KSE-3, KER-size single tube 1.6 percent enriched with brazed closures. The KSE-3 elements were charged in Loops 2 and 4 on November 11. The supports were steel strip attached to the jacket with Zircaloy-2 studs.

Two Zircaloy-2 billets were extruded into 1-1/4 inch OD by 5/8 inch ID tubes at an extrusion ratio of 13.7 to 1. The billets were fabricated from a 3-5/8 inch diameter Zircaloy-2 forged bar. Lengths of the bar were upset to a four-inch diameter at 700 C for the extrusion billets. One billet was beta heat treated by heating to 1050 C and holding for 30 minutes. Both billets were vacuum canned in copper.

The non-heat treated billet was extruded at 730 C. The extrusion OD surface was very rough with large longitudinal grooves on the surface which apparently resulted from the forging memory in the billet. The OD surface was smooth on the extrusion from the beta heat treated billet, which was extruded at 750 C, showing only fine striations from the large grain size in the billet.

A new lubricant called "Crawford Necrolene" was tried on the extrusion mandrel of the heat treated billet and appeared to provide adequate lubrication for the mandrel. Considerable copper was noted seized to the mandrel after extruding the non-heat treated billet using the usual heavy oil dag lubricant. The usual die and billet lubrication appears not to be adequate at billet temperatures above 620 C and at higher extrusion ratios.

Closure and Joining. Attempts to bond a Zircaloy-2 cap to the uranium surface in the projection welded brazed closure have produced some very encouraging results when using a Zr-2 - 4 Be - 8 Cu braze material and when brazing the cap directly to the uranium without any braze material. This closure consists of projection welding a 1/8 inch thick Zircaloy-2 cap directly onto a projected cladding ring produced by acid milling approximately 0.030 inch from the end of the rod. The pressure is maintained and the power continued for several cycles after the initial projection weld in an effort to resistance braze the cap to the uranium. Initial work is being done on rods due to the limited capacity of the available welding machine.

A bond between the cap and the uranium surface was obtained using a thin layer (0.004 to 0.008 inch layer) of -100 mesh particle size Zircaloy-2, Be, Cu braze material. Results indicate the braze material must be thin and very evenly distributed and the pressure must be maintained for a short cooling time after the brazing power is discontinued.

Work in brazing the Zircaloy-2 cap directly to the uranium has resulted in an apparent 100% bonded surface which could not be broken by the usual destructive tests. However, the high temperature obtained in getting the bond resulted in a large heat-affected zone in the uranium and small voids in the uranium. This heat-affected zone can be minimized by reducing power input and by finding the proper electrode shape to give proper heat distribution.

One rod closed on both ends with the projection weld brazed closure was given a 62-hour autoclave test (1500 psi at 400 C) which showed the projection weld to be sound and apparently free from contamination.

A number of welds placing a layer of filler metal over the braze area have been made. The majority of these welds have had braze contamination due to diffusion of the braze through the molten weld metal during welding. As the welding procedure becomes more refined, it is apparent that the braze width is a major factor in obtaining a satisfactory, braze-free weld. There appears to be a limit to the width of the braze over which a weld bead can be placed without braze contamination. This width is in the neighborhood of 10 to 15 mils. When the braze width was below 10 mils, braze-free welds have been made. In continuing the evaluation of this method as the final one for NPR fuel element closure, it appears that the braze width should not exceed 15 mils.

Metallographic examination and dissection of specimens made up with extrusion closures containing various bonding media were carried out as outlined below:

a. Iron-Faced Nickel Cup Between Zircaloy Cap and Uranium

Fabrication and surface preparation of components for this closure system are considerably more difficult and demanding than for the copper-faced cap. Whether because of inadequate preparation of the nickel surface, or for some other cause, the bonding between the Zircaloy cap and the nickel layer was found to be spotty in the specimen studied, and strength of adherence was low.

b. Wrought Copper Cup Between Zircaloy Cap and Uranium

This cup is formed from 0.003" sheet. Metallographic examination of the interfaces of processed specimens showed good bonding both at Cu/Zircaloy and at Cu/U faces. By chisel test, the bond strength was found to be fair. Electrographic tests of the mechanically separated surfaces showed that copper had diffused into both uranium and Zircaloy to a slight depth; the Cu/U bond was stronger than the Cu/Zircaloy bond.

c. Thin Copper Plate on Zircaloy Cap Face and Side Walls

Using an alkaline copper electroplating bath, the Zircaloy caps are plated to the desired height up the side wall by suspending them to a controlled depth in the bath. Pre-plating preparation is simple but exacting, as are the plating conditions. By chisel test, the bond strength is much greater than that of the wrought cup closure. This approach appears to give the best results of the several tried.

d. Thin Tin Shim Between Zircaloy Cap and Uranium

The Zircaloy cap, tin shim, and uranium faces were cathodically etched in vacuo prior to assembly, to insure maximum surface cleanliness. Metallographic examination of a processed specimen showed spotty alloying between the tin and the Zircaloy and

uranium, respectively. The tin, when pressed while in the liquid state, flowed readily, to collect in pockets at the interfaces between components, leaving unbonded regions interspersed among these pockets. Tin appears to be an unpromising material for bonding the cap to the uranium core.

Two principles emerge from these experiments:

1. Successful diffusion bonding between Zircaloy and uranium requires a bonding medium which forms a eutectic alloy with the substrate components at temperatures not far above the processing temperature (730 C).

2. Regardless of the bonding medium used, chemically clean interfaces must be provided if adequate bonding is to be obtained in any case. The more perverse the bonding medium with respect to alloying, the more important absolute cleanliness becomes.

Projection welding tubular end closures is being carried out at Sciaky Bros., Los Angeles laboratory, under DDR-84. Ten NPR inner size tubes headed on both ends were shipped for further weld studies. These are not reactor quality extrusions because of poor clad bonding, but will be used to arrive at proper welding conditions.

A monotube charging machine will be used with the NPR. The elements must resist axial compression during charging. Several types of closures on NPR inner tubes were tested for resistance to damage from axial loading. Tests were run on six specimens. Two were brazed and welded, one was a flush fitted and welded cap, and three were recessed caps with welded closure. All of the specimens withstood 40,000 pounds load without failure. One of the recessed end cap specimens suffered a slight permanent compressive strain. The brazed specimens had good surface appearance after testing but have not yet been examined for internal cracking.

Work on the design and testing of a pinning device for axial restraint of the NPR fuel elements is under way. The spot welded or mechancially bonded pinning devices are simple sheet metal stampings of the flush end plate type. A third method of mounting the support (spider) with a projected welded stud that is riveted over to hold the spider will be tested.

A clamp to hold NPR fuel elements onto a variable "g" testing machine is being built. Assembled fuel elements will be tested to ascertain the number of cycles at a given acceleration that supports will withstand. Acceleration, mostly in the range of 1 to 15 g, will be made in both the axial and radial directions. The axial accelerations should test the strength of the spider to resist impact loads during charging. The radial accelerations should indicate the ability of these supports to withstand shipping conditions.

Allied Fuel Studies. Failures of Zr-2 clad uranium rods and tubes as a result of localized clad straining have occurred in NaK capsule and high

temperature recirculating water loop irradiations. From the appearance of the fuel elements, the same mechanism is operating in these failures. To establish the effects of cladding thickness variations on the susceptibility to failure, a series of NaK capsule irradiations of Zr-2 clad fuel rods is planned for the Hanford reactors. Variables of cladding thickness, cladding thickness uniformity, temperature, and exposure will be investigated. An etching technique was worked out to apply a grid of 150 squares to the inch on the cladding surface. Comparing the pre- and post-irradiation grids will give information on the amount of uniform and localized cladding deformation.

Metallographic studies have been completed on the thirty samples of NPR inner tube (20-mil outer and inner clad, 1.420 inch OD, 0.513 inch ID) which underwent various beta heat treatments. Of all the heat treatments studied, in general those involving a quench into the low temperature (250 to 400 C) nitrate salt bath gave the smallest and most uniform grain size. In particular, 10 minutes at 730 C, followed by a 20- to 30-second air delay and a quench into 250 C nitrate salt bath appears to constitute the optimum heat treatment, from a grain size and uniformity point of view. X-ray results on the preferred orientation of these samples have not yet been received.

Since all the previous heat treatments were performed on single samples, it was desired to see what degree of reproducibility could be obtained in a given heat treatment, and also what effect small variations in heating and quench bath temperatures would have in the final product. Groups of three to five samples of NPR inner tube (30-mil inner clad, 38-mil outer clad, 1.263 OD, 0.431 ID) were each given a different heat treatment involving beta temperatures of 710, 730, and 740 C, holding times of 10 minutes, air delays before quenching of 20 seconds, and quench temperatures of 250 C and 300 C in a nitrate salt bath. Cooling rates of samples within each group showed fairly good reproducibility. Metallographic examination to determine grain size and uniformity are being conducted and samples are being prepared for x-ray studies of the degree of preferred orientations.

Tube burst tests under various states of multiaxial stress were made on 3/4-inch diameter Zircaloy-2 tubing. These tubes were used as a stand-in for coextruded Zircaloy-2 jacket material now ready for testing. A 150 mesh screen was photoengraved on the surface of the specimens before testing and plastic strain after testing was determined from the distortion of the screen. Axial to tangential stress ratios from two to -0.25 (tensile stress considered positive) were investigated. The fracture strain for internal pressure only, an axial to tangential stress ratio of 0.5, was ten percent. Although all of the specimens were not fractured, the trend of the strain data was for a minimum in fracture strain to occur when the axial to tangential stress ratio was one to one. The fracture strain was 3.5 percent when the stress ratio was 0.66 contrasted with 10 percent when the stress ratio was 0.5. No localized necking as observed in fuel jacket failures was observed in these specimens.

If the uniform straining of the outer surface cladding of a fuel element can be reduced, the probability of cladding failures due to excessive

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localized straining should be reduced. A mathematical model for tubular uranium fuel elements with Zircaloy cladding was written. The computer program for this model is "de-bugged", and several example calculations were run. The results indicate exterior cladding deformations can be limited by increasing outer cladding thicknesses. The benefit of thicker outer cladding increases with increased swelling. The assumed strength of the fuel material was doubled without greatly altering the amount of exterior cladding needed to restrict exterior circumferential straining. Since the interior cladding is undergoing large compressive strains, it offers high resistance. Decreasing inner cladding thickness is as effective as increasing outer cladding thicknesses in limiting the exterior circumferential strain.

Constant load tests are in progress on uranium samples undergoing large temperature cycles. The anisotropic thermal expansions of the uranium has increased deformation rates under the constant load conditions. A specimen loaded to 1000 psi and cycled between 150 C and 435 C strained $\sim$1.4 percent after fourteen temperature cycles. The mean strain per cycle was 0.075 percent. A specimen loaded to 1000 psi and cycled between 150 C to 350 C showed no appreciable straining per cycle during ten temperature cycles.

Metallurgical Development. A series of 13 zirconium base alloys are being melted and fabricated for the Coatings and Corrosion group. These alloys are to be double vacuum arc melted and fabricated to 0.030" sheet. The primary melting of four of the alloys has been completed. Primary electrodes are weighed, compacted into 1-1/2" octagonal x 12" long bars, welded together by electron beam, and melted in the arc furnace using a 2.9" diameter crucible. Melting takes place at 10-25 microns, 30-35 volts, and 1400-1600 amperes. Approximately four to six minutes are required to complete the melting of a 13-lb ingot. The primary ingots will then be forged to 1-1/2 diameter electrodes and remelted in the same 2.9" diameter crucible.

2. REACTOR PROGRAM

Coolant Systems Development

NPR Secondary Cooling Water. A brief literature search was conducted to determine whether gamma radiation from the NPR primary coolant should cause breakdown of morpholine or hydrazine in the secondary coolant in the primary heat exchangers. No data were found on morpholine; however, published information indicates no serious decomposition for hydrazine. At a concentration of 0.2 ppm hydrazine and a pH of 9, the predicted decomposition rate is 0.18% per day, with decomposition products reported as N_2, H_2, and NH_3. This rate applies for an estimated gamma flux of 250 mr/hr from the N_{16} present in the primary coolant. Gamma tests will be conducted at Hanford on morpholine decomposition if no off-site information can be found.

Fretting Corrosion. A test was initiated at 20 C and a pH of 10.0, using LiOH for pH control, to evaluate temperature as a variable in Zr-2 fretting. Two vertical assemblies identical to those used in previous tests were exposed at 15 and 30 fps using both natural loop vibration and an applied vibration of three cps to promote fretting. After two weeks of testing, the assemblies were examined and found to have only minor penetrations (less than 0.1 mil). Comparable testing at 316 C had produced penetrations of approximately two mils. This is interpreted as an indication that the testing has been measuring a true fretting corrosion phenomenon and not simple mechanical wear. The low temperature test will be continued in operation for an additional two weeks.

Detection of Fretting by Analysis for Zr-95. A Zr-2 fretting specimen was charged into KER-3 on August 9, and analyses of the loop water for Zr-95 have been made as a measure of fretting corrosion. A definite increase has been noted in the magnitude of Zr-95 present compared to the period when the sample was not charged. The Zr-95 activity level has been erratic, probably because the Zr-2 is not corroding at a uniform rate but has ranged from five to 100 times higher than during the control period. Examination of the specimen will be made after discharge.

Fuel Rupture Tests in ELMO-4. Several test runs were made with Zr-alloy core and high carbon core uranium metal fuel rods at 200 C, 15 fps, and 1700 psi for comparison with similar rods run at 300 C. Four of the Zr alloy core rods (two with 2 w/o Zr and two with 1 w/o Zr) did not exhibit any indication of rupture after 10 hours. Comparable rods previously run at 300 C first showed rupture indications after two hours. Four other rods with high carbon content (two with 62 ppm C and two with 1675 ppm C) were run for six hours at 200 C with no noticeable rupture. After a total of eight hours, one of the high carbon and one of the low carbon rods had ruptured with a typical 3/8" diameter raised and torn mound. After 10 hours total exposure, two of the rods still had not ruptured. The other 62 ppm C rod had a tremendously large ruptured area measuring 1-1/2 inches in length by 1-3/8 in width. One item of note is that the rod had increased in diameter from 0.59 inch to 1.37 inches. The 1675 ppm rod had a ruptured area about 1/2 inch x 5/8 inch.

Rupture of Irradiated Fuel Element in IRP. An isothermal rupture test at 300 C was made in IRP employing a 20-mil coextruded Zr-2 clad uranium rod, beta heat treated, 1.6% enriched. It had been exposed to about 2200 MWD/T in KER-2 at nearly 300 C. It was planned to rupture the element for one hour after first indications. However, after 30 minutes, the high loop activity readings necessitated a rapid cool down. The loop was decontaminated, and the rod again ruptured but only for an additional 20 minutes before it was necessary to shut down. The filter activity, which retains most of the rupture products, was plotted versus time adding the last 20 minutes to the first 30 minutes. A good continuous curve was obtained. As suspected, the rupture rate was increasing significantly with time. Up to about 30 minutes, the maximum rate was about 450 mr/minute. The interval, however, between 40 and 50 minutes gave an average rate of 840 mr/minute, almost a 100% rate increase. Previous tests of irradiated rods show the rupture proceeds around the rod, effectively decladding the uranium. The rate increase is attributed to this increase in exposed uranium surface area.

Aluminum Nitrate Production Test. The effects of aluminum nitrate water treatment on film formation may be significant. The H Reactor is presently operating with one-half of its cooling water treated with aluminum nitrate, while the other half is still treated with aluminum sulfate. The original objective of this test was to find ways to reduce effluent activity. Obvious film differences were first noticed on low exposure fuel elements and process tubes discharged from that portion of H Reactor cooled with $Al(NO_3)_3$ treated water. Control pieces (cooled with $Al_2(SO_4)_3$ treated water) show the characteristic reddish brown film, while pieces cooled with aluminum nitrate treated water show no colored film at all. However, the significance of this film difference is not clear, because another important variable was inadvertantly introduced in this test. Appreciable turbidity breakthrough was occurring on the $Al_3(NO_3)$ side of the water plant because of a lower chemical dosage. Certain types of turbidity have been found to actually remove in-reactor film instead of depositing film. Therefore, the cleanliness of fuel elements in this test may be due either to the increased turbidity or to the aluminum nitrate treatment. Water treatment is now under control, and the next discharge of test elements should show clearly the effects of $Al(NO_3)_3$ treatment without the simultaneous effects of high turbidity.

Structural Materials Development

Retubing Program. Zircaloy-2 tubes needed for the overbore test at C Reactor are on order with two qualified vendors. These vendors have cooperated in scheduling for the extremely short delivery time required. Approximately 10 tubes may be available in early January and 20 in late January.

NPR Process Tubes. Harvey Aluminum Company met their delivery commitment on October 31, for the first 30 NPR process tubes on the production order. Thirty-one tubes were delivered on that day out of 31 put through the nondestructive testing equipment. This performance is indicative of the excellence of the tubes. There were a few ultrasonic indications on the immerscope equivalent to the 0.003 inch scratch standard but none at the 0.005 inch level. None of these areas showed indications in the fluorescent penetrant test (Zyglo). The few Zyglo indications that were found in testing these tubes were removed by surface polishing, and the tubes passed a re-test.

Intensive vendor liaison in activating new nondestructive testing equipment was provided during a ten-day period in the last half of October. This work involved manufacture of standards for the immerscope and mechanical, electronic, and process modifications on all the tests. This assistance was largely responsible for the meeting of the delivery deadline. Another contributing factor was the excellent quality of the tubes, which obviated extensive conditioning and retesting. The vendor is ahead of schedule on the 70 tubes due by November 30.

Three full length NPR Zircaloy process tubes have now been autoclaved in the White Bluffs' facility. The last one had a good oxide film inside and out with certain localized exceptions. The outside was blemished by

white stains where the support hooks had contacted the tube. The inside showed a streak of "rust" deposited along the bottom and bordered on each side by a gray stripe. Mechanical modifications are being made which are expected to correct these conditions.

The autoclave persists in having a large temperature gradient top to bottom. The eight zones along the length of the autoclave show a uniform 425 C from end to end. The temperature in the bottom of these zones, however, varies from 325 C to 390 C. Abrasion test specimens exposed in these cooler zones show films greatly inferior to those achieved in the 425 C locations. Kaiser Engineers and a consulting firm they have retained are working to eliminate this temperature gradient.

Nonmetallic Materials Development

NPR Graphite Irradiations at the ETR. The GEH-13-5 experiment containing NPR reflector graphite continues to operate satisfactorily in the ETR N-5 position. The sample temperatures in the four positions are being controlled at 675, 700, 725 and 725 C.

The design of a temperature-instrumented capsule, GEH-13-7, is nearing completion. The test will provide qualitative comparisons of NPR core and reflector graphites with CSF graphite. It will contain 24 quarter-round samples and will be irradiated in the F-6 position of the ETR.

Physical Properties of NPR Graphite. Room temperature modulus of elasticity as determined by a sonic modulus apparatus was measured on two transverse and two parallel samples of NPR reflector graphite manufactured by the National Carbon Company. The parallel samples were solid rods six inches long and one inch in diameter and had an average modulus of 1.07×10^6 psi. The transverse samples were solid rods five inches long and one inch in diameter with an average modulus of 7.5×10^5 psi.

Irradiation Damage to Plastics. Low gamma dose rate studies on polyethylene ($\sim$ 300 r/hr) have shown no oxidation in a total exposure of 5×10^5 r. Irradiations to higher total exposures are continuing.

Lexan polycarbonate has been irradiated in a vacuum capsule at a gamma dose rate of 1×10^6 r/hr to 1×10^8 and 3×10^8 r. The gases evolved as determined by mass spectrometer (volume percent) are approximately:

Gas	1×10^8	3×10^8
CO	79.3	61.6
CO_2	15.8	34.4
Remainder, principally H_2, CH_4, O_2	4.9	4.0

The large increase in favor of CO_2 at the higher exposures is consistent with data on physical properties which show a complete loss of tensile strength in between these two exposures.

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Graphite Compatibility with Helium Containing 0.1 mm of Water Vapor. It has been observed that a 10% partial pressure of CO in helium effectively inhibits the C + H_2O reaction at water vapor pressures of 0.1 mm and at temperatures of 825 C. In the absence of the CO, the water reacted with the graphite at the appreciable rate of about 3×10^{-5} g/g hr.

Thermal Hydraulic Studies

Fuel Element Temperatures Following an Inlet Fitting Failure at K Reactor. Laboratory experiments were conducted to simulate a sudden complete failure of a front face hydraulic connector on a K Reactor process tube during reactor operation. Such an incident on the reactor would immediately initiate a scram; however, the only means of removing the heat generated during the post-scram period is by reverse flow of hot water from the rear header pressures would be required to achieve adequate cooling during the post-scram period. Data were obtained to show maximum fuel surface temperature during the transient heat transfer conditions versus rear header pressure for tube power levels from 750 to 1800 kw.

The experimental results indicate that a rear header pressure of 60 psig would be inadequate to prevent melting of fuel element cladding in process tubes with initial heat generation rates greater than about 1400 kw/tube. Since present K Reactor rear header pressures range from 60 psig down to 15 psig, it is indicated that central zone tubes with present tube powers of about 1500 kw would be subjected to fuel clad melting upon sudden failure of a front hydraulic fitting.

Heat Transfer Experiments Pertaining to NPR. The studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel element were continued. An electrically heated test section was used with the heated surfaces being of the same shape and size as the middle annulus of the tube-in-tube fuel elements. The tube-in-tube fuel element is simulated with only one flow channel at a time because full simulation of all channels at once would involve a very costly test section and an unwieldy number of experimental variables.

Four burnout determinations were made with different flow rate conditions as follows:

Pressure = 1500 psig
Inlet temperature = 585 F

Run No.	Mass Flow Rate ($lb/hr\text{-}ft^2$)	Burnout Heat Flux ($BTU/hr\text{-}ft^2$)
I	0.51×10^6	0.395×10^6
II	1.02×10^6	0.630×10^6
III	2.10×10^6	0.773×10^6
IV	3.12×10^6	0.877×10^6

The heat flux values are for the outer surface of the annulus and are about 19 percent greater than the flux on the inner surface. Burnout indications were detected at the outer surface in all cases.

Following Run IV, a steam leak prompted shutdown. Upon examining the test section, some small cracks were observed near the downstream end of the heated section. Although metal color indicated that a very high metal temperature was reached, local thermocouples had not indicated this. Concentricity of the inner and outer elements was verified as being proper and thus flow distribution was probably good. The cause of failure is unexplained at this time. The test section was repaired by replacing the outer tube of the assembly and was re-installed to continue this program. The above data will be combined with results from previous and future experiments to verify the fuel element design conditions. Such information is expected to be useful to IPD in establishing the maximum allowable power levels for the NPR.

Calculated Time Before Melting of an Uncooled K Reactor Fuel Element. During reactor fuel discharge operations the possibility exists of a fuel element becoming lodged in the rear face piping or other obstructions and not falling into the discharge basin where it is cooled by water. At the request of IPD personnel, calculations were made to predict the time required for such a fuel element to reach melting temperatures.

Ejection during reactor operation was considered as well as discharges occurring up to 10^6 seconds after reactor shutdown. It was found that for discharge during operation at tube powers of 1400, 1600, and 1800 kw/tube, the uranium of the "hottest" fuel element of the charge would reach its melting temperature at 118, 80, and 60 seconds, respectively. However, if fuel element discharge occurs more than 4.7, 6.7, and 8.9 hours following reactor shutdown at the respective tube powers above, there will be reasonable assurance that the exterior jacket of the fuel element will not reach its melting temperature.

Experiments to Investigate the Effect of Eccentric Fuel Elements on Boiling Burnout. The program to determine the effect of annular eccentricity on boiling burnout was continued. A test assembly was used which simulates a two-foot length of the annular coolant passage which is attained with I&E fuel elements in a K Process tube. The vertical position of the heater rod within the process tube can be adjusted on this assembly.

During the present series of runs the apparatus was adjusted to give a top-of-annulus gap which was 50 percent less than the concentric case, i.e., 0.056 inch versus a normal 0.112 inch annular gap. With flow rate and pressure conditions approximating those of a K Reactor fringe zone tube, the following burnout data were obtained.

Burnout Conditions

Eccentricity - 50% upward
Pressure - 53 psig

Run No.	Flow at 70 F gpm	t in °F	Q/A x 10^{-6} B/hr-ft^2	Subcooling °F
10	23.0	235	0.867	9
11	23.0	217	0.851	26
12	23.0	202	0.824	45
13	23.0	185	0.841	61
14	22.8	161	0.896	80
15	23.0	142	0.962	94
16	22.8	124	1.040	108
17	22.9	98	1.120	125

A plot of the burnout heat flux versus subcooling indicates a minimum burnout flux of 820,000 Btu/hr-ft^2 at 50 F subcooling. The data at a smaller subcooling than 50 F show an unexpected increase in burnout heat flux although otherwise the experimental data were quite consistent. Certainly the effect of subcooling shown by the data is hard to ignore even though it is quite unexpected. Further experiments which are planned will undoubtedly aid in understanding this condition.

Shielding Studies

Shielding Instrumentation. An improved type of fast neutron spectrometer has been suggested and is under development for use in shielding measurements. It is estimated that the improved instruments will cover a neutron energy range from about 200 Kev to at least five Mev. This represents an extension of the range of the Perlow counter by at least a factor of five in the high energy region and should significantly increase the utility of the instrument for measurements of fast neutron attenuation by shielding materials.

This proton recoil neutron spectrometer consists of three proportional counters filled with methane. Proton recoils from the methane in the first counter are collimated and enter the second and third chambers for a triple coincidence. The pulse height from the central counter is analyzed whenever a triple coincidence occurs in all three counters. A preliminary calibration was made for a methane pressure of 7.00 cm Hg (at 0°C). At this pressure neutron energies up to 4.45 Mev were successfully detected. Further work is in progress to determine experimentally the useful energy range of the instrument.

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.

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C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

PRTR Fuel Fabrication. Thirty-six Pu spike fuel elements were transferred to PRTR in November. These elements will be used in the criticality tests. Twenty-two clusters were of the Mark-I-G design using 30-mil wall Zircaloy-2 sheath tubing and the CRB core alloy containing silicon. These clusters were considered Class III fuel elements for zero power use because of the internal cracks in the tubing. The remaining 14 fuel elements were the Mark I-H design using 35-mil wall Zircaloy-4 sheath tubing. Eight of the Mark I-H elements were Class III elements because they used the CRB core alloy and were loaded with unknown gaps between core and tubing. The tubing used in these elements was undersize on the ID and could not be gaged at the time. Six of the Mark I-H fuel elements used the CSO (1.8 Pu, 2 Ni, Al) alloy, with the correct gap and were Class I clusters. It is planned to use these six for both the criticality tests and the power tests.

The second spike loading of 36 clusters to be used in the power run will be made up of Class I Mark I-H fuel elements. Three hundred and seventy-two of the 600 fuel element rods required are fabricated, but slow and erratic delivery of tubing has delayed completion of the remainder. However, all the core alloy required has been cast and extruded, and all auxiliary Zircaloy hardware is finished or in the final stages of fabrication.

Fabrication Development. In order to determine PuO_2 distribution, rods which had been previously loaded with PuO_2-UO_2 and swaged to 90% TD were machined into three horizontal and six transverse samples per rod. A technique of polishing has been developed which appears to hold the oxide particles in place satisfactorily. The milled horizontal surface is first vacuum-impregnated with boat resin. This surface is then polished flat with 180-grit silicon carbide until the impregnated surface is just ground through. This surface is then reimpregnated with resin. Five micron diamond paste is used to polish this surface down to the point where particles are just starting to pull out. This technique fixes the particles enough to keep them from pulling out while they are polished down to a truly representative surface. The polished samples were loaded, in an airlock, into a can filled with padding. While in the airlock the top of the can was placed over the sample so that a mylar covered "window" cut in the lid was stretched tightly over the sample surface. This assembly was then turned upside down, in a dark room, over a nuclear emulsion plate (Kodak NTA). When the surface was polished correctly and the emulsion was placed flat on the sample, excellent resolution of PuO_2 particles resulted. Not enough samples have been finished yet to come to any conclusions as to fuel distribution.

Nine rods were loaded and cold swaged to approximately 25 percent reduction in area for hot swaging studies. These rods will be used to study the effect of swaging temperature on density, hydride formation, O/U ratio

change and general physical properties. Ceramic grade oxides are of interest for hot swaging studies. Aside from the disadvantage of the characteristically low green density, ceramic grade powders have an extremely high absorbed gas content. This was proven by heating a cold swaged rod containing ceramic grade UO_2 to 700 C. After one hour at temperature the rod showed a bulge in one end and a split in the most severely stressed section. The tube used in this study had a wall thickness over 40 mils. Vacuum fusion analysis was performed on ceramic grade UO_2 and two types of fused UO_2. Nitrogen and carbon dixoide appear to be the two gases which are released from ceramic grade UO_2 in sufficient quantity to cause high internal pressures. A pressure system is being built to measure more accurately the gas volumes liberated from various types of UO_2. Preliminary data indicate that at 1000 C there are 2.5 cc of gas liberated per gram of ceramic grade UO_2.

The possibility of rupturing a fuel rod containing UO_2-PuO_2 during swaging has been of some concern due to the contamination clean-up problem. If a serious rupture occurs, a considerable amount of "down" time may be required to decontaminate the swage to a low enough level to continue developmental fabrication. With this in mind, the two-die rotary swage is being considered for use as back-up. Two 24" long elements were swage compacted on the rotary two-die machine. The tubes were loaded to an apparent density of 8.0 gms/cc. Existing dies allowed a 41.5% reduction to 0.573" OD. Excellent surfaces were obtained and measurements on the gamma absorptometer indicate densities of the order of 89% of theoretical. Lack of sufficient standards did not allow precise density measurements.

Development of Zr-clad, plutonium-bearing extended surface fuel elements was begun. Initial work concentrated on developing a suitable steel container to (1) protect the zirconium from oxidation and (2) serve as a contamination barrier for plutonium; a container was developed which withstood 95 percent reduction in area without cracking and was easily stripped from the zirconium sheet. Initial work also concentrated on bonding two sheets of zirconium. Bonding between Zr-Zr sandwiches was unsuccessful at 600 C with 95 % R.A.; however, some bonding occurred at 700 C and 91% R.A. Using dissimilar metals to aid bonding, bonds were obtained in Zr-Al-Zr sandwiches at 600 C and 650 C and in Zr-Ni-Zr sandwiches at 700 C. Work will continue on Zr-Zr bonding at higher temperatures and dissimilar metal sandwiches will be investigated further, particularly their corrosion behavior.

Two pneumatic injection cast irradiation capsules were completed up to autoclaving. The three and a half inch long capsules were made with 0.035 inch wall Zircaloy tubing and Al - 1.8 w/o Pu - 2 w/o Ni alloy cores. Four 90-inch long rods were made with Al - 2.5 w/o Pu - 2 w/o Ni alloy cores. This alloy will be used for a three-foot long, 7-rod, ETR irradiation cluster. If longitudinal Pu segregation is found when the chemical analyses of the four castings are completed, a change will be made in operating procedure which will permit mechanical stirring in air prior to casting. Minor piping modifications will be required before effecting such a change. Both the ingots and the injection cast rods of the latter alloy showed evidence of a greater tendency toward hot tearing than was found with the lower plutonium alloy.

Fuel Evaluation. An Al-Pu, 7-rod cluster has successfully completed 65 thermal cycles in the ETR 3x3 Loop plus five to seven reactor scrams. This element which is 42 inches long was made as representative of the PRTR plutonium fuels as possible. The in-reactor operating conditions were also as close to PRTR conditions as practical with a coolant pressure of 1050 psig. A thermal cycle consists of varying the coolant temperature between 180 and 480 F at the rate of 5 F/min. The core temperature then varies between 389 and 693 F. Rates of cooling were somewhat faster during the reactor scrams. The element is now being returned to Hanford for examination.

The ruptured UO_2 - 5.67 a/o PuO_2 capsule (GEH-14-89) is currently under examination. The Zircaloy-clad specimen was unintentionally placed in a thermal neutron flux eleven times the design value. The capsule was measured and sectioned. The cladding increased 9-10 percent in diameter and nearly one percent in length. All of the oxide fuel was missing. Metallographic samples of the cladding are being prepared.

Of the eleven UO_2-PuO_2 capsules at the MTR, nine were discharged at the end of October. Six are low-density specimens and three are high-density. Exposures for all eleven pieces will be about 5000 MWD/T. The companion specimens, irradiated to 1000-1800 MWD/T, are currently being evaluated in the Radiometallurgy Laboratory. Melting of the fuel core center was observed on one sample only (GEH-14-65). It contained low-density UO_2 - 0.187 a/o PuO_2 fuel pellets. Average power generation for this piece was 12 kw/ft.

Two Zircaloy-clad capsules (GEH-14-27, 28) were fabricated with Al - 2 w/o Ni - 1.9 w/o Pu alloy cores by injection casting. The pieces are being autoclaved. Design of the capsules differs from the description in the original test proposal; however, approval for charging was received from the MTR.

The examination of the 7-rod, Al - 1.8 w/o Pu alloy PRTR prototype cluster with Zircaloy cladding, stainless steel end fixtures, and quick-disconnect end caps is currently in progress. Several discrepancies in the initial length measurements were found. The uncut rods have been measured again and warp determinations are in progress. Measurements indicated that the rods increased from 0 to 0.019 inch (20.5-inch gauge length) in length.

The plutonium analysis for the 13.13 percent Pu-240 reactivity experiment capsules was low, necessitating refabrication. A new set of samples using 16.00 percent Pu-240 material is now being made for replacement. Also, another set of samples containing an Al-U-Pu alloy containing as much uranium as possible and using plutonium containing 16.00 percent Pu-240 is being fabricated for reactivity comparison with the same type of material without uranium. The RMF lattice subassembly has been completed and the sample holders are being fabricated.

The fabrication of the Al-Pu 7-rod cluster for an in-reactor rupture experiment is nearing completion. This cluster has an over-all length of

about 28 inches and is as prototypical of the PRTR elements as possible. The point of rupture will be in a flux of 1 x 10^{14} nv with an associated heat flux of about 253,000 BTU/hr-ft^2. It is proposed to conduct the test during the first part of January 1961. The element will operate in the ETR 3x3 for 10 to 20 days prior to rupture. The element will continue operation for a maximum of three days after the failure or until the radiation level in the cubicle reaches 40 R/hr. Gross gamma, delayed neutron activity, and the gamma energy spectrum will be monitored from the time of rupture. The rupturing device is being tested with a dummy cluster on which a welded Zircaloy rupture tip is sheared off. A new scheme is being investigated in which a brazed rupture tip is broken off, thus exposing the core. This type of device would provide a more authentic rupture area on the tube, ie., one which is not reinforced with weld metal. The write-up is being submitted for Reactor Safeguards approval.

UO2 Fuel Development

PRTR Fuel Elements. Seventy-eight PRTR 19-rod cluster swaged UO_2 fuel elements were delivered to the reactor. These included 10 elements equipped with neutron source holders and one element containing foils for the critical tests. In addition, two PRTR 19-rod cluster swaged lead elements clad in Zircaloy-2 and similar elements containing lead-cadmium were delivered for critical tests.

Fabrication Development. Metallographic examination of hot swaged Zr-4 cladding did not reveal any hydride phase. However, relatively high concentrations of hydrogen were detected spectrochemically. This indicates that the hydride present in hot swaged Zr-4 cladding is not precipitated but is present as a very fine precipitate which cannot be detected metallographically.

Electrodeposited UO_2 having randomly sized particles (all -48 mesh) was cold swaged to ~88% T.D. Similar particle sizes of fused UO_2 can be cold swaged to only ~84% T.D. Examination of photomacrographs of both powders showed that the electrodeposited UO_2 particles were angular and non-equiaxed.

High energy (Dynapak), impacted UO_2 (99.4% T.D.) was vibrationally compacted into a Zircaloy-2 capsule (4" long x 0.565" OD) to a bulk density of 90%. The UO_2 had a O/U ratio of 2.0057 and a particle size distribution of 65 w/o (-6+10 mesh), 15 w/o (-35+65 mesh), and 20 w/o (-200 mesh). The fuel capsule will be irradiated in the ETR.

The cladding geometry does affect the bulk UO_2 density obtained by vibrational compaction. UO_2 mixtures which can be compacted to 90% T.D., in 9/16" diameter rod segments have a density of 85% T.D., in a 1-3/4 inch OD, 1/2" ID, 18" long tubular fuel segment. Two procedures are being evaluated for increasing the UO_2 bulk density in the tubular fuel segment. Particle size compositions specifically selected for each cladding geometry will be determined and fixture modifications will be made to provide a more efficient coupling between the cladding and the vibrator.

Welding Development. Work piece speed during high frequency resistance welding of the spacer ribs has revealed many desirable aspects of high speed. The speeds investigated ranged from 18 to 60 inches per second. Average optimum speed of 45 inches per second produced less distortion, less atmosphere contamination during welding, greater sensitivity in welding parameters and possibly greater freedom in rib configuration. Both empty tubes and swaged UO_2 fuel rods were used for this investigation. The welds were evaluated by shear tests and by autoclave corrosion tests. Shear strength varied between 750 to 1000 pounds per lineal inch of weld. A thin line of grey oxide corrosion occurred at the base of the rib during the autoclave exposure. This corrosion is probably due to trapping etching solution during cleaning, prior to autoclaving.

Zircaloy ribs were welded to six UO_2 pellet loaded fuel rods supplied by Westinghouse Atomic Power Division. The high frequency resistance welding process is being considered by Westinghouse for joining spacer ribs to fuel rods for the CVTR. These preliminary tests indicate that the process is applicable to continuous welding spacer ribs on loaded fuel rods at high speeds.

Corrosion Studies

Effect of Gamma Irradiation on Corrosion of Zirconium Alloys. Two lots of Zircaloy-2 and three of Zircaloy-4 were autoclaved at 400 C, 1500 psi, in a gamma flux of 2×10^6 R/hr for seven days at K-East. One set of samples was tested under static conditions and another set was tested under refreshed conditions. Weight gains for the samples in the static test (in which a short temperature excursion took place) were two and three times more than normal. However, weight gains for the samples under refreshed conditions were normal. Another static test is being run to recheck the first results.

Chromium Plating of Zircaloy-2. The chromium plating of Zircaloy-2 by a vapor deposition process employing dicumeme chromium showed some promise of slowing hydrogen absorption by Zircaloy-2. Initial work on this process produced non-uniform plates. Further work on the process, adjusting temperature, gas flow, and rate of vaporization, has not appreciably improved the non-uniform deposition. Experiments without a carrier gas are now planned.

Aluminum Alloy Development. Several compositions of super alloys have now received nine months and others one year of exposure in refreshed 360 C deionized water and are continuing to maintain their excellent corrosion resistance. Those with one-year exposure (fabricated by Alcoa) are 1.5% Ni, 1.5% Fe (0.66 mil penetration); 2.85% Ni, 0.37% Fe (1.39 mils); and 2.85% Ni, 0.27% Fe, 0.37% Cr (2.57 mils). Those with nine months of exposure (fabricated at HAPO) are 1.5% Ni, 1.5% Fe (two melts); 1.2% Ni, 1.8% Fe; 1.0% Ni, 1.5% Fe; and 0.64% Ni, 2.1% Fe. The highest penetration of any of the latter alloys is 0.30 mil.

Melts of 1.8% Fe, 1.2% Ni high purity base alloy prepared by casting techniques differing in cooling rate, holding time, holding temperature and casting temperature are being compared in a 360 C corrosion test.

A SAP alloy from Alcoa which contains 7.03% Ni and 4.81% Fe shows only 0.42 mil penetration after two months of exposure. This is the lowest penetration obtained with a SAP alloy, but the high alloying element content precludes it from serious consideration at the moment. Another SAP alloy containing 7.8% Fe, 0.2% each of Cr, Ti, V, and Zr, and 0.5% Al_2O_3 failed in ten days.

Fretting of Zircaloy in PRTR Fuel Elements. A test to determine whether breakage of a spiral wrapping wire on a PRTR fuel element would cause fretting has been completed. This test was run in the ELMO-7 loop using deionized, deoxygenated water at 300 C with the pH adjusted to 10.0 with LiOH. The single rod fuel element was suspended in a vertical, 1-inch OD x 0.065-inch wall stainless steel tube during the test. The fuel element was fastened in a mounting bracket at the top only. Prior to exposure the wire wrapping was clipped at the bottom end to simulate a broken wire. The flow rate was 95 gpm, producing a water velocity of 67 ft/sec. The high flow rate was purposely used in order to encourage fretting. The fuel element was periodically visually inspected for fretting. After 57 days, only one shallow pit was noted. A few areas showed signs of wear, but the depth was very shallow. However, after an additional 20 days, four grooves, five to 10 mils deep by 1-1/2-inch long, were found uniformly spaced along the lower third of the fuel element. At the point where the wire was vibrating against the test section, approximately one-third of the wire thickness remained.

Initial studies to determine whether fretting would occur on a PRTR process tube due to vibration of a PRTR fuel element have been made. The test was made in 300 C, pH 10 (LiOH), deionized water. A ten-foot section of PRTR Zr-2 process tube was inserted inside a vertical four-inch schedule 120 stainless steel pipe section. A 19-rod cluster PRTR fuel element containing UO_2 was suspended inside the process tube. The maximum PRTR tube flow rate of 123 gpm was used. Inspection of the process tube after four days of exposure did not reveal any fretting. Inspection after an additional two weeks of exposure revealed that fretting to an estimated depth of two to five mils deep had occurred at each of the six points corresponding to the six bottom supports of the fuel element. Only three fretted areas were found at the top, again corresponding to the fuel element support positions. These three fretted areas did not appear to be as severe as those at the bottom of the process tube.

Structural Materials Development

Process Tube Monitoring. The PRTR Mark I monitor and a rented TV camera were used to inspect the Zircaloy process tube in the 314 Building Single Tube Mockup. Fretting penetrations estimated to be one to two mils deep were found at the location of the top and bottom fuel element spacers.

Fabrication of the eddy current gas gap measuring instrument developed by Instrument Research and Development has been completed. Initial tests of the instrument in a PRTR mockup tube indicate the instrument to be very stable and reproducible. Calibration tests are now in progress.

The wall thickness testing probe has been designed and fabrication is complete except for installation of the transducer crystals. The Vidigage type ultrasonic wall thickness measuring unit has been shipped. A special transducer crystal mounted in lead-filled epoxy with a silicone impregnated fiberglass base has been subjected to 10^8 R total gamma irradiation with no noticeable effect. Gamma testing is continuing. Various types of epoxy potting compounds used for sealing around electrical leads and for mounting crystals have also been subjected to 10^8 total gamma. Eccoceram Type CS failed at this dosage by expansion and formation of a cellular type structure.

KER Process Tube Examination. Examination of the central section of the irradiated KER Loop 1 Zircaloy-2 pressure tube was continued. The burst sample which failed at a low pressure was found to contain up to 1000 ppm hydrogen at the cooler, inner surface; with the concentration gradually declining to normal (about 20 ppm) at the outer surface. A two-inch long, oval-shaped patch of scale five to ten mils thick was found on the inside surface of the tube associated with the hydrided area. An x-ray diffraction pattern of the scale indicated the primary constituent was ZrO_2. Examination and chemical analyses of the scale and parent metal will continue in an attempt to identify any impurity or other explanation (such as evidence of localized overheating) to account for the severe localized corrosion. Several cracks were found at one end of the burst test specimen. These cracks were in the area of localized hydriding and extended about 1/2 inch from the end of the sample. Since this portion of the tube is constrained by the end-closure grips during burst testing, it is doubtful that these end cracks could have been caused by the loop stress set up by the burst test. Since the tube is brittle in the hydrided region, it is probable that the specimen was cracked in handling during or after reactor discharge. The presence of cracks in the specimen would account for its unusual behavior in the burst test.

Zircaloy Sheath Tubing. The fabricator of the 0.495 inch ID Zircaloy-4 sheath tubes for the Pu-Al fuel elements has been making a concerted effort to expedite new material through a modified fabricating process to replace tubes rejected because of impressed foreign particles on the inside surface. Chemically removing the foreign matter leaves pits up to 10 mils deep. Recent shipments have shown a marked improvement in surface quality, and it is anticipated that a steady flow of good quality tubing will be delivered for the next few weeks.

Failure of all nondestructive tests, except white light borescoping to detect the presence of these deep pits on the inside surface emphasizes the need for an intensification of the work to evaluate and refine nondestructive tests for sheath tubing. A series of holes, 0.010 inch deep and ranging from 0.002 inch to 0.012 inch in diameter in 0.002 inch increments, were drilled in a section of 0.495 inch ID sheath tubing. Using the routine ultrasonic testing techniques, it was found that the ultrasonic equipment would not detect any of the holes. The applicability of the eddy current test in detecting pits and wall thinning is being studied. Several eddy current standards have been fabricated, most

of which are designed for use with the encircling coil of the Metrole Unit. However, a probe-type coil has also been fabricated and development testing is in progress to determine what kinds of standards are needed.

Radiometallurgy Laboratory Studies

A longitudinal section at the downstream end-cap of a defected ceramic element was examined to determine whether there was any variation in hydriding of the Zircaloy-4 sidewall cladding and the Zircaloy-2 end cap. It was impossible to determine the presence of hydrogen by metallographic examination due to the recrystallization which occurred during welding (RM-611). The "sintered" rod of a four-rod cluster showed no change in the structure of the UO_2 fuel. However, the "swaged" rod had partially recrystallized and a small void was seen at the center of the core. Only limited amounts of hydrides were observed in Rods 2 and 3 near the outer surface of the cladding (RM-616).

Metallurgical examination of a longitudinal section from a low density UO_2-PuO_2 capsule disclosed that complete recrystallization of the oxide fuel had occurred. This was the only capsule from this examination request in which the fuel had been completely recrystallized. A sample was obtained for burnup analysis (RM-654). A 7-rod cluster, 45 inches long, has been photographed and disassembled. Diameters of the individual rods were measured (RM-661). The ruptured high density UO_2-PuO_2 capsule irradiated in an extremely high flux zone in the MTR was sectioned, but it was found that none of the core material remained. The Zircaloy-2 cladding was badly deteriorated with a thick diffusion layer on the inside and numerous cracks in the weld area.

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

Thermal Hydraulic Studies

Experiments to Determine Boiling Burnout Conditions for the 19-Rod Cluster Fuel Element. An electrically heated test section was used in an attempt to further define the boiling burnout conditions for the PRTR 19-rod cluster (Mk-I) fuel assembly. Flow rate and inlet coolant temperature were held constant while the heat generation rate was increased in small steps. The test was terminated at a rod flux of 720,000 BTU/hr-ft^2 because of a steam leak and a change of electrical resistance in the test section.

The test section consisted of 19 Inconel tubes of 0.008 inch wall thickness with a machined ceramic insert (ALSIMAG 222, American Lava Corp.) inside of each tube. The ceramic was used to prevent collapse of the thin wall tubes under 1050 psig external pressure. Wire wraps were used on the rods and around the entire bundle just as they are used on actual Mk-I fuel assemblies. In the test assembly there was heat generated in the bundle wrap with a heat flux of about 1.1×10^6 BTU/hr-ft^2 at test termination.

Upon removal of the test section, the over-all bundle wrap (0.072 inch diameter Inconel wire) was broken and a section about 15 inches long was missing from the downstream end of the assembly. Eight tubes were found to have ruptured, two by burning (melting) through at a spot extending

at a frequency of about 15 cycles per minute and had amplitudes as great as ± 0.4 inch. However, it was observed that instability could be eliminated completely by raising the gasholder volume.

The reflector system was completed by J. A. Jones Company and turned over to PRTR Operations on November 1. Design tests on the reflector system were terminated when it was found that the throttling valve in the system was vibrating excessively as a result of the large pressure drop across the valve. Opening the throttling valve to allow increased system flow with less pressure drop caused pump cavitation. The throttling valve has been removed from the system and sent back to the factory for alterations to make the valve more suitable for throttling service. In addition, it is intended to install a fixed orifice in series with the valve to take part of the system pressure drop.

Construction work on the reactor control and flux monitoring systems was completed and these systems were turned over to PRTR Operations on November 9 for design testing. Initial operation of these systems was generally satisfactory though considerable trouble was experienced with the preamplifiers of both startup channels. These problems were finally traced to the lack of proper provision for fission chamber high voltage supply and ground loops. Both startup channels also exhibited excessive fluctuations (considerably greater than could be explained by statistical considerations) at levels below 1000 counts per minute, as well as spurious period trips in this region of operation. The solution to these problems was to incorporate a somewhat longer time constant in the log count rate meter circuit and a reduction of the coupling between the period and LCRM circuits.

The intermediate level period channels have also caused a number of spurious reactor scrams. These can usually be associated with transient conditions such as the pulling in or dropping out of relays in the vicinity of the instruments. Efforts are being made to eliminate or reduce these interactions.

There appears to be considerable stray voltage pickup in the containment instrumentation, resulting in frequent spurious tripping of the containment circuits. Attempts are under way to isolate and eliminate the sources of the pickup.

Process tubes were swabbed clean and were capped at the inlet prior to filling with D_2O for critical tests. Motors were installed on the primary pumps and pump auxiliary piping is nearly complete. The injection system, primary storage tank, and primary cleanup system have been flushed, cleaned, and rinsed. Injection pumps were fitted with plungers and packing and operated satisfactorily during the cleaning. Work has been started on all Phase III-A primary system piping modifications; several items are complete and the remainder are being completed to the extent required prior to cleaning the system.

The mechanical portion of the fuel element rupture monitoring system was completed and moved into the containment vessel. It has not yet been

set in place at the -21 foot level of "C" Cell pending completion of floor support modifications. Some preliminary electrical wiring work is progressing at its present location in the reactor hall.

The electronic portion of the fuel element rupture monitoring system still has not been received. The manufacturer still has not solved all of the switching transient problems although he reports that improvements have been effected. Efforts are being made to determine the magnitude of the problem and to develop potential solutions in case the manufacturer fails to provide a workable system. If it is determined that the current method of switching using stepping relays shows only marginal chance for success, the switching system will be re-designed.

Considerable effort has been expended in fitting up the fuel transfer system and in making small alterations to improve operation. The system is not yet fully operable.

The PRTR Load-Out Cask and accessories were shipped from the vendor on November 14, 1960. Upon arrival at Hanford, the cask and accessories will be mounted on a modified 25-ton low-boy trailer.

The fuel element manipulator for the PRTR fuel element examination facility has been installed in its normal operating position for testing at the vendor's shop. Preliminary tests indicate that the manipulator is operable but that several adjustments will be required. Certain portions of the manipulator still require minor additional finish work.

The Maintenance and Mockup Facility (including the Critical Facility Building and Rupture Loop Annex Facility) is estimated to be 15% complete versus a scheduled 17.4% complete as of November 30, 1960. Excavation for the Rupture Loop Annex was completed and is in progress for the Critical Facility and M & M Buildings. The concrete pour for the PRTR ventilation filter vault is approximately 25% completed. The majority of underground service line installation has been completed.

PRP Critical Facility (Project CAH-842). Over-all design of the project is 96% complete versus 100% scheduled. No progress was made on the major remaining design item - the reactor control console - because of PRTR startup demands.

The M & M construction contractor has finished driving the pilings needed to permit excavation of the Critical Facility structure to the required depth. The pilings will be used as the outer form of the cell. Construction on the structure contract is approximately three percent complete.

A trip was made to the Henry Pratt Company, Chicago, Illinois, to review the design of the Fuel Transfer Lock for the Critical Facility in order that fabrication could be started promptly.

Drawings of the fuel element thimble tube development have been issued for comment.

A mockup of the revised level control weir has been completed and is now being tested.

Fuel Element Rupture Test Facility (Project CAH-867). The GE portion of the design is 81% complete as against 88% scheduled. Preliminary design of the water plant was submitted by Cornell, Howland, Hayes, and Merryfield. The material was reviewed and discussed with representatives of the AEC. Detail design started November 16, 1960.

The only construction contract now in effect is that with George T. Grant Company which includes construction of the Maintenance and Mockup and Critical Reactivity Measuring Facilities. It is estimated that the Fuel Element Rupture Test Facility part of the contract is five percent complete. No schedule for individual parts of the work has been provided by the contractor to date.

Negotiations on a contract with Chase Brass Company for the rupture loop pressure tubes have been completed, and a contract has been awarded by HOO-AEC. Total cost will be $25,300 for the tube lot of three to five tubes. Orders have been placed for $213,206 worth of equipment to date. Total estimated value of equipment to be GE procured is $416,000. Additional requisitions for equipment estimated to cost $37,000 are out for bid. Major equipment items yet to be requisitioned are the instrumentation and electrical packages. It is expected that specifications for these items will be completed by January 2, 1961.

The inlet valves have been ordered from Aero Supply and requisitions for other long term delivery items have been issued.

A spare PRTR process tube and a section of NPR tubing have been procured for fabrication of a simulated rupture loop process tube for critical tests.

Design and Component Testing

PR-10 - Primary Loop Mockup. The spare primary pump operated 579 hours during the month for a total of 3217 hours. The pump was shut down on November 1, 1960, due to high vibrations, greater than three mils on the pump, and a definite motor bearing howl. One of the upper motor thrust bearings was faulty. The two upper thrust bearings were replaced with one deep groove type bearing, giving both radial and thrust protection. The seals were examined during the motor repair and were in excellent condition with no measurable wear on the seal faces. Pump vibrations have been consistently below one mil since resuming operation. The above change is being considered for the reactor pumps, also. The leak rate suddenly and unexplainably increased from less than 0.1 gph to approximately two gph on November 22, 1960. The seal temperature and motor current have remained in a normal range.

The prototype pump with the self-adjusting seal assembly has operated 612 hours this month for a total of 4024 hours of operation. The seals were examined at 3644 hours with no signs of wear or failure evident.

The Aldrich injection pump has now operated 2683 hours with the molded Vee-Flex rings. Leakage rates for the three plungers are presently 80 ml, 520 ml, and 200 ml/hour.

Process Tube No. 586-6063 has operated for a total of 5110 hours at reactor conditions. Examination of the fuel element was made by the Fuels Development Operation representative with no irregularities observed. The process tube was examined by the Materials Development Operation representative and revealed evidence of wear primarily at the fuel element lower spider location.

The replacement nozzle-to-process-tube gasket in the single tube prototype has averaged less than one ml/day leakage.

PR-40 - Shim Control Mockup. Three special shim control assemblies for use during criticality tests have been completed. New Western Gear motors and friction brakes have been installed on these units.

All shim control assemblies have been received from GE, APED, and have passed acceptance tests.

PRTR Special Reactor Tools. Seventeen drawings have been issued for approval.

The fuel element extractor was demonstrated under a simulated load of 1900 pounds following severance of the outer wire wrap from a 19-rod cluster. Maximum pushing force required was 2570 pounds, 400 pounds greater than required for removing an intact fuel element.

Several shroud tubes were removed from a simulated calandria bottom plate arrangement by a new technique of collapsing the tube to release the rolled joint.

Fabrication of the access plug core saw, load-out cask valve wrench, and load-out facility extension hook has been completed.

Calandria Tests. The calandria mockup was reactivated to study moderator level instability and water carry-over observed in the gas lines during reactor tests. Observation indicated that water was carried over when 500 or more gallons per minute were flowing over the weir. Modifications of the bottom drain plug and down-comer baffles for the gas lines are being studied.

Design Analysis

PRTR Primary Coolant Leak Study. A comprehensive review of PRTR primary coolant leak studies including the problem of maintaining fuel element cooling following the injection of light water was completed. This review showed that primary coolant leaks should not result in any fuel element melting. The emergency light water injection system can provide an adequate supply of backup coolant for leaks of all sizes and locations. For small leaks it is necessary to rapidly depressurize the primary coolant system by opening the two-inch vent valve on the pressurizer so that light water can be injected by the secondary light water injection system before any fuel melting occurs. After light water injection has been started, the size and location of the leak will determine what action must be taken to assure continued adequate cooling.

Hazards Analysis for PRP Critical Facility. Equations were developed for analog computer calculations of the consequences of various nuclear accidents in the PRP Critical Facility. Cases to be studied include excursions from:

1. Withdrawing control rods at the maximum possible rate.
2. Raising moderator at the maximum possible rate.
3. Dropping an enriched fuel element into the core with the reactor critical.

The above excursions are being studied for the case of D_2O moderator with full and half moderator level.

Preliminary runs indicated that the rod safety system would limit fuel temperature increases to a few degrees for any credible reactivity input.

PRTR Physics Analysis. A summary of two-dimensional multigroup calculations has been prepared and issued as HW-67246. These results substantiate previous estimates of power distributions from one-dimensional analyses. However, there appeared to be substantial disagreement in reactivity values obtained. An analysis of these data will be carried out when critical test results become available.

Some additional preliminary data on coolant void tests in CVTR critical experiments was obtained. Their results indicate a decided negative coolant coefficient which they attribute mostly to the annulus of coolant surrounding the cluster. A similar effect should be observed in the PRTR lattice.

PRTR Startup. Detailed procedures for Critical Tests have been organized in final form to conform with the startup schedule. The exponential measurement in CT-1 has been deleted and several shim rod configurations which appeared to be duplicated were dropped from Critical Tests 5, 8, and 11.

Critical Tests have been initiated with the first loading to critical. Criticality was achieved with 59 UO_2 fuel elements surrounded by a blanket of 26 Pu-Al spikes and a moderator level of 104 inches. Further evaluation of data from this test is in progress.

Preparation and review of power test descriptions is continuing in conjunction with the Power Test Sub-Council. Descriptions were completed for Power Test 20 (Flux and Power Distribution) and Power Test 24 (Long Term Reactivity Changes).

During most of the month engineers have been assigned to shifts at the reactor building to provide a continuous reactor safeguards audit during critical testing. Personnel have also been assigned to the shift physics crews for performance of critical tests and analysis of data.

PRTR Primary Coolant System - Stress Analysis of Bimetallic Welds. There are four bimetallic (carbon steel to stainless steel) welds in the PRTR Primary Coolant System Piping. The stresses in each of these four weld regions were calculated and compared to the requirements of the U.S. Bureau of Ships tentative code for nuclear pressure vessels. This code was used because it evaluates the effects of transient stresses and cyclic fatigue stresses as well as the usual static stress criteria found in the ASA or ASME codes. The results of the analysis show that transient conditions (as presently outlined in the Process Specifications) will not cause stress intensities unacceptable to the Ships Code. However, the steady state stresses in the inlet and outlet nozzles of the pressurizer are unacceptable to the BuShips Code unless it can be shown that these stress levels will cause no harmful effects (such as creep or stress rupture) in the piping. These four areas of high stress are also being checked independently by the Electric Boat Division of General Dynamics Corporation. After their report is received, a complete report will be issued.

PRTR Operations Planning

Preparation of PRTR Operating Standards continued through November. Sixty-four of the 86 standards pertaining to the reactor have been approved; nine additional standards were issued for review and approval. The remaining standards are currently being written. Review and approval of the PRTR Operating Procedures by the Startup Council continued. Seventy-five procedures have been approved to date. The remaining 16 are under review. Operational training of the PRTRO technologists continued with emphasis on console and scaler operation in preparation for, and in conjunction with, critical tests.

Testing of the river pumps continued with Pump #1 operating 340 hours and Pump #2 in operation 304 hours. The condenser orifices were reamed to prevent over-pressurizing the water jacket with both pumps operating. Rotameters have been installed in the air compressor cooling system to permit close control of the cylinder wall temperatures. Spare parts for the Hofer compressors were shipped from Germany and are expected to arrive at Hanford in early December. Special cold-rolled (half-hard) stainless steel for Hofer compressor diaphragm replacement has been received. In addition, a number of specialized reactor spare parts items have been obtained on direct purchase to support the design and critical test effort.

The 1-1/2-ton hoist was removed from service shortly after being turned over to PRTR Operations by Minor Construction since the mechanical brake was defective. All charging operations are being performed with the 30-ton hook until new brake shoes are obtained and installed on the 1-1/2-ton crane.

Review of vendor drawings for the Rupture Loop and Critical Facility continued. Day-to-day assistance has been rendered the personnel responsible for installing the Gas Loop.

Discussions were begun with members of Programming Operation and Reactor Technology Development Operation concerning the detailed procedures for the approval of reactor experiments after the startup testing program is

completed. The general requirements are outlined in the PRTR Final Safeguards Analysis Report.

Performance of PRTR Critical Tests, as described in HW-61900B, began during the month. Installation of critical test instrumentation began on November 6. This instrumentation was tested on November 13, with a Pu-Be source attached to a UO_2 element. The process tubes were filled with D_2O and charging of UO_2 elements began on November 15, in preparation for Critical Test 1A. Multiplication data obtained from this experiment did not yield usable information because the loading was so far sub-critical. Exponential portion of the test is scheduled for later in the testing program.

On November 18, Pu-Al elements were loaded in a ring outside the core of 61 UO_2 elements as part of Critical Test 2A. Results of this test indicated it would take approximately 61 UO_2 and 26 Pu-Al elements to achieve criticality with a moderator level of 103 inches. Preparations for Critical Test 9 (Critical Experiment, Full Load, Two-Zone Loading) began on November 20, with the replacement of UO_2 elements with Pu-Al. On November 21, the loading was changed to 59 UO_2 and 26 Pu-Al. Criticality was achieved with a moderator level of 103.6 inches.

Critical Test 10A (Level Sensitivity, Full Level, Two-Zone Loading) began November 21. Results indicate the moderator to be worth 0.5 mk/inch at 104 inches. Critical Tests 2B and 2D, designed to establish criticality at 93-inch moderator level in preparation for shim rod calibration was begun immediately after completion of Test 10A. With fuel loading of 56 UO_2 and 29 Pu-Al, the moderator was found to be worth 1.6 mk/inch.

Critical Test 11 (Shim Worth, Full Level, Two-Zone Loading) was begun November 25. Preliminary results indicate the maximum worth of a single 36-inch shim is 3.2 mk. With the shim positioned such that the three shims in an assembly are covering the core, from 0 to 100 inches, assemblies in the inner, middle and outer rings evaluate at 4.7, 5.1, and 3.3 mk, respectively.

Critical Test 10B (Moderator Void Tests) performed on November 27 indicates there is no discernible increase in reactivity when a gas bubble is released in the moderator D_2O. The test was not performed at typical PRTR operating conditions and will therefore be repeated at a later date.

Tests 2B, 6, and 7 were completed on November 28, and Critical Test 8 was begun. Test 8 (Shim Worth, Three-Fourths Level, Two-Zone Loading) is in progress at month-end.

In order to start up the PRTR Gas Loop safely and on schedule, an extensive training program for PRTRO personnel is planned. A training schedule has been set up, lectures have been outlined, training materials have been designed, and manuals and operating procedures are being prepared. As presently planned, the formal portion of the training program will last eight weeks, beginning February 1961. Informal training and refinement of operating procedures, standards, electrical and instrument manuals, etc., will continue until loop startup.

Preparation of the detailed test descriptions and procedures continued. Three of the Power Tests previously planned were found to be unnecessary and were, therefore, eliminated. The amount of effort devoted to preparation of the Power Tests was restricted during the month because of the necessity for personnel to assist in performance of Design and Critical Tests.

Performance of Design Tests continued with major emphasis being placed on those systems needed for the Critical Test Program.

Design Test 5C (Helium Gas Balance System - Cold) has been modified and extended by two addendums. Testing of this system was begun and the effects of different gas balance control valves on the moderator equilibrium level were determined, thus completing Addendum 2 of this test.

Sections of Design Test 9 (Reflector System - D_2O) and Design Test 7 (Moderator System, Cold - D_2O) were completed in preparation for critical testing. The moderator storage tank was calibrated as part of Design Test 48 (Moderator System Volume Determination - D_2O).

Testing of the Annunciator System under Design Test 28 was begun, and the Criticality Alarms were checked as an addendum to Design Test 33 (Communications and Alarm Systems).

The shim rods were recalibrated under Design Test 30, using a new trim pot. Some of the indicator units had failed since the first run of this test. Minor problems still exist in the position indicators of individual assemblies. These are presently being corrected.

The following Design Tests were essentially completed during the month:

Design Test 27 A - Safety Circuit - Pre-Critical Testing
Design Test 36 - Ion Exchange System, Deuterization and Dedeuterization (Primary System Ion Exchanger still to be deuterized)
Design Test 39 - Flux Monitoring System
Design Test 46 - Reflector System Volume Determination - D_2O.

The Manual Control Interlock Tests of Design Test 44 (Reactor Automatic Controller) were performed for Critical Test purposes. Design Test 44 will be done in its entirety at a later date.

The water softeners were retested under Design Test 12 (Secondary System - Miscellaneous). Difficulty is still encountered with the automatic cycler. The vendor has been requested to assist in correcting this problem.

Testing continued on Design Test 20 (Electrical System, Motor Control Centers) in conjunction with other tests.

2. PLUTONIUM CERAMICS RESEARCH

Plutonium Dioxide - Uranium Dioxide

Experiments relating oxalate calcination temperature, and hydrogen atmosphere moisture content, to the structural stability of plutonium dioxide have been continued. Pellets calcined at 150 C intervals from 150 to 1050 C gave an almost constant O/Pu ratio of 1.81 after heating for one hour at 1500 C in tank hydrogen (0.5 v/o H_2O). Pellets heated in He reduced to an O/Pu ratio of 1.88. Pellets heated in very wet H_2 (greater than 2 v/o H_2O), all exhibited an O/Pu ratio of 1.98, while those heated in very dry gas (approximately 0.02 v/o H_2O) showed a decreasing O/Pu ratio of 1.99 (150 C calcine) to 1.86 (1050 C calcine). These comparatively high ratios were reproduced in a repeat experiment.

X-ray patterns of the as-sintered PuO_2 surface have repeatedly identified PuO_2 and alpha and beta Pu_2O_3; however, these suboxide phases may easily be removed by grinding as little as 0.003 inch from the pellet surface. It had been thought that perhaps the reduction of PuO_2 was simply a surface effect; however, calculation of the depth of oxygen depletion was not consistent with the x-ray data on the ground surfaces. There are still several possible reasons for the reduced surfaces.

1. The reduction may exist as a gradient, i.e., a lower O/Pu ratio toward the surface with the ratio gradually increasing with depth.

2. There exists the possibility of reaction with Mo or Al_2O_3 from the furnace to form a reduced "skin".

3. Possibly grinding the surface oxidizes the Pu_2O_3 to PuO_2.

These possibilities are now being investigated.

Samples of PuO_2 sintered at low temperature have been observed to have an anomaly in the thermal expansion at about 650 C in which there is a plateau or arrest in the expansion for an interval of about 100 C. The British have also observed anomalous expansion for partially reduced PuO_2. High temperature x-ray diffraction measurements are being made to observe the lattice expansion for comparison with dilatometric results, and to identify any changes of lattice structure. Results so far obtained are consistent with the British dilatometric results (Grenoble Paper #5).

Plutonium Carbides

Several experiments were carried out during the past month on stabilization of the PuC peritectic. UC, PuH_3, and carbon were mixed to give compositions of PuC-35 UC and PuC-65 UC. The samples were heated to 1450 C for four hours in Ta crucibles and gave lattice parameters of 4.966 and 4.963 A, respectively. These samples were reheated to 1730 C for one and one-half hours in 1 x 10^{-4} mm Hg vacuum. X-ray diffraction after this treatment gave a single carbide phase with no indication of Pu_2C_3, although a small

amount of oxide was present. Lattice parameters were 4.965 and 4.958 A, respectively, for the PuC - 35 and 65% UC compositions, respectively. In this same treatment a sample of pure PuC showed a small amount of Pu_2C_3.

A 50-gram batch of PuC has been formed by reacting Pu hydride with carbon. Good x-ray resolution of this phase and a lattice constant of 4.969 ± 0.003 A resulted, although a small amount of PuO_2 was detected. Some PuC was mixed with UC to give PuC - 50 UC. This sample and one of pure PuC were heated to 1550 C in a 10^{-5} mm Hg vacuum. The PuC-UC mixture produced a very gray metallic-appearing button with a_o = 4.966 A, corresponding to a carbon-rich structure. The PuC sample contained about 10 w/o of Pu_2C_3.

Another PuC specimen heated to 1700 C produced about 40 w/o of BCC Pu_2C_3. This specimen and the aforementioned sample containing 10 w/o Pu_2C_3 were heated to 1450 C for three and one-half hours in an effort to homogenize the non-equilibrium structure. Instead of approaching pure PuC, the samples increased from 10 and 40 w/o Pu_2C_3 to approximately 70 and 100 w/o Pu_2C_3, respectively.

Two preliminary conclusions are drawn from the above data:

1. Insertion of PuC into PuC-UC solid solution stabilizes the PuC-Pu_2C_3 decomposition on heating above 1650 C.

2. There appears to be, under high vacuum and below the peritectic, a breakdown of PuC to result in plutonium vaporization and the formation of the higher carbide Pu_2C_3. Investigation into this hypothesis will continue.

Plutonium Oxide-Zirconium Oxide

The room temperature equilibria of the system PuO_2-ZrO_2 have been studied by means of x-ray diffraction. ZrO_2 forms a FCC solid solution with PuO_2 up to a maximum of 60 to 62 w/o ZrO_2. A two-phase field lies between approximately 0.5 w/o PuO_2 and 38 to 40 w/o PuO_2. This two-phase field consists of monoclinic zirconia and a FCC PuO_2-ZrO_2 solid solution.

Plutonium Silicides

An attempt has been made to produce $PuSi_2$ by heating a stoichiometric mixture of alpha Pu and silicon metal to 950 C for fifteen minutes. X-ray diffraction studies on the reaction products are under way.

3. URANIUM DIOXIDE FUELS RESEARCH

Fuel Evaluation

A purposely defected, 4-rod cluster, UO_2 fuel element containing sintered pellets was discharged from a KE test hole after nearly three weeks of operation. During the irradiation, essentially no activity was detected in the effluent coolant by the gross gamma monitor system. Radiochemical analyses of the effluent water revealed only trace quantities of Xe-135,

Xe-133, and I-131. Purposely defected, Hanford elements numbers 2 and 3 were fabricated and transferred to Special Irradiations Operation. These elements are scheduled for irradiation about January 1, 1961.

A three-foot long, 7-rod cluster of depleted UO_2 swaged in 304-L stainless steel tubes to a finished diameter of 0.906 inch, failed during irradiation in the ETR 6x9 Loop. The failure occurred after several thermal cycles and very soon after the reactor reached full power. Detailed examination of the cluster will be performed after the fuel element is returned to HAPO.

A vibrationally compacted fused UO_2 stainless steel clad fuel element (1.44" OD) was successfully irradiated in the MTR with a heat generation of 30 kw/ft.

Basic Studies

Irradiated UO_2 samples with burnups of 8.40 a/o and 11.25 a/o have been examined under the microscope at temperatures up to the melting point. Melting temperatures of 2760 C and 2660 C $\pm$ 20° were observed for the 8.40 a/o and 11.25 a/o burnups, respectively. Non-irradiated UO_2 melts at 2790 C $\pm$ 15°. UO_2 melting point versus irradiation exposure has been established for 13 different burnups. Specimens with 8.40 a/o and 11.25 a/o burnup were observed to vaporize rapidly at the melting point as does non-irradiated UO_2. Some crystal growth by vapor deposition was also observed although growth rates were substantially lower than those observed for non-irradiated UO_2. The completely non-crystalline nature of the high burnup UO_2 may explain this inhibition of crystal growth rates. It was apparent from the regular crystals formed that crystallinity is restored by re-deposition of the vaporized oxides.

The JEM electron microscope was accepted from the vendor. Satisfactory performance of the microscope and accessories was demonstrated. In addition to operation as a high resolution, high magnification transmission microscope, the instrument can be used: at sample temperatures between -140 C and 1100 C; to record tensile deformations of thin specimens; with still, stereo, and cine photography; for reflection microscopy of solids; and for electron diffraction examinations.

Examination of micronized UO_2 powders sealed in stainless steel capsules and high energy impacted at 1100 and 1200 C revealed numerous small pores. The porosity was attributed to release, and entrapment, of the excess oxygen at these temperatures from the non-stoichiometric oxide. A series of experiments was performed, using the Bridgman anvil ultra-high pressure technique for attaining pressures of 500,000 psi, in which the UO_2 powder was contained in stainless steel capsules having porous end caps to allow the evolved gases to escape. These experiments demonstrated that densities of 99% T.D. were consistently attainable at temperatures of 1100 C and 1200 C. The oxygen/uranium ratio of the UO_2 compacted by this technique was 2.04. Experiments were conducted to determine the effect of porous end caps on stainless steel capsules using conventional impaction techniques. Three-inch long by 1.75-inch diameter stainless capsules containing micronized UO_2 were heated to 1000 C and 1200 C and compacted at the maximum

impact pressure permissible without deforming the punch (2" diameter). The UO_2 densities attained were 95.5% T.D. at 1000 C and 97.2% T.D. at 1200 C. Additional capsules containing micronized and PWR type UO_2 were heated to 1300 C and compacted under the same pressure conditions. Densities of 91.7% for micronized UO_2 and 90.9% T.D. for PWR type UO_2 were achieved. The decrease in density at 1300 C is probably caused by a decrease in plasticity of the UO_2, as more of the excess oxygen is evolved at the high temperature.

4. BASIC SWELLING STUDIES

Irradiation Program

General swelling capsule No. 6 was discharged from the reactor this month. It had operated at approximately 300 C. A total of three capsules are now awaiting sufficient radioactive decay to permit post-irradiation examination by Radiometallurgy. The day after capsule No. 6 was charged it was noted that the control temperature of 500 C could no longer be maintained even though auxiliary heat was being supplied to the capsule and the reactor was at a high power level. Prior experience with bench testing of capsules has shown that behavior of this type indicates water leakage into the annulus between the inner and outer chamber. The water boils and extracts heat as rapidly as it is supplied by the heater. Investigation of known instances of similar capsule failures at other AEC sites did not reveal any history of the reaction that could be expected in a double chambered capsule if the second and inner NaK containing chamber should rupture permitting the liquid metal to react with the coolant in the outer chamber.

Due to the uncertainties regarding possible damage to reactor components should water leak into the inner NaK containing chamber of double walled capsules, a general swelling capsule (without uranium specimens) was assembled with perforations in both chambers and tested in a water filled section of a process tube. The test was conducted to simulate in-reactor failure of a capsule including the conditions that the capsule would necessarily have to endure after reactor shutdown and capsule discharge. Temperature and pressure indications during the test were recorded on a strip chart recorder. Only a mild reaction between the NaK and coolant water took place. The temperature adjacent to the hole in the NaK chamber momentarily rose as high as 400 C during one portion of the test, but no large pressure surges were observed and no apparent damage occurred to components. It would appear that double chambered NaK capsules are no more dangerous than are single chambered capsules. A complete report describing the test and the results is being written.

Pore Size and Distribution

Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. Such information is needed for understanding how gas atoms migrate, coalesce, and form large pores. Statistical analysis of pore density and size relationships which exist in irradiated uranium subjected to post-irradiation annealing is continuing. Statistical significances of values determined from individual electron micrographs are being compared with those from

other micrographs of a given set to establish variances associated with random sampling of the non-uniform pore distributions revealed by the high magnification electron micrographs. The annealing of uranium specimens with 0.29 a/o and 0.41 a/o burnup at 400 and 500 C for times of one and 100 hours has been completed. Densities of the specimens were determined before annealing, and density determinations after annealing are in progress. The metallographic preparation of specimens having a one hour post-irradiation annealing treatment at 880 C is also in progress.

Fission Product Mobility

A knowledge of the mobility of rare gas fission products in uranium is important to the understanding of the mechanism of pore formation. Several approaches are currently being pursued in order to acquire this knowledge. Rare gases are being introduced into non-irradiated uranium by flow discharge with the subsequent evolution upon heating being observed; and U-U diffusion couples are being prepared by either bonding depleted uranium to enriched uranium for subsequent irradiation or bonding irradiated uranium to non-irradiated uranium. The latter technique will employ electron microscopy and statistical methods to determine the extent of diffusion of rare gas fission products into that portion of the diffusion couple containing little or no fission product. The long time "glow" of a uranium disk in krypton has been completed, and the system is now being evacuated to remove any gas that may have adsorbed on the walls of the system. The specimen will then be heated and the evolved gases monitored quantitatively with the mass spectrometer. A U diffusion couple has been produced by coextruding a core of depleted uranium and a shell of enriched uranium in a thick copper can. Two end specimens from the extrusion have been examined metallographically and by microautoradiography. The Cu-U interface and the U-U interface were quite irregular, but the contour of one roughly followed the contour of the other. Metallography and autoradiography agreed as to the position of the U-U interface. Accurate counts of the alpha tracks present in the microautoradiography will establish the extent of intermixing which has occurred during the coextrusion process. Specimens from the coextruded rod are undergoing various annealing treatments to establish the effect of heat treatments on the original U-U interface. Due to the irregular Cu-U interface the copper will be left on the specimens and short cylinders will be irradiated cold in unmonitored NaK filled capsules. Attempts at joining uranium to uranium with various welding techniques have continued. Ultrasonic joining methods have been investigated as a means for obtaining a sharp metallurgical interface between uranium having different grain sizes. If such an interface can be achieved in couples of uranium, the technique can be applied in the preparation of couples of enriched and depleted uranium for subsequent irradiation, as well as for couples of irradiated and unirradiated uranium.

Restrained Irradiations

In-reactor swelling experiments of Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposure are being conducted employing NaK filled, temperature monitored capsules. Five swelling capsules, GEH-14-95, 14-98, 14-99, 14-104, and 14-105, are presently

being irradiated in the MTR with goal exposures in the range 0.25 to 0.31 a/o B.U. One capsule, GEH-14-102, similar in design to those in the MTR is now being irradiated in the ETR at a central uranium temperature of 425 C.

Three, 1.6 percent enriched uranium rods coextrusion clad with Zircaloy-2 and irradiated in capsules at Hanford are awaiting examination at the Radiometallurgy Operation.

5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

The creep measurements of a Zircaloy-2 specimen in-reactor are continuing in a single prototype capsule. During the month difficulties associated with reactor modification work for the new capsule instrument facility caused malfunctioning of the capsule's readout equipment. However, since the capsule cannot be discharged until the construction work is completed, the readings will continue. There is no assurance that operation will not be disrupted again.

Capsule and Instrument Development

The first of the second generation creep capsules is at the reactor awaiting charging. The capsule contains an annealed specimen of Zircaloy-2. Thorough bench testing of the capsule shows it to be performing entirely satisfactorily. Thermal conductance measurements were within ten percent of the calculations and the mechanical extensometer repeats to within two microinches. The other three capsules are being shipped now. The three capsules were held at the vendor's plant to be used in testing the complete digital data recording system which was added to the creep monitoring instrumentation. This unit is also completed and is being shipped with the capsules. The data-readout system automatically interrogates itself and prints the data on a pre-determined time cycle. This automatic data recording will permit data readout during reactor shutdown and startup conditions to assist in interpreting the influence of such transients on the in-reactor creep rate data.

Pre-Irradiation Material Characterization

The determination of activation energies for creep of two Zircaloy-2 specimens, one in the 25 percent cold rolled condition, the other in the 45 percent cold rolled condition, as a function of temperature has continued. Creep rates established at 25,000 psi just before and just after an abrupt temperature increase of 15 C are being used to calculate the activation energies. Values found at 348 C and 364 C were 61,500 and 60,900 respectively. Transient creep conditions prevailed during these tests. Characterization of Zircaloy-2 creep specimens scheduled for in-reactor testing has continued. Texture studies have been completed on annealed Zircaloy-2 scheduled for the second HAPO in-reactor creep test. A weak texture having (0002) planes parallel to the rolling direction of the rod and inclined 60° to the assumed plane of rolling used to fabricate the Zircaloy-2 rod was observed in this annealed material.

6. GAS GRAPHITE STUDIES

Thermal Oxidation Studies in CO_2

A series of samples of all-flour needle coke graphite having different purities was oxidized at 750 C in CO_2 flowing at 1.5 cfh. The results are as follows:

Purity (Dih)	Avg. Oxidation Rate (g/ghr)
0.027	1.902×10^{-4}
0.399	1.842×10^{-4}
1.047	3.420×10^{-5}
1.073	1.001×10^{-4}

In general, the oxidation rate decreased with increasing purity. However, the effect is not so marked as in the case of oxidation by oxygen.

Surface Oxide Studies

From Arrhenius plots of log K vs 1/T for surface oxide formation on graphite in CO_2, least squares slopes corresponding to activation energies of 28 and 48 cal/mole were obtained for two graphite samples. These very low activation energies indicate that physical adsorption processes are involved. Similar low activation energies are found when CO and O_2 are adsorbed, again indicating that physical adsorption takes place. This fact is difficult to explain since these reactions are generally regarded to involve chemi-sorption.

It has been observed that the measured amount of weight gain is affected by adsorption of gas on the surface of the quartz sample holder. Although this effect is relatively small, it may account for some previously unexplained fluctuations in the adsorption rates.

Static Gas-Graphite Reactions

Experiments in a static system containing CO_2 and graphite at 750 C and pressures between 0.4 and 1.0 atmosphere gave interesting results. During the first five minutes there was rapid adsorption of molecular CO_2 into the outgassed pores of the graphite sample. Then, during the next one-to-two hours, the pressure remained constant. This may be explained by the following reaction, which is generally regarded as one step in the oxidation of graphite by CO_2.

$$C_f + CO_2 \rightleftharpoons C(O) + CO \qquad (1)$$

After this period of no pressure change, the pressure changed according to the relationship:

$$\Delta p = at^b \qquad (2)$$

where Δp = pressure increase,
t = time, and a and b are constants.

In the three runs conducted to date, with initial pressures of 243 mm, 328 mm, and 756 mm, b has had the value of 0.51 for about the first five days and then abruptly changed to 0.40. The reaction has continued for approximately 50 days, and equation (2) still holds. The mechanism is yet to be worked out.

EGCR Burning Rig Experiment

A series of 17 experiments was run this month to determine the effect of graphite reactivity, air flow variation, and prior oxidation on the combustion characteristics of EGCR graphite. Data analysis has not been completed; however, the following trends have been noted:

1. Graphite reactivity reduction by a factor of two (achieved by replacement of the core with purer graphite) reduced the temperature rise rate at 650 C from approximately 3 C/min. to less than 1 C/min. No exponential temperature rise ($>$ 25 C/min) was noted with the less reactive graphite up to 1000 C.

2. After about 5% surface oxidation, temperature rise rates increased significantly (a factor of 5 at 650 C); however, further oxidation produced no change in the burning rate.

3. Air flow increases from 4 lb/hour to 16 lb/hour caused temperature rise rates to increase from 0.2 C/min to 0.7 C/min at 575 C.

Coatings Evaluation Studies

Further testing of irradiated SiC coatings on graphite is continuing. Six samples of SiC-coated, SA-35 graphite prepared by the National Carbon Company have been tested in flowing air at 1000 C. These had previously received an exposure of 3082 MWD/AT. Of the six, four failed and lost weight. One failed in 148 hours, and one in 128 hours; the other two failed in 74 hours.

Irradiation of Graphite Under Compression

Five additional boats containing various types of graphite under a static compressive load of 150 psia have been charged into KW Reactor. The graphite will be irradiated at about 500 C and examined after discharge for radiation-induced creep.

EGCR Graphite Irradiation

The H-3-2 capsule was installed in the E-7 position of the GETR during the Cycle 18 shutdown. Since reactor startup, the test has run successfully and all nine thermocouples are operating satisfactorily. The sample temperatures are in close agreement with those achieved in the H-3-1 capsule during its early operation.

Data from the samples from the H-3-1 experiment are being obtained and analyzed. Length and x-ray measurements are completed. Temperature plots are nearing completion and flux data are being calculated and evaluated.

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

Construction installation of the services and auxiliary equipment by Head Mechanical forces is approximately 50% complete versus 61% scheduled. Some delay has been encountered due to limited access to the process water system.

The repairs have been started by Minor Construction on the portions of the "A" and "B" frames which were damaged in shipment from Warren, Pennsylvania.

Struthers-Wells has yet to ship valve ORV-5 and the bellows for valve V-6. The ORV-5 body is apparently cracked beyond repair and will have to be recast. The bellows for V-6 is complete and ready for test.

Gas Loop Component Testing. Fabrication of the two substitute main heat exchangers was completed and the in-reactor test section was operated at rated flow conditions of 190 pounds per hour. Operation of the process tube assembly at 1500 F was delayed by a lack of insulating spacers for the 50 kw heater. The annulus compressor shaft seal continues to leak helium excessively.

The Solar gimbal joint which failed after a 500-cycle hot test has been examined by the vendor. Insufficient clearance between a bellows convolute and gimbal pin apparently caused premature failure. The bellows will be replaced by Solar.

7. GRAPHITE HIGH TEMPERATURE IRRADIATION DAMAGE STUDIES

NCC Research and Development Contract

The first series of samples received under the National Carbon Company research and development contract have been discharged after irradiation in a hot test hole. These samples were intended to yield information on the mechanism of high temperature radiation damage. Lampblack graphite heat-treated to 3000 C, graphitized Continental dendridic coke, Z-type hot worked graphite, natural flake graphite, CSF (as a control), and TSX (NPR core graphite) formed this first set. Post-irradiation measurements are in progress.

Additional samples have been received under the research and development contract. Lampblack base graphite heat-treated to 1400 C and with a density of 1.90 gm/cm^3 is being prepared for irradiation. These samples are included as a material of a class expected to have large contraction rates under high temperature irradiation.

By means of electron spin resonance techniques, it has proved possible to monitor quantitatively the generation of certain types of damage centers in graphite. In these studies, single crystals of graphite are being irradiated both in a hot test hole and in the Snout Facility. Irradiations of 2.5, 10, and 20 MWD/AT were completed in the Snout at a temperature of 26 C.

Graphite Additive Studies

The results of irradiations of Texas Lockport coke graphite samples which were prepared with and without iron oxide additives indicate that for low exposures the additive induced favorable dimensional behavior normally associated with needle coke graphites. After an exposure of 2500 MWD/AT at 550 to 600 C, transverse cut samples without additives had contracted 0.01 percent while those with additive expanded 0.01 percent. Needle coke graphites show an initial expansion of 0.005 to 0.025 percent during the same exposure. Since needle coke graphite contracts with continued exposure, the graphite with additive is expected to behave similarly.

A contract is being prepared for research and development to be conducted by the Speer Carbon Company in the use of chemical additives in the preparation of graphite base mixes. In an effort to maximize this additive effect, research covered by the contract will study graphites in which the concentration and composition of iron compound additives are varied. Other additive systems will be screened for similar or improved effects. These will be applied to a needle coke mix with processing similar to that specified for the NPR core graphite. Thus, if improved behavior is noted after irradiation, this increased stability will, hopefully, be in addition to that attained through the use of special cokes, fine particle size mixes and high graphitization temperature.

Experimental Graphite Irradiation at the ETR.

A temperature-controlled experiment to investigate the effects of flux intensity and exposure on experimental reactor graphites in the temperature range of 600 to 800 C has been designed. The capsule will be irradiated in the N-14 position of the ETR. The graphites to be compared with CSF in this capsule are a furfuryl alcohol impregnated graphite, a hot-worked graphite, a raw coke graphite, and a special isotropic graphite.

High Temperature Experiment

Tantalum capsules to contain graphite samples at about 2000 C in the center of ceramic fuel elements during irradiation have been fabricated. Laboratory tests will be made with the first capsules to determine the amount of carburization to be expected during irradiation.

Electron Microscopy

Two samples of KCF graphite which have been studied with the electron microscope by replica techniques were irradiated at 30 C to an exposure of 10 MWD/AT. Each sample had been polished, cathodically etched, and

referenced by scribing to facilitate before and after irradiation studies of identical areas. Polished surfaces are parallel and perpendicular to the extrusion axis of the bar from which they were cut.

Shadowed replicas taken before irradiation show systems of parallel trenches etched into the surface. In cross-section these trenches are either V-shaped or have one nearly vertical and one sloping side which suggests their shape is controlled by the angle of intercept of graphite layer planes with the surface. They are spaced from 0.5 to one micron apart and have been traced individually for distances up to 40 microns. These features can be straight, up to 20 microns, or curved, and are occasionally interrupted or offset by transverse crack systems. Interfaces between two differently oriented systems of trenches are not often clearly defined.

In explanation of the trenches, it is proposed that they represent a system of separations parallel to layer planes. The distance between trenches is about 10 times the crystallite dimension in the L_c direction as measured by x-ray diffraction. This would suggest groups of crystallites separated into sheets which contain 5 to 10 crystallites across their width. The formation of such separations can be explained as resulting from the relief of stresses induced by differential contraction as the material cools after graphitization. Accelerated etching at the separations would result in formation of the observed trenches.

8. FUEL CYCLE ANALYSES

Conceptual Design - Fuel Element Fabrication Plant

A study was commenced with the purpose of estimating costs of the various operations in the manufacture of plutonium-bearing fuel elements using advanced, high volume fabrication methods. The resulting work will provide input data and several check points for the FEFJ code being developed by the Programming Operation. A diagrammatic flowsheet was prepared in some detail, and estimates of reject and spoilage rates in some of the steps were made. Preliminary assumptions upon which the study will be based were listed. A preliminary report outlining the scope of the study will be issued in December. An offshoot of this work is a statistical study of economical group size in testing. This study indicates that when reject rates are low, go-no-go tests conducted in groups will substantially reduce the number of tests required. This study is being reported as HW-67524, "Economical Groupings in Testing," by H. E. Hanthorn, November 30, 1960 (Unclassified).

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals, namely, copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. Complete microhardness recovery occurred in irradiated copper after a one-hour isochronal anneal at 550 C. No recovery of electrical resistance has occurred at temperatures below 725 C.

Studies of lattice parameter variations are being conducted on molybdenum. The molybdenum specimens, containing 0.06 w/o carbon, appeared to age harden in the range 275-525 C. The increases in microhardness were 6% for the unirradiated control and 10.7% and 16.7%, respectively, for specimens with exposures of 4.4×10^{18} and 1.5×10^{20} nvt. An unirradiated molybdenum specimen was isochronally annealed, and it was found that the lattice parameter increased significantly at 250 C. Attendant with this increase was a marked sharpening of the (400) diffraction peak. The (400) line width reached a minimum at 300 C, then reached a second maximum at 400 C, at which temperature the lattice parameter also reached a maximum. The lattice parameter then decreased steadily up to 700 C, and the line width remained nearly constant. Without further information it is difficult to postulate a mechanism, although it is probable that the process involves carbon atoms and is enhanced by the presence of radiation-induced defects. Work is in progress to determine the reaction kinetics in both irradiated and unirradiated specimens. Irradiated molybdenum specimens have exhibited two distinct recovery regions at high temperatures. A specimen exposed to 4.4×10^{18} nvt recovered at 800-825 C and 875-950 C. Recovery occurred at 800-825 C and 975-1000 C in a specimen with an exposure of 1.5×10^{20} nvt. No kinetics have yet been determined for these reactions.

Recovery of irradiated iron has been studied at 175 C and 375 C. Recovery at 375 C in a specimen with an exposure of 1.5×10^{20} nvt is characterized by first order kinetics. The activation energy for the reaction, calculated on the basis of incomplete data, is 0.5 ev (11,400 cal). A possible mechanism is the radiation-induced re-solution of Fe_4N or a complex nitride upon annealing. Recovery at an exposure of 4.4×10^{18} nvt at 175 C involves an activation energy of 0.3 ev. The reaction order appears to be intermediate indicating a complex reaction. Further interpretation of the data will follow.

E. CUSTOMER WORK

Radiometallurgy Service

The stainless steel lead rod from the most recent Maritime Gas Loop experiment in DR Reactor was removed and sectioned into one-foot lengths. These were sent to Chemical Effluents Technology Operation for examination of film deposits. After examination, the stainless steel was returned and disposed of (RM-340). An antimony-beryllium neutron source was received from 105-D Area, decontaminated, and transferred to Radiological Physics Operation (RM-341).

Examination was started on an I&E fuel element (1656 C) to determine the cause of rupture in the inner spire. The spire was blocked one and one-quarter inch from the male end, but because of the intense radioactivity encountered, further examination in the ten-inch cell was impossible until some of the activity had decayed off. Examination will be resumed in December if the radioactivity has dropped to a suitable level (RM-421).

Metallography Laboratories

Work on preparation of substrates which will be used to support extremely fine particles during examination in the electron microscope continued during the month. Good carbon substrates were obtained for normal usage but not for the study in progress, i.e., the examination of fine particulate matter trapped in millipore filters. A small amount of sputtering of the carbon rod during evaporation resulted in dark spots on the substrate which could be misinterpreted during a particle count. However, superior quality silicon monoxide substrates were prepared, and the fine particulate matter which collected on the millipore filter paper was transferred to the silicon monoxide covered grids by dissolution of the millipore in acetone. Examination of the particles in the electron microscope will follow.

Sections of a reactor-grade graphite rod, 10 mils thick, were glued to bakelite mounts and a metallographic finish was given to the exposed surface by Syntron polishing. The sections were removed from the mounts and the opposite face also was polished. This time, however, the polishing was continued until the graphite became so thin that the bakelite could be seen through the graphite specimen in several areas. The graphite sections were again removed from the mounts and thinned further by etching in a potassium dichromate-phosphoric acid bath for 30 minutes at 100 C. The thinned graphite was then washed, floated in acetone, and collected on grids for examination in the electron microscope. Areas of interest were located and a series of electron micrographs taken at various magnifications. Electron diffraction patterns were also made to show preferred orientation and particle size. The grids containing the specimens will be used by Nonmetallic Materials Development Operation in irradiation tests to study irradiation damage. Thin films of natural flake graphite will also be included in the irradiation tests.

Other metallography service work performed during the month will be reported in connection with the respective research and development program served.

Samples Processed During the Month

Total Samples	680
Carbon Replicas	19
Photographs	
Micrographs	418
Macrographs	220
Electron Micrographs	140
	778

NPR Charging Machine

Two work orders totaling $23,000 were received on November 23 for initiating work on the full-size NPR charging machine.

Design development of a nozzle adapter has been completed and fabrication of a prototype has begun.

An engineering evaluation of the "C" elevator magazine guidance system has started. The guidance system must support the charging magazine over the 15-foot elevator space, be retractable to the 11-foot elevator width, permit unimpeded personnel passage when not in use, permit connection to several adjacent tubes with one elevator setting, and allow limited elevator movement while in position.

J. W. Woodfield

For Manager, Reactor and Fuels
Research and Development

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

NOVEMBER 1960

FISSIONABLE MATERIALS - 2000 PROGRAM

REACTOR

Exponential Pile Measurements for N-Reactor

Material buckling measurements have been completed in the condensed lattice for the fuel elements with water coolant. The fuel elements were concentric tubes 2.3" x 1.8" and 1.1" x 0.5". The enrichment was .946% U^{235}. The lattice spacing was 7.56". Preliminary results are available for the fuel elements with air coolant. The information is summarized in Table I.

TABLE I

RESULTS FOR THE CONDENSED LATTICE

Buckling $10^{-6}cm^{-2}$	Coolant	λ(s-s)	λ(F-R)
239	Water	1.0	0.8
48	Air	1.0*	0.8*

* Estimated extrapolation lengths taken from measurements for the water cooled fuel elements.

The λ(s-s) in Table I is the side-to-side extrapolation length. The λ(F-R) is the front-to-rear extrapolation length.

Bucklings were measured in the mockup lattice with graphite rods, with Lucite rods, and with aluminum tubes full of water in the control rod channels. The change in buckling upon removal of the graphite rods and insertion of nine one-inch diameter Lucite rods is $+3 \pm 4 \times 10^{-6}cm^{-2}$. The change in buckling upon inserting nine 1.93" I.D. aluminum tubes full of water is $-22 \times 10^{-6}cm^{-2}$.

PCTR Measurements for N-Reactor

a. Lattice Parameters

The analysis of data from PCTR measurements is proceeding. The values obtained for ϵ and p are calculated assuming that the δ should be measured by the BNL method which does not use cadmium covered foils.

	Mockup Wet	Condensed Dry
ϵ	1.050	--
p	.820	.710
η inferred	1.420	1.397

.946% U-235

Reactor physics calculations for NPR are being normalized to PCTR results.

b. Fuel Temperature Coefficient

The niobium wire was received on November 14 and the heater assemblies have been built and tested, using a graphite dummy fuel element. This test assembly has been operated successfully to temperature exceeding 900°C.

Since the outer fuel cylinder will be heated internally, a large ($\sim$ 100 - 200 C) temperature difference will be present between the inner and outer fuel cylinders. This difference may cause some difficulty in deducing the appropriate mean fuel temperature. However, this difference may also make it possible to infer the size of the surface and volume components of the fuel temperature coefficient by generating a large temperature difference between the inner and outer cylinders, while the outer cylinder is near room temperature.

c. High Temperature Flux Distributions

A study is being made to design a core for the PCTR which can provide flux distributions with the graphite and water near operating temperatures. Calculations of the fast and slow flux distributions indicate that a 9-cell array needs additional buffer fuel to flatten the fluxes in the array. However, this buffer fuel need not be the same as the NPR lattice. In fact, the amount of this fuel, its enrichment, and its spacing can be adjusted to allow better matching of the neutron temperature. The hot core region should be as large as possible to allow most of the neutrons to slow down into the hot Maxwellian distribution of the core, rather than the cold distribution of the driver region.

The possibility of water loss in the 9 tubes is not a hazard to reactor operation, since the core is undermoderated and water loss will result in a loss of reactivity.

d. Flux Traverses in a Heated Lattice

Experiments in the PCTR or TTR thermal column are planned at high temperature.

Heating is to be provided by silicon carbide resistance heaters that will have a minimal effect on neutron distribution. Heat loss to the water will be limited by a layer of lampblack between tube block and process tube, and water temperature will be controlled by a small recirculation system.

Design work continued on the heating and temperature control systems. A heater was tested and graphite temperature of 860 C obtained. Installation of power lines for heat control is 20 percent complete.

e. Uranium Foil for Measurements of p and ϵ

Several kinds of uranium foil are used in lattice parameter measurements: depleted, natural, slightly enriched, and fully enriched U^{235}-Al alloy. At least two offsite vendors now have the capability to prepare this foil for our uses, eliminating our dependence on the present on-site facilities which have become unsatisfactory. An order is being processed for enough of the uranium foil to satisfy our needs, including some 0.0005" foil to use in the study of resonance absorption on uranium surfaces.

NPR Startup Planning

A tentative list of startup tests circulated by Operational Physics, IPD, was reviewed and returned with comments and additions.

Optimization of Retubed Lattices

IPD is preparing to install larger process tubes in C-pile. The limiting factor appears to be the strength of the safety system in the flooded pile, so an experiment is being prepared to measure the change in the rod strength for the overbored lattice. Materials are being ordered so that an 8-foot exponential can be constructed containing six safety rod supercells. The change in rod strength upon substitution of the larger fuel element can be measured with Lucite in lattice voids to simulate flooding. The first experiment would use natural uranium, but a later measurement is under consideration with a mixed loading of natural and enriched fuel. No experiments will be performed until IPD receives approval from the Atomic Energy Commission to proceed with the research, development and design work needed for the retubing.

Data Correlation and Analysis

a. Buckling Results

A report consolidating exponential pile data is almost complete. The report will include all available unclassified data on the geometry and physical characteristics of both the lattices and the exponential piles, and the measured nuclear data including bucklings, extrapolation lengths, and cadmium ratios. Cross references to published data and unpublished notebooks will be included.

b. Neutron Temperatures Derived from Flux Traverses

The neutron temperature for several lattices has previously been derived by fitting experimental flux traverses, assuming the epithermal absorptions have the same distribution as the thermal absorptions (NPRO Quarterly, Fall, 1960). Calculations of the epithermal flux distributions have now been made to allow separation of the effects of neutron temperature and epithermal flux depression. As expected, inclusion of the eipthermal flux depression reduced the derived neutron temperatures, which now vary from 20 to 80° above the physical temperature for a factor of three variation in the carbon to uranium ratio. A

single epithermal group using standard cross sections did not give an adequate description of the epithermal flux, so up to six groups were used. Using the six group results, a single epithermal group can now be defined, using adjusted cross sections, to give the same results. The reduction to a single group is needed to allow simpler analysis of the large amount of buckling data available.

Lattice Parameters of Large Diameter Fuels

a. Manuscripts of two formal reports have been submitted to Technical Publications. The first describes the PCTR measurements on cluster fuel elements in a 7" lattice, and the second describes measurements of k_∞, f, p, and ϵ for a concentric tube fuel.

b. Measurements of lattice parameters of a 2.5 inch diameter, natural uranium fuel element in a 10-1/2-inch graphite lattice have been made in the PCTR. Analysis of the data has yielded the preliminary results listed below.

	Wet	Dry
k_∞	1.015	1.024
f	0.871	0.941

Exponential Measurements of Large Diameter Fuel Elements

Material buckling measurements have been completed for a 2.5 inch x 1.6 inch natural uranium fuel element at a lattice spacing of 12 3/8 inches with water coolant. The final buckling is $-45 \times 10^{-6} cm^{-2}$. The extrapolation lengths used were 2.4 inches side-to-side and 1.03 inches front-to-rear with the sources clustered.

PCTR Safety Specifications

A physics analysis of the PCTR operating safety specifications is in progress. The safety analysis is deemed wise in view of the facts that operating conditions and experiments have changed appreciably over the past five years and that the effective enlargement of the cavity has been a further substantial change. Particular attention is being given to the safety specifications that will be necessary when the PCTR driver fuel is loaded into the newly drilled outer rings.

Digital Computer Codes for Reactor Analysis

A FORTRAN listing of C-6 was received during the month and a copy of the source deck is expected shortly. C-6 is the most recent ANP slowing down spectrum code. It is written in FORTRAN II language with 35 subroutines, whereas C-5 was written in FORTRAN I language with no subroutines. This difference makes C-6 the easier of the two to convert for local use with the 100 point cross section data tape. All work on converting C-5 has been halted and most of the present coding will be discarded in favor of an improved method for coupling the slowing down calculation to the 100 point data tape. The new method will simplify input and make the resulting program more compatible to the present

C-6 code. Six of the C-6 subroutines have been completely recoded and six others have been revised. Compilation and debugging will not be started until the arrival of the FORTRAN cards from ANP.

The multigroup code AIM-6 was used for a few trial runs during the month. AIM-6 is potentially an improvement over AIM-5 in two respects: 1) its input is somewhat easier to prepare because of an internal library of cross sections for common materials, and 2) its limit is 18 groups instead of 12. These advantages are offset by the disadvantage of sketchy information about the code. Since only a binary deck is available here, the detailed FORTRAN information needed for effective error location is missing. Although some of the trial runs gave results which are reasonable, others, using different options, gave obviously incorrect results. Efforts to locate the cause of these errors have so far been frustrated by the sketchy information available.

Computational Programming Services

The exponential pile data reduction code, VTOCL, has been placed in routine production status and is operating satisfactorily. The programming portion of the revisions to COFIT-2, the cosine-fitting companion code of VTOCL, has been completed and the code is being debugged. The over-all effort is estimated as approximately 60% complete.

Instrumentation and Systems Studies

Work proceeded on extending the reactor kinetics equation study. It has already been proved the basic equations have only unstable solutions. If a reactor is represented by two reactors coupled together, with neutrons passing back and forth between them, the solutions can be even more unstable.

One can reason from physical intuition that with negative temperature feedback, the solutions would always be stable, but it might be possible to have sustained oscillations. Using as a first approximation a very simple equation to represent reactor temperature, the stability of the solutions has been verified--but the oscillatory solution does not appear. Either intuition is wrong, or a better temperature representation must be used. Exploration of the second possibility is the next step to be taken. This must be done before the synthesis of a possible control system can begin.

Preparation of functional specifications for the Slow Scan portion of the NPR Fuel Failure Monitor is nearing completion. Active experimental development work was resumed on the Fast Scan System concept. New slip rings are ready for installation on the full-scale mockup. Satisfactory tests were completed on a new magnetic amplifier which will replace the more expensive original solid-state dc amplifier.

Extensive phototube testing has confirmed that the prototype NPR Dual-Probe Scintillation Area Monitor will not give acceptable performance under the operating conditions now expected. Although the instrument performance meets the criteria established a year ago when development began, photomultiplier fatigue effects following occasional exposures to high radiation levels which are now predicted would cause excessive reading errors. No satisfactory solution to this problem has been demonstrated as yet. In addition, IPD personnel now strongly favor a logarithmic response rather than the linear system. At this writing, Instrument

Design - CE&WO is considering an ion chamber detector plus electrometer system. However, it appears that the cost of such a system may be more than double the $600-700 per monitor (106 stations) originally estimated. Accelerated evaluation tests are continuing on two commercial instruments to assist Design.

The prototype scintillation transistorized NPR Beta-Gamma Air Monitor was completed, tested satisfactorily, and delivered to 100-D Area for field tests.

Design sketches have been prepared for an experimental radiation ratio pyrometer to be used for reactor moderator temperature measurement. The design is similar to the unit built for FPD coextruded fuel temperature measurement but includes modifications to permit accurate focusing on objects 15 to 30 feet distant.

Neutron flux and outlet temperature data obtained during the recent power ratemeter tests at 100-D reactor were analyzed to determine an approximate temperature-versus-flux transfer function. Additional tests, using the zone temperature monitor RTD's and high-sensitivity recorders, are planned in the near future to confirm the power ratemeter data and to obtain a more accurate relationship between outlet temperature change and control rod position change. These data will be useful in studying the control characteristics of the closed loop control test referred to below.

A meeting was called by Operational Physics Operation, IPD, to discuss a proposed closed loop control test for 100-D reactor. It was decided that Systems Research Operation should determine the approximate control characteristics of the individual test loops as a guide in the selection of control equipment and test procedures. This information will be obtained from actual test data (on 100-D reactor) and from an analog computer simulation of the test loops. The question of whether to use a scanning system, with a single controller, or separate controllers for each rod was discussed. It was decided that more information was needed on the loop control characteristics, and on available equipment, before a decision could be made. Systems Research had suggested scanning because it appeared that (1) system reliability could be better than with a group of controllers, (2) self-checking circuitry could be incorporated with little additional cost, and (3) some type of scanning or logic circuitry appears necessary even with the continuous controllers because of the limits presently placed on the number of rods which can be moved simultaneously. Systems Research Operation and Instrument Development Operation, IPD, will be working together on this test, and preliminary contact has been made with IDO engineers.

The heat exchanger analog computer model for the NPR has been checked out against the model used by GEL. The results were identical for the two models.

The speed of control problem for the old reactors and C-pile was again run on the analog computer this month. The lifetime ℓ^* was varied to determine the effects on the operating curves.

The NPR pressurizer analog program has been completed and the system is presently being studied on the GEDA computer. The analysis of the pressurizer should be completed by mid-December.

A study of the secondary loop of the NPR has been started. This study will consist of a transient analysis and stability analysis of the entire secondary system. This system will include the secondary side of the primary heat ex-

changer, dump condensers, surge tank, primary pump and turbine generators as well as automatic control for the heat exchangers, dump condensers and surge tank. The time table for this problem consists of developing the equations and analog simulations by mid-December, and having the problem on the computer as soon as possible so that it can be used during the HAPO review of the Burns and Roe primary and secondary systems control specification. The simulation will be complex and require the use of both the GEDA and EASE analog computers. Equipment limitations, particularly multipliers and function generators, may require that the system be simplified by making linear approximations.

SEPARATIONS

Plutonium Critical Mass Facility

The control and safety rod assembly, and tamper tank assembly for the reactor vessels, were received at the Critical Mass Facility on November 7. Installation of these components in the reactor hood was begun in preparation for the initial series of criticality experiments with Pu solutions.

Work was continued on modifications to the Facility preparatory to the first criticality experiments. Minor Construction (J. A. Jones) personnel are currently moving process valves into the reactor hoods and are extending the pump hood in the reactor room to include additional valves and tubing fittings. All fittings which cannot be located within hoods will be back welded. Bypass relief valving is to be installed on the metering pump and the fast pump in the pump hood.

In pre-startup testing by personnel of Critical Mass Physics, the transfer pump in the mixing hood and the fast fuel addition rate pump in the reactor room were found to be unsatisfactory because of their inability to self prime. Two Vanton "Flex-i-liner" pumps were ordered as replacements.

Cost estimates are being prepared by Minor Construction for a number of the modifications to the Facility (primarily the solution handling system) which are expected to result in over-all improved flexibility, safety, and contamination control.

Design of a split table remote assembly machine is proceeding again after considerable delay because of the lack of draftsmen. This machine is to be used in the conduct of criticality experiments with PuO_2-plastic mixtures. The 234-5 Development Operation reported that stability and gas evolution tests were being made on a sample PuO_2-polystyrene compact. The first results indicate this material to have a much smaller gas evolution rate than polyethylene samples and less than methyl methacrylate samples. If so, the first experiments with PuO_2-plastic mixtures will be made with the polystyrene mixtures.

Miscellaneous Experiments for Nuclear Safety Specifications

1. Pulsed Neutron Source Experiments Applicable to Nuclear Safety

   A theoretical investigation of the feasibility of using a pulsed neutron source technique (pulsed neutron source and time analyzer) in pre-criticality instrumentation for nuclear safety applications in the separations plants was

completed. The details of this study will be included in a forthcoming document, HW-67562, On the Application of Pulsed Neutron Sources to Safety Problems, by W. A. Reardon.

In utilizing the pulsed neutron source technique, a burst of neutrons is fed into a subcritical assembly; the time decay of the neutrons is then measured. From this measurement it is possible to determine the effective multiplication constant (k_{eff}) and to obtain other useful information concerning the criticality parameters which characterize the system.

The results of the current study are summarized below:

a) As a device for measuring k_{eff} as a "spot check" or as part of a periodic safety check of vessels that are potentially a safety hazard, the method is certainly applicable.

b) Calibration on critical or near critical systems would be needed, unless some new way is found to relate the decay constant to the k_{eff}. Considerable work remains to be done on the theory of such systems.

The application to systems of storage arrays has not been studied in any detail at present.

The study reveals some ancillary benefits, most notably the possibility of measuring independently, the neutron generation time, and the effective delayed neutron fraction. A considerable number of other items of interest can also be rapidly evaluated, e.g., control rod strengths, reflector worth, reactivity coefficients, and temperature effects.

2. Measurement of k_∞ in the PCTR for Aqueous U-235 Solution

Plans are being firmed up for measuring the limiting just critical concentration of U-235 in an aqueous solution utilizing the PCTR. Design drawings of the containment vessels for the experiment were submitted to the Technical Shop for fabrication.

A UO_2F_2 solution will be used in the experiment. The uranyl fluoride is being obtained on a loan basis from the ORNL Criticality Group.

The purpose of the experiment is to re-evaluate and check the maximum concentration of U-235 for which $k_\infty \leq$ unity. The results of these measurements will be compared with those reported by ORNL, and will serve as a cross check between the two laboratories. This measurement will also provide another "known value" against which to check the PCTR method.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

The AIM-6 multigroup, one-dimensional, diffusion code has been made operable on the Hanford 709 monitor system. At the present time, the cross section library consists of an eighteen group set for fast and intermediate reactor calculations published by C. B. Mills.(1) To check on the applicability of this particular

(1) C. B. Mills, Neutron Cross Sections for Fast and Intermediate Nuclear Reactors, LAMS-2255.

cross section set to plutonium systems, calculations were made for plutonium spheres. The range of hydrogen-to-plutonium ratios used was from 500 to 0. The results of the survey are given in the table below along with similar results given by Dr. H. C. Paxton of Los Alamos.

H/Pu Ratio	Pu Density (gm/l)	Critical Volume in Liters	
		AIM-6	Dr. Paxton
500	53	12.75	11.0
300	87	10.27	9.8
200	128	9.95	9.2
100	258	8.13	8.6
50	495	7.41	8.1
30	760	6.86	7.6
20	1020	6.40	6.8
10	2330	4.61	3.9
5	4200	3.07	2.2
3	6100	2.19	1.4
2	7900	1.68	1.0
1	11200	1.14	0.62
0	19600	0.58	0.29

As noted from the results in the foregoing table, the calculations with the AIM-6 code and its present cross section library are in poor agreement with the values given by Dr. Paxton. In anticipation of improving the applicability of the code to plutonium solution calculations, the cross section library is presently being replaced with the cross section set utilized by the 9-Zoom code. The AIM-6 code is a much more versatile code than 9-Zoom in that it will perform a criticality search on buckling, fuel concentration, poison concentration, dimension, or the position of a poison boundary. For example, if the dimensions were specified, the critical concentration could be determined; or if the fuel composition were specified, a search could be made to determine the critical dimensions, etc.

Criticality Hazards Specifications

1. Nuclear Safety in HLO

a) The nuclear safety of the autoclave facility in the 308 Building was reviewed and comments submitted to the Plutonium Metallurgy Operation[1]. It was determined that the present batch limit of 35 PRTR fuel rods per autoclave could safely be increased to 70 rods. There are two autoclaves in this facility spaced six feet apart; each is 6.5 inches in ID and 12.3 feet in length. Calculations show that for the PRTR fuel rods (plutonium-aluminum alloy rods of 1.83 w/o Pu, 0.5 inch in diameter), the minimum critical spherical mass is 94 Kg of alloy and the minimum critical cylinder diameter is 13 inches. Since the 70 rod

(1) Letter from C. L. Brown to R. E. Sharp, "Revision of Nuclear Safety Specifications for 308 Building Autoclaves," November 11, 1960.

charge contains only 53 Kg of alloy and the autoclave is only 6.5 inches in diameter, the autoclaves are adequately safe for the new limit.

b) Nuclear Safety Specifications for HLO

The following specification was issued by the Fuel Element Design and Fuels Fabrication Development Operations:

F-1 General Rules for the Storage, Handling, and Transporting of Enriched Uranium Metal (up to 5% U-235)

This brings the total number of HLO specifications issued to date to 19. It is estimated that six specifications are required to cover the Plutonium Metallurgy Operation; as soon as these are issued, specification coverage in the laboratories will be essentially complete.

c) Nuclear Safety in Transportation

A meeting called by the Radiation Protection Operation was attended on November 7, 1960, to discuss standards for radioactive shipments.(2) Representatives from CPD, IPD, FPD, HLO, CCAO and CECUO were in attendance. It was pointed out that the Radiation Protection Operation has functional responsibilities toward preparing and publishing HAPO radiation protection standards and radioactive shipment standards. RPO, therefore, offered to become the focal point for published HAPO documents and letters on this subject.

2. Nuclear Safety in FPD

Comments were submitted to Advanced Engineering of FPD concerning the nuclear safety of uranium in the enrichment range of 0.95 - 1.10% U-235(3). This information was needed as a guide for the evaluation of future production plans in FPD. The characteristics of homogeneous and heterogeneous systems in this enrichment range were compared and basic criticality values were given.

Mass Spectrometry

The work on investigating the effects of pretreatment of ion source filaments on ionization efficiency was continued using the mass spectrometer for this program.

A new study was started on the effects on abundance sensitivity of a simple potential barrier ion energy discriminator on this mass spectrometer. The electrode structure at the detector of the spectrometer was modified and installed

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(2) Letter from J. W. Vanderbeek to E. D. Clayton and C. L. Brown, "Standards for Radioactive Shipments," November 15, 1960.

(3) Letter from C. L. Brown to C. E. Fitch, Jr., "Comments on the Nuclear Safety of Slightly Enriched Uranium," November 28, 1960.

on the spectrometer. Experimental studies of this system have begun. Studies are also in progress on the ion optical properties of the barrier and of the electrode geometry through the use of analog electric field plots.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Cross Sections

During a reactor outage early in the month some work was done by Facilities Engineering Operation, IPD, on the X-2 level at 105-DR adjacent to the single crystal spectrometer. Following the outage it was discovered that the neutron intensity was one to two orders of magnitude less than that immediately preceding the outage indicating that some severe misalignment had been caused to the spectrometer during the outage. Work is in progress to determine the source of the misalignment, and the spectrometer is presently shut down.

Fission Cross Sections

Some previously reported data on the fission in low lying resonances of Np^{237} was reanalyzed. A method of deriving resonance parameters of two overlapping resonances was developed and applied to obtain peak resonance fission cross sections by a least squares criterion to the 1.325 ev and 1.476 ev resonances.

Slow Neutron Scattering Cross Sections

The three axis spectrometer was set up to be better optimized for the study of large down scattered energy changes. The resulting resolution is now 20 percent at an incident energy of 0.15 ev. Measurements are in progress on the down scattering of 0.15 ev neutrons from a thin (15 percent) scattering sample of room temperature water. Under these conditions the measured intensity of scattered neutrons of about 0.05 ev energy is about 15 c/m on a background rate of about 10 c/m. Energy analyses have been made at 30 and 50 degree scattering angles.

Fast Neutron Cross Sections

An alternating-current, rotating-coil gaussmeter has been developed to use in measuring the demagnetization of the analyzing magnet of the Van de Graaff for beam alignment. The new instrument uses a coaxial transformer, instead of slip rings, to bring out the signal from the search coil. It has been used successfully in reducing the magnetic field to less than the earth's field.

A review of the literature on fast neutron total cross sections has been completed. A number of important systematic discrepancies worthy of investigation here were revealed.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE

Low Exposure Plutonium Lattices

The experimental data from the 8 3/8 and 10 1/2 inch lattices has been analyzed. Final results are dependent upon the generation of the appropriate neutron spectrum over which the Pu-239 capture-to-fission ratio, α, is to be averaged. Calculations have begun, using the code Spectrum-Gas, to attempt to generate this

spectrum. These results, while strictly applicable only for an infinite homogeneous medium, should give a reasonable indication of the spectral shape. Further calculations, which would generate the spectrum as a function of lattice position, are being considered.

PRTR Startup

Special tools for mounting neutron sources and foil holders on the PRTR fuel elements have been fabricated.

The Critical Test Procedures for radial traverses, vertical traverses and the mounting of the neutron sources on the fuel elements have been written.

Active participation in the startup tests began November 10 and continued throughout the month. The critical tests will be reported in detail by the PRTR Operations unit.

Neutron Rethermalization

a. Graphite Experiments

In the October Monthly Report it was stated that the agreement was good between the experimental and fitted curves of the spatial dependence of the thermal activity of a 1/v detector near a temperature discontinuity. This statement was based upon the value of ± 2% for the maximum pointwise residuals (aside from a few statistical outliers with residuals as high as ± 4%). Close inspection of these fitted curves indicates some trends which in general result from rethermalization cross sections which are too large. The latter is also indicated in independent experiments on the effective neutron temperatures near the temperature discontinuity. These results indicate that perhaps the spectrum model (thermal and epithermal) could be improved. Further the experimental data near the temperature discontinuity, where rethermalization takes place, and far from the discontinuity have been weighted equally in the analysis. It is felt that the data near the discontinuity should be weighted more heavily than that which is far from the discontinuity.

Various spectrum model improvements and weighting methods are being considered for further analysis of these experiments.

b. Water Experiments

Best theoretical fits to the experimental traverses in these experiments have been obtained. The value of the rethermalization cross section for hot neutrons in 295 K water was adjusted to obtain the best fits. In general the cross section seems to decrease with increasing temperature and is approximately 1.0 cm^{-1}. However, the results for these experiments are dependent upon the results from the graphite experiments and may have common shortcomings.

Further analysis of these experiments will be similar to that for the graphite experiments.

c. Effective Neutron Temperature Calculations

The lead, water, and graphite experiment reported in "An Investigation of Effective Neutron Temperatures" by W. P. Stinson, L. C. Schmid, and R. E. Heineman has been investigated with the two-thermal group model used in the graphite and water rethermalization experiments. The effective neutron temperatures at the center of the water-cooled lead cylinder have been calculated. The calculated results agree with experiments to within 5% for both the Pu-U and Lu measurements between 400 and 700 K. Improvements in these results can be obtained by adjustment of the rethermalization cross section of the water within its uncertainty. However, the adjustment for the Pu-U case is from 1.00 to $\sim$1.25 cm^{-1} while for the Lu case it is from 1.00 to $\sim$0.87 cm^{-1}.

Code Development

GPR

A comparison of once-through fuel cycle operation of the generalized Plutonium Recycle (GPR) code with the MELEAGER fuel code is being made. Some difficulty was experienced in the matching of the cross sections.

MELEAGER

The code has been completely converted to the FORTRAN Monitor System, and much of the tape writing formerly required is now optional. This is expected to save a considerable amount of running time. The economics data output can now handle analysis of arbitrary fuel cycles rather than just uranium-plutonium. The tape preparation code (MEL-B) was found to be incompatible with the 7090. This was remedied by a recompilation which omits on-line printing.

LOLA

The matrix in the quadratic differentation routine is now inverted by the Crout method, which appears more satisfactory. A paper for presentation at the San Francisco meeting of the American Nuclear Society has been prepared.

RBU

The Pre-Monte-Carlo appears to be incompatible with the 7090, apparently in an on-line printing routine. The trouble has not been finally located. A complex problem has been prepared by the Input Code. Short Monte Carlo runs on this problem have been made but extensive testing has been deferred until the problem in the Pre-Monte-Carlo is resolved. A modification to the Input Code to improve the treatment of void regions and isotopes with negative cross sections (such as pseudo-fission-products) was also made. Assistance was given to IPD personnel in preparing input for an RBU calculation on an NPR cell.

Analysis of Finite Heterogeneous Lattices

The study of matrices in connection with the use of small source theory in heterogeneous lattice calculations has led to the writing of a subroutine, POWER, which solves the matrix equation, $Ax = Kx$. Here A is the input matrix describing the interactions between the fuel elements, K is the largest eigenvalue of the matrix, giving the reactivity of the system, and x is the eigenvector which gives the relative absorptions for each rod type. An informal report which describes these heterogeneous lattice calculations is in preparation.

Instrumentation and Systems Studies

New calculations were made, based upon accurate tubing sizes, for measuring UO_2 packing densities in various sized Zircaloy tubing by a gamma transmission method. The new calculations definitely remove Co^{60} as a required source. It will be possible to use only Ba^{133} for all measurements although certain of the sizes will be more amenable to a Cs^{137} source. A memo-type report will be written covering the details.

Investigative work was temporarily suspended on the "last ditch" safety circuit system for the Plutonium Recycle Critical Facility until the necessary commercial items, which are on order, are received.

Special instrumentation for the PRTR critical tests was installed, tested, and used. This instrumentation was required to obtain better sensitivity and accuracy than that available from the installed instrumentation. During the initial tests the equipment proved to be entirely adequate and nearly trouble free except for a high voltage breakdown problem in the detectors. This was caused by very high humidity in the "dry" gas blanket. D_2O condensed on the cool upper parts of the detector cables and trickled down to the detectors. Protective plastic bags and silica gel seem to have alleviated the problem, although it may still be necessary to insert the detectors in thimbles.

The PRTR calandria Unit Motion Camera has been tested by the customer, who reports it works well. Previous low-contrast images have been fully corrected by the threaded and blackened brass tubing liners installed early in October.

A second improved probe for measuring the inside diameters of PRTR process tubes was assembled and calibrated.

The instrument for measuring the PRTR Gas Gap has been completed and calibrated for use in a clean and cold reactor. This instrument will henceforth be referred to as the "PRTR Process/Shroud Tube Annulus Spacing Gauge". Calibration tests were made to ascertain the maximum adverse effects due to variations in process tube wall thickness which will be encountered in actual operation in the reactor. It has been established that the confidence band, defined here as the maximum observed output variation due to non-symmetrical process tube wall thicknesses, decreases in width as the shroud tube is progressively displaced from its normal concentric position. Laboratory data indicate that for non-symmetrical process tube thickness variations corresponding to the worst in-reactor condition of 0.030 inch, the confidence band decreases in width from a maximum of 0.025 inch near nominal gas gap to a minimum of ± 0.010 inch when the shroud tube has been displaced approximately 0.150 inch off center. The confidence band then remains constant at ± 0.010 inch from 0.150 inch displacement to its maximum displacement

corresponding to a 0.00 inch gas gap on one side. These results are most encouraging and indicate that as the process and shroud tubes approach each other, the confidence band normally associated with process tube thickness variations is decreased in width to a point where the indicated shroud tube position is reliable to ± 0.010 inch, independent of process tube wall thickness variations.

Structural Materials Development is being assisted in completing the development of an instrument to measure the PRTR process tube wall thickness. This will use a locally developed sensing probe in conjunction with a commercial ultrasonic "Vidigage" instrument.

The PRP Critical Facility simulation was set up on the EASE computer in mid-November and is now 80 percent complete. Considerable scaling difficulty is expected in completion of the remaining runs. These include the response to step and ramp reactivity inputs. The results are in good agreement with expectations.

The motor and brake assemblies for the Ampex tape handling mechanism for the PRTR neutron lifetime measurement were received and installed. A preliminary test of the reactor "noise" measuring instrumentation was made during Critical Test No. 11 on the PRTR. The test indicates that the signal level obtainable with the present equipment is too small for accurate analysis. Tests will be made at the reactor during the first week in December to determine the actual instrumentation requirements.

NONDESTRUCTIVE TESTING RESEARCH

The output of the broadband eddy current test equipment was measured using a six-section orthogonal exponential filter to obtain data upon which to base the design of a network to transform the complex signal into individual test specimen parameter values. In this test the test specimen was replaced with an approximate equivalent electrical circuit having two variable parameters, and the outputs of the six-section filter were read using a cathode ray oscilloscope. The data were given to the Experimental Statistics Operation for analysis.

The six-section pulsed diode sampling circuit was completed by the electronics shop and was checked for proper functioning. This sampler comprises a phantastron time delay circuit, six single-stage amplifiers, six pulse amplitude samplers, and six cathode follower output circuits. It will be used to sample the outputs of the six-section orthogonal exponential filters.

The research contract with the Johns Hopkins University concerning application of a signal space concepts to the analysis of eddy current nondestructive test signals has now been approved by all concerned to be effective for one year beginning January 1, 1961.

Resonant vibrations were generated in 1/8- and 1/4-inch-thick aluminum plates by means of the eddy current ultrasonic transducer. The first application of this technique will be in measuring plate thickness by the ultrasonic resonant method without the conventional use of grease or liquid couplant between transducer and metal surface.

A modified infrared radiometer, for use in heat transfer testing equipment before constructed at HAPO, has been completed and mounted on the scanning device.

Increased detector-test piece spacing was incorporated in the radiometer to reduce interference from the strong fields generated by the induction heating coil. A 13-inch-diameter elliptical mirror is used in conjunction with an f 0.6 arsenic trisulphide lens in this instrument. Preliminary tests indicate that the total instrument noise, using an integrated output, is equivalent to a temperature change of approximately ± 2°C at 50°C within the 1/8-inch-diameter area viewed by the radiometer on the surface of an autoclaved X-8001 aluminum jacket. A chopping frequency of 2000 cps is utilized in this instrument to minimize interference between the chopper and signals of short duration produced by small fuel element defects during rapid scanning. Tests of the heat transfer testing equipment using a 7-1/2 KW Lepel induction heater showed that spurious signals due to heating coil fields had been eliminated, and that no magnetic shielding of the detector was necessary. However, it was not possible to detect 1/2-inch mica-produced voids in the bonds of AlSi-bonded, X-8001-clad uranium fuel elements with this equipment. This may be due to the low efficiency of this induction heater when used with a single-turn heating coil.

Tests of flat multiple-turn coils indicate they will be more efficient. However, increased spacing is necessary to allow adequate radiometer viewing, and this will reduce the power density. Several coils having the necessary increased inside diameter are being fabricated from 0.005-inch-thick copper foil by Technical Shops. In addition, thin-walled 1/8-inch-O.D. copper tubing has been ordered to facilitate future fabrication of such coils.

Literature on induction heating indicates that it should be possible to obtain at least 40 percent efficiency in heating an aluminum cylinder with a single-turn coil by matching with a special output transformer. However, the conditions such as coil inside diameter, size, and material of the coil were not specified. These factors markedly affect the efficiency. An experimental transformer has been fabricated in the laboratory and is being tested in conjunction with a 15-KW 10-KC/sec induction heater. Flexible leads three feet long connect the primary of this transformer to the high frequency generator to allow scanning of test pieces. A power of 1/2 KW was coupled into an aluminum dummy from a 1-5/8-inch-I.D. single-turn work coil in the initial tests.

Other methods of heating are being explored. The plasma arc torch method offers possibility of rapid transfer of heat to small areas. A preliminary evaluation of this type of heating for heat transfer is being made using a 40-KW unit on site. The use of an electric arc to heat a copper mass is being investigated for heating parts having special shapes by the contact (conduction) method.

The two inductive (eddy current) thermometers were completed and adjusted. Sensitivity of each is about two millivolts per degree Centigrade when used to indicate the temperature of an aluminum surface. The units are transistorized and each is contained in a small box 5 by 4 by 3 inches with external probes.

NEUTRON FLUX MONITORS

The Meleager computer code is being used to examine the performance of various plutonium and uranium isotopic combinations as extended lifetime neutron detectors. Some combinations have been demonstrated, by computation, to give a response constant to within ± 10 percent for at least a year and probably for 20 months. This is for operation over practical ranges of flux level, epithermal-

to-thermal flux ratios, and reactor temperatures. Holding these parameters constant gives a response constant to better than ± 5 percent for 20 months.

Further work on the microwave flux monitor idea is awaiting specification and procurement of the necessary experimental equipment.

PHYSICAL RESEARCH - 5000 PROGRAM

Mechanism of Graphite Damage

During tests of the beam sweep system for the electron Van de Graaff it was found that the Van de Graaff beam was not centered. Centering is important to operation of the system. A flexible bellows was ordered that should permit proper centering.

An experiment was designed in which graphite resistivity and length changes can be measured following the electron bombardment with compensation for room temperature changes.

Tests were made of the feasibility of substituting a Wien bridge oscillator for the Wheatstone bridge in calorimetric measurements. With the oscillator, changes in resistance are converted to changes in frequency and measured with a precision counter-timer. It was found that with standard techniques the two were about equivalent. However, with a non-standard oscillator circuit it was possible to obtain five times more sensitivity than with the Wheatstone bridge. The stability of this non-standard type of operation is under study.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Assembly and installation of air sampling equipment on the field grid covering the Northeast quadrant centered on the Meteorology Tower, work which has continued since last February, reached the point of beneficial use of the grid during the month. The course consists of seven concentric arcs covering the sector 340° to 100° to a distance of 800 meters from the source. Arcs at 1200 meters and 1600 meters are still under construction. The new sampling grid is designed for studies of the dispersion of tracer material from an elevated source during unstable temperature gradients. The first experiment was conducted successfully on this course during a period of moderate wind on November 18, 1960, with the zinc sulfide tracer material released from a height of 200 feet on the Meteorology Tower.

Additional calculations of the flux of zinc sulfide tracer material through vertical surfaces defined by the vertical and horizontal sampling grids were completed. Estimates of the mass flux through successive vertical surfaces continued to substantiate the exponential decrease with distance reported last month for moderately stable conditions (Richardson's Number, 0.50). The rate of decrease appeared to depend on both the atmospheric stability and the height of release. For the single case of very stable conditions calculated (Richardson's Number, 3.0), the loss of material from the cloud was found to be very

large, 96 percent of the material being deposited within the first 3200 meters of travel. Preliminary attempts to reconcile these data with existing theoretical diffusion models emphasized the inadequacy of existing models in failing to account for the change in vertical dosage profiles due to erosion of the plume near the ground due to deposition.

Development work continued on a two-color tracer technique for studying the effect of height of release on ground level dosage patterns. It has been found possible to discriminate between green, orange, and red fluorescing pigments with our present assaying equipment.

DOSIMETRY

Our old and new large scintillation counters were cross-calibrated with our plastic phantom. The phantom does not give precisely the same results as a human but it suffices forrelative calibrations. Seven people were counted with both the old and new counters and the results using this calibration were quite good. Both counters were calibrated for Na-24 in humans.

The new counter is being substituted for the old one for whole body counting. Measurements indicate that the resolution of the old counter for Cs-137 has slipped from 9.2% to 10.5%. The resolution of the new counter is 8.6%.

Attempts to improve the low energy response of the multichannel analyzer were concentrated on the analyzer itself and amplifiers used with it. Some improvement was obtained.

The positive ion accelerator was in operation during all but one week during which the ion source and stapled belt were replaced and some causes of sparking eliminated. The belt had been in use for over 1000 hours which is a very good record.

Two of the three precision long counters that have been built agreed to within 0.3% in sensitivity. The third agreed to only 1.3%. A new core was built for this counter and initial tests indicate that this third counter will now agree with the other two within the 0.3%. This is a very encouraging result for the development of truly precision counters. In other work it was shown that the sensitivity of the BF_3 counter used did not affect the position of the effective center of the precision long counters. Final drawings for the precision long counters were completed. A precision long counter for laboratory intercomparisons is being built.

Another attempt to obtain an Sb-Be source failed due to contamination of the source when activated.

The early results with the Perlow spectrometer were interpreted as possibly due to instrument artifacts. Some of these instrument defects have been found and eliminated. Others were found to be inherent in the spectrometer. It was found that high energy neutrons produce signals that are interpreted as due to low energy neutrons. This makes it improbable that the device can be used for low energy fast neutron spectroscopy. A member of Reactor Engineering Development Operation conceived a new way of using the spectrometer that would extend its range to higher energies. Tests show the technique to be very promising.

Five new exit canals were made for the helium ion source to see if they would reduce the sputtering that leads to short source life. Two of these were tested. One of them gave very good results.

Another calorimetric measurement of the stopping power of aluminum was made. A thinner foil was used with the result that the estimate of systematic errors was reduced from the 1.2% of the previous measurement to 0.5%. The result was within 0.3% of the accepted value.

INSTRUMENTATION

Experimental modifications were made on one prototype self-reading and alarming dosimeter using a standard "pencil" ionization chamber detector. An astable transistor multivibrator circuit was developed to replace the modified stop watch used as a lamp switch. At present, the battery life for the two miniature batteries employed is 24 hours continuous duty.

Development continued on an experimental gamma beam-scanning system using a mechanical X-Y scanner plus electrical controls. The scanner will move in one-inch increments over an 11-by-11-inch area. At each indexed position, pulse height analysis information is read into a multichannel analyzer. The unit will be used for shielding studies for personnel protection in reactor areas. The electrical control system uses two servo motors for positioning by relay control of the motors.

Investigative work continued on the personnel alarming dosimeter to central station radio link equipment for a part of the Integrated Monitoring Program. Complete transistorized dose and/or dose-rate transmittal plus voice communication is required. Some commercial components were reviewed but none will serve the purpose.

Experimental work continued on a thermistor-controlled oscillator for precise measurements of temperature. Initial tests indicated good feasibility.

Initial experiments with a 20-cc ionization chamber plus electrometer tube for use as a "pocket" alarming dosimeter were discouraging due to excessive leakage both from the insulators and from tube grid current. A new design was made using better insulators and a CK-5889 electrometer. This unit is now being fabricated. Leakage currents of less than 10^{-16} amps must be obtained to permit the compact and simple unit to perform at low dose-rate (less than 10 mr/hr) levels.

Experimental work continued satisfactorily on the CaF_2:Mn thermoluminescent dosimeters. A successful miniature glass-sealed unit was fabricated 0.6 inch in diameter and 0.2 inch thick. Induction heating is used to produce the read-out light linearly related to absorbed dose. The complete readout can be accomplished in ten seconds, with the dosimeter then ready for return to service. Several more experimental configurations of the dosimeter will be fabricated and further gamma energy dependence tests are scheduled.

Additional transistor binary circuitry was added to the experimental scintillation transistorized Alpha-Beta-Gamma Hand and Shoe Counter. The hand and shoe beta-gamma channels now count down by a factor of 32 previous to the registers. Laboratory performance has been quite satisfactory.

The blocking oscillator pulse generator circuits for the experimental ion beam deflection system (electron Van de Graaff) were designed, fabricated, and satisfactorily tested. Except for minor modifications in shielding and hydrogen thyratron circuitry, the complete system is nearly ready to test.

Several Li^6 metal targets were prepared for use with our silicon surface barrier diodes for neutron detection and energy analysis experiments. Twenty-five diode detectors were sliced for a new batch; however, a defect was noted which was apparent in all slices. These will be discarded, since performance would be materially affected. A new thin diamond saw was ordered. This will be used on the 1100 ohm-cm silicon ingot.

Fabrication is nearly complete on three experimental prototype scintillation transistorized beta-gamma dose-rate meters of the portable type.

Laboratory tests were continued concerning a new type of zinc sulphide particle counter for use at the Atmospheric Physics Operation. By using two pigments (ZnS-CdS and ZnS) and a multi-channel analyzer, the amount of each pigment deposited can be determined using simultaneous equations. The system should permit simple detection of less than 200 particles deposited on the filter. The new pigment is now being examined experimentally to determine if it has desirable airborne characteristics.

The operation and reliability of the whole body counter multichannel analyzer and spectrum stripper were greatly improved through modification of circuits and operating procedure. The engineering study of analyzer reliability is about 50 percent complete.

An experimental radio transmitter was developed to aid in developing the position-sensing circuits of the robot monitor. Information on turning rate, distance of travel, and direction of motion are transmitted by coded subcarriers to a fixed receiving station for translation to a chart plot of the robot's motion.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis

The planned series of National Bureau of Standards uranium standards isotopic analyses has been completed. The results obtained indicate that no systematic mass discrimination effects greater than about 0.3 percent are present in the mass spectrometer of this program. Final conclusions must await the receipt of more precise information on the standard values from the National Bureau of Standards.

The mass spectrometer for this program was shut down about the middle of the month after the backlog of program samples was exhausted. The down time is being used to install and test the new ion count control circuit for the ion counting system.

An improved sample filament bakeout system has been fabricated and is being assembled.

Research work on the effects of a simple energy analysis system on abundance sensitivity is being performed with the other mass spectrometer.

TEST REACTOR OPERATIONS

The PCTR was shut down for maintenance and reactor improvement during the entire month of November. During the outage, the following maintenance items were completed:

1. The reactor instrumentation was checked for faulty tubes and for proper operation.

2. The 305-B Building was repainted.

3. The R X G Beckman in the building radiation monitoring system was replaced with a Type V Beckman. The space gained by this replacement will be used for the TV Receiver and control panel installation.

The following reactor improvement items were completed during the month:

1. Ninety-nine additional driver element channels were drilled in the reactor. The maximum test assembly size is now 41 1/4 inches vs. the previous 37 1/2 inches. The new channels will permit moving the driver ring further from the test cavity in order to get a better flux match in the buffer region. It is also hoped that these improvements will make possible accurate high temperature neutron flux and reactivity measurements.

2. A new source drive was installed to accommodate the larger physical size of a Pu-Be source.

3. Six slots 2 inches wide and 5/8 inch deep were cut into the fixed face of the PCTR from the outside to the core, and 6 corresponding slots were milled in the moving face. The slots in the moving face were cut 1 inch in depth. The slots will permit electrical and thermocouple leads and water lines to be brought out from the core without interfering with opening and closing the face.

4. Eight holes were drilled through the steel plates on the moving face corresponding to the 70 cm position of the control rods. These positions are necessary for insertion of 8 foot resistance heaters for measuring the reactor temperature coefficient.

5. A new key lock bypass switch was installed to separate the level and period functions of Channel 2 safety circuit. The safety circuit was modified to continue making it impossible to bypass Channel 2 and 5 period functions simultaneously.

6. A key switch was added to the source drive power circuit in order to lock the source in the out position during the time the core loading is being changed.

7. A key switch was installed in the moving face power circuit in order to keep the moving face from opening when the reactor room doors are opened. This switch will be used only for those tests where reactivity reproducibility requires that the face remain closed during the tests and where it has been specifically authorized to do so.

8. Installation of the closed circuit TV was started during the month.

9. A period meter of the DC differential amplifier type was developed, tested, and installed in Channel 5 of the PCTR. This instrument is simpler and can be calibrated more accurately than the instrument it replaced.

Two foil irradiations were made in the TTR during the month, one for PRTR experiments and the other for NPR experiments.

Wiring of the timer scaling strips of the automatic foil counter continues and is 30 percent complete.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Consultation service was rendered on meteorological and climatological aspects of 1) exposure of temperature sensing elements for air conditioning control in reactor buildings, and 2) experimental design for environmental studies of large transformer operation in desert regions.

Meteorological services, viz., weather forecasts, observations, and climatological services, were provided for plant operations and management personnel on a routine basis.

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	81.0
24-Hour General	60	80.2
Special	142	82.4

November was a little warmer, wetter, and windier than normal. All but 0.03 of the 0.92-inch precipitation total occurred between the 9th and 24th. At least a trace occurred on 14 of 16 days during this period. Best winds were on the 20th and 24th. Peak gusts on these days were, respectively, 45 and 59 mph. There was no snow and only one hour of fog.

Instrumentation and Systems Studies

The sampling probe (air intake) for duct installation in the 325 Building for a combined alpha and beta-gamma air stack monitor was completed. Paper design of the complete system was nearly finished.

Continued advice and consultation was rendered to Redox instrument maintenance personnel regarding operation and adjustment of the Redox Stack Effluent Monitor.

Two experimental 5-by-14-inch scintillation beta-gamma shoe monitors were

satisfactorily tested. These will be used with the Clothing and Shoe Scintillation Transistorized Beta-Gamma Monitor for 308 Building use.

The two experimental Sensitive Scintillation Airborne Recording Monitors for Regional Monitoring, RPO, are being modified to incorporate desired changes.

Basic design work was continued on a beta-gamma (mixed fission product) air monitor for use in the 327 Building. The first unit, using transistorized circuitry and a moving tape, will be considered experimental. If satisfactory, three more units will be fabricated.

A work request was received from the Radiological Chemical Analytical Laboratory for engineering services required to develop channel summing circuits for their multichannel analyzer (RIDL).

Ceramic Fuels Development Operation has requested assistance in the development of a high-speed temperature control system for a swaging operation. The temperature of the object to be swaged is to be raised quickly from room temperature and controlled as it is passed into the swaging machine. Tests to determine system characteristics are being planned.

A problem has been accepted from Operations Research. This problem concerns the buildup and decay of radioactive iodine in a person's thyroid after an injection.

Two X-ray diffraction peak integrators have been received and installed for the Manufacturing Operation, FPD. It may be necessary to alter the integrators in the near future. Operating experience will determine the final requirements. The integrators were not received from Perkin-Elmer entirely as specified. It will be necessary for them to send us certain modification parts to change the printer tape speed.

Work is continuing on the reference system to be used in calibrating the Schaevitz DRS-100 system. The DRS-100 is intended for future use by the Physical Metallurgy Group in making in-reactor creep measurements. Modifications to a furnace and controller for use in elevated temperature calibrations have been completed and are being tested to determine the "degree" of temperature control that will be available with the modified units. The reference system has been completed for use with the DRS-100 and is essentially ready for a "laboratory standard" type calibration after which it will be placed in service as a standard reference system.

A work request authorizing evaluation and calibration of two more displacement readout systems was received from the Physical Metallurgy Group. These systems, two Physical Science LVDT units with readout provisions and two Technology Instrument Corporation TIC linear potentiometers, respectively, can be evaluated using the reference system mentioned above although some minor coupling modifications will be necessary.

A paper study is nearly complete on the modifications necessary to make the TIC RST No. 4 potentiometer capable of being used to make in-reactor creep measurements. To date the only apparent modification necessary is the replacement of the epoxy potting compound presently used, by a ceramic compound called "Durock".

Work is currently being done to develop a system by which the position of the slider of the RST No. 4 potentiometer can be detected. This position of the slider is a direct measurement of the creep. At present the most promising system of readout is a null device whereby the slider of a second potentiometer is nulled with the slider of the RST No. 4.

The FPD nickel plating process has been set up on the GEDA computer and a solution found. It was discovered that the process was extremely stable. Because of the very small load changes, the process could probably be controlled by an on-off controller. The computer showed the process was so easy to control, the limiting factor probably lies in the pH measuring equipment.

A problem on the two dimensional temperature distribution in a separations waste burial cask was received in mid-November. The customer desires a study of the effect of a discontinuity in a burial cylinder as a function of the waste material thermal conductivity. The presence of the discontinuity requires two-dimensional techniques which in turn require extensive use of computer potentiometers. The simulation is nearly completed and will be ready to run at any time in December, 1960. Some difficulty in scheduling is expected since equipment from both computers is required.

Optics

Internal Diameter Optical Micrometer

This unit was designed in October, 1959, for measuring the internal diameter of discharged fuel elements in the 105-C Fuel Examination Facilities. It is now installed. Tests performed this month demonstrated the expected accuracy of ± 0.002 inch.

Length Measurement Periscope

Design drawings for this periscope are about 50 percent complete. The unit will be installed beside the Internal Diameter Micrometer at 105-C so that inside diameter and length measurements will be made from one station.

Microdensitometer

Modifications necessary to convert a Leeds and Northrup microdensitometer for use by Biology Operation in studying autoradiographs of bones are about 50 percent complete.

Borescope Camera

Adaptors which will permit photography through the latest model large Lenox borescope have been designed. Improvements which will permit better electrical connections have been designed for the latest model small Lenox borescope.

Shop Work

A total of 394 manhours' work was performed during the four-week period (October 30 to November 27) included in this report. Of this, 8% was for IPD, 14% for CPD, 74% for HLO, and 4% for Code 9215.

The work included:

1. Repair of two microscopes for 327 Building.
2. Modification of two cameras for photography.
3. Miscellaneous fabrication for the PRTR Gas Gap Measurement equipment.
4. Repair of two Purex crane periscope heads.
5. Assembly of infrared pyrometer for Physical Measurements.
6. Fabrication of several filters for the radiation ratio pyrometers.
7. Evaporation of lithium for Nucleonic Instrumentation.
8. Repair of three underwater viewers.
9. Repair of one cathetometer.

Analog Computer Facility Operations

The major problems on the analog computers this month include:

1. PRTR Critical Facility Analysis.
2. Nickel Plating Process Control System Study.
3. Reactor Speed of Control Study.
4. NPR Pressurizer Study.

The routine maintenance procedures on both analog computers have been started. Some routines cannot be performed until the necessary spare equipment has been received. The present work load for the instrument maintenance personnel and the computers prevent the performance of some of the routines.

An order for twelve products of electronic multipliers was placed with Beckman/ Berkeley for $11,190.00. Delivery is expected in January, 1961.

Computer Operation:

GEDA	164 hours up	EASE	150 hours up
	12 hours scheduled downtime		30 hours scheduled downtime
	16 hours unscheduled downtime		12 hours unscheduled downtime
	0 hours idle		0 hours idle
	192 hours total		192 hours total

Instrument Evaluation

Field tests (satisfactory) continued on the Model II Alpha "Scintran" line-operated monitor at Redox and Purex. With the new wedge-shaped 2-by-4-inch and 2-by-7-inch cast plastic alpha scintillation probes, as little as 50 d/m of Pu^{239} (spot source) can easily be detected in routine use. This is a factor of 5 to 10 better than with the older model probes.

A second Model II "Scintran", using a thin detector (NE-102) for beta-gamma use, was field tested quite successfully at 100-D. The combination was found to have three times the sensitivity for Sr^{90} than could be obtained with a GM tube. The scintillation beta-gamma probe used is a simple modification of the new 2-by-4-inch wedge-shaped plastic head alpha probes.

Some testing was completed on a directional scintillation neutron (fast) detector for use with our transistorized portable neutron instruments. To obtain the

desired directional response, the moderator-collimator (lined with Cd) will weigh nearly 50 pounds.

Advice was rendered concerning adjustment of the Scintillation "Criticality" Alarm Monitors for use in the 308 Building.

Evaluation tests were started on an NMC "Gammaguard" and a Keithley 412 plus ion-chamber area monitor at the request of IPD and Instrument Design, CEcUO.

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Uranium Oxidation and Fission Product Volatilization Studies

In further studies of the release of fission products from overheated uranium, the fractional release from uranium irradiated to 10^{20} nvt (equivalent to 300 MWD/T or 0.04 atom percent burnup) was measured. Rare gas release was 99.8 percent during the 24-minute heating period at 1200 C. Analyses for other isotopes are in progress. Seventy-five percent of the uranium was oxidized. This is the same degree of oxidation as measured for uranium irradiated in the 10^{14} to 10^{18} nvt range.

The graphite shroud and lead rod from a fuel element assembly test in the DR gas loop was obtained from General Atomics to study in-reactor retention of fission products released from the apparently ruptured fuel rod. Decontamination of the 18-foot stainless steel lead rod was accomplished by stripping the fission products from one foot sections. Initial I-131 data showed a correlation of increasing deposition with increasing distance and decreasing temperature. Depth sampling of the graphite bar shroud is in process in Radiometallurgy for evaluation of the fission product diffusion into the graphite.

Fifteen experiments employing oxidation by air, for purposes of determining particle size distribution, have been carried out to date at 400, 500, 600, 700, 1000 and 1200 C. The majority of the experiments were conducted at air flow rates of 3500 cc/min, giving an air velocity of about 400 cm/min at the collection filter; a few were at 1000 and 2300 cc/min to correlate the effects of air flow rate on particle size distribution. Time at temperature was varied accordingly with temperature to give relative degrees of oxidation in all runs.

Optical microscope observations of the millipore filters indicated that the majority of particles generated during oxidation are of submicron size. No information is available as yet on the actual size and size distribution of these. Microscope examination of the micron size particles shows that nearly all of these fall in a size range from 1 - 8 microns. Particles as large as 50 microns have been observed although these are usually conglomerates of smaller irregular particles. Temperature has an effect on both the quantity and size distribution of particles with a larger number of micron-size particles being generated at lower temperatures. This can be attributed to the nature of the oxide formed at the various temperatures. At 1000 and 1200 C an adherent oxide coat is present on the specimen, whereas at lower temperatures a powdered or sintered mass results.

Marked thermal cycling was observed during the oxidations at temperatures of 600, 500, and 400 C. It was evident that thermal cycling begins after an induction period of 40 - 80 minutes. The length of the induction period is quite reproducible for a fixed set of conditions but varies with temperature, air flow rate and specimen size. A series of experiments at 1000, 2300 and 3500 cc/min flow rates and 820 F gave induction periods of 59, 75 and 45 minutes, respectively, so that no generalization could be made. Also, 1/8, 1/4 and 1/2-inch uranium cylinders when oxidized at 820 F gave different times of induction. From this experiment it was observed [redacted] the larger cylinder remains ignited for a longer period than the smaller cylinders.

NPR Effluents

Laboratory studies were directed toward the development of methods for removing radioactive contaminants from phosphoric acid decontamination solutions proposed for NPR coolant loops. Scavenging methods were examined to conform with treatment processes developed for other chemical decontaminating agents to be employed at the site. The objective of these experiments was to determine the minimum chemical addition and sludge volume to give adequate removal of radiocobalt from solution. The precipitate formed by the addition of ferrous sulfate followed by caustic neutralization effectively removes radiocobalt from the phosphoric acid solution. The process is ineffective without the addition of near stoichiometric amounts of caustic to neutralize the phosphoric acid. It may be possible to achieve adequate removal of radiocobalt with as little as 500 ppm iron. Better removal is achieved with somewhat more ferrous sulfate and with the addition of potassium permanganate. Scavenging with 1000 ppm iron and 500 ppm permanganate removed more than 99 percent of the radiocobalt and produced a sludge volume of 3 - 10 percent of the volume of waste treated.

A study was completed of the aquifer characteristics of the materials underlying the 100-N Area. The observed response in the water levels in appropriate wells to the seasonal change in the river level was used to evaluate these characteristics. The calculated permeability of the material beneath the site indicated that the proposed trenching of large volumes of NPR effluent from time to time will not affect the water table enough to interfere with the operation of the trench. Thus, the size of the disposal facility required will be governed by the infiltration capacity of the soil.

Well drilling is being considered to substantiate the high ground water table altitudes in the area centering a mile and a half north of Gable Mountain. If the water table contour locations and thereby the ground water flow directions postulated can be substantiated, disposal of proposed NPR phosphoric acid decontamination wastes to ground to the south of the site is potentially desirable. Under such conditions wastes would enter the Columbia River only below the 100-F Area where activation of the wastes by reactors downstream from NPR could not occur.

Reactor Effluent Treatment

The pilot-scale aluminum shavings bed was operated during the month at a flow of six linear ft/min. Radiation level stabilized at 1200 mr/hr at contact. Sample results available indicated that isotope removal equilibrium at this flow rate was reached for Cu-64, As-76, Zn-65 and Np-239. Decontamination factors at this higher flow rate were about the same as for the lower flow rate except for As-76, which was removed to the extent of 52 percent vs. 60-70 percent at the lower flow. P-32 removal had not reached an equilibrium value at the time the other isotopes removal had stabilized, but was still increasing. A 60 percent removal was shown by the most recent sample; this is about the same decontamination which was achieved at the lower flow rate.

Ten-foot long columns packed with aluminum shavings were installed on the 100-B and 100-H riser sampling lines. Effluent flow through these columns is 2 ft/min. The experiment will help to evaluate the effect of increased alum and the use of aluminum nitrate in current reactor water treatment tests on the decontamination.

Of 17 minerals examined for P-32 adsorption from reactor effluent, pyrite, pyrrhotite, calcite, and scapolite showed the greatest promise. At 80 C these minerals removed

50 to 76 percent of the phosphorus from solution after one hour contact time in batch experiments. Of 13 minerals examined for As-76 adsorption from reactor effluent, pyrite was the most promising. In a batch experiment this mineral removed 56 percent of the arsenic from solution after one hour at 80 C. All of the minerals except pyrite exhibited favorable adsorption of Zn-65 from solution at 80 C.

SEPARATIONS PROCESSES

Solvent Evaluation Studies

Three new hydrocarbon mixtures (Shell Turbine Fuel Code 16550, Shell Paraffin Base Code 82000 and Humble Oil Penola-100) were tested as potential TBP diluents. Penola-100 is said to be identical with Solvesso-100 which has been studied at ORNL. It contains a high proportion of aromatics. Following severe nitration (24 hours in contact with 8 M HNO_3-0.05 M $NaNO_2$ at 80 C) the diluents were made 30 volume percent in TBP and used in batch contact tests simulating Purex first cycle extraction, scrub and strip operations. Gross fission product behavior was compared to that obtained when using similarly nitrated carbonate-washed Shell E-2342 as diluent. Gross gamma extraction coefficients (E_a^o) were less by factors of from four to seven when these three hydrocarbons (after nitration) were used as diluents than when nitrated Shell E-2342 was used. Removal of gross gamma activity by scrubbing was more efficient (lower E_a^o) for the three test hydrocarbons than for Shell E-2342. Stripping contacts removed gamma activity more effectively from the organics containing the three test hydrocarbons. The results obtained in testing these three hydrocarbons were very similar relative to Shell E-2342 to those obtained in testing Ashland Oil Company samples (HW-67254 C).

Removal of Sulfate from Hydroxylamine Sulfate Solution by Ion Exchange

A program was initiated to determine the feasibility of converting hydroxylamine sulfate ($2NH_2OH.H_2SO_4$) to the nitrate salt by anion exchange. Initial feasibility studies were made in small burette columns with one weak-base (Dowex 3) and four strong-base (Permutit-SK, Amberlite IRA-401, Duolite A-40 and Illco-TAD-1) anion exchange resins. Later studies were made in a two-inch diameter by 20-inch long Plexiglass column and a four-inch diameter by 80-inch long glass column to determine (a) the feasibility of operating with the bed slightly fluidized, and (b) optimum operating conditions. The preliminary studies showed that the distribution of sulfate to the resin was unfavorable for the nitrate and chloride forms of the resin, but high for the hydroxide form of the resin. Subsequent studies were therefore directed to the removal of sulfate from an aqueous solution of hydroxylamine sulfate. The observations and results are summarized below:

1. Both Permutit SK and Amberlite IRA-401 were relatively unstable to repeated acid-base cycles and so were eliminated from further consideration.

2. Favorable exchange characteristics were exhibited by Duolite A-40 and Illco-TAD-1 resins. The Dowex-3 weak-base resin exhibited less exchange capacity and greater tendency for the sulfate to "bleed" through in low concentrations.

3. Gassing was noted with both the Illco and the Duolite resins at room temperature. However, the problem was more severe with the Duolite resin. At temperatures above 35 C both resins gassed excessively.

4. Studies in the 2-inch diameter column to determine the feasibility of upflow operation with the column partially fluidized were successful. Satisfactory sulfate removal was obtained at upflow rates of 165 gal(hr)(sq.ft) (one liter/min in a 4-inch column). Resin utilization under these conditions was 55 percent of theoretical capacity to a breakthrough of five percent of the initial sulfate concentration.

5. The initial studies in the 4-inch column were successful and appeared to verify the results obtained with the small column.

Reclamation Facility

Continuous Dissolver - The Recuplex cold pilot plant continuous dissolver was successfully run at capacity factors of 1, 2 and 6 (Runs CF-1, CF-2 and CF-6) for 5 to 6 hours at each rate. The operation was easily controlled, with no evidence of entrainment in the off gas or foaming. A typical can dissolved in 3 to 6 minutes, followed by a vigorous one-minute reaction between the can contents and the dissolver solution. The duration of the fast reaction limits the dissolver throughput rate.

A very small heel was predicted for all practical feed rates with either plug or mixed flow in the dissolver. The CF-1 run was made without sparging and produced a tightly packed agglomerate heel less than 1/2-inch in depth. The sparged pilot plant runs produced no heel at CF-2 and a 2-inch heel of loose chips at CF-6. On cooling, a gelatinous precipitate formed in the dissolver product, but when diluted with ANN in the product tank the solution was clear.

Pulser for Reclamation Facility Columns - A plug-piston pulser with a graphite piston operating in a U-Column (pulse leg as high or higher than the column) filled with CAX has a service record of 8-1/2 million cycles without a significant change in the piston stroke/column amplitude ratio. Pulser studies to date show that the graphite plug piston is (a) low cost, as compared to the split-ring piston, or other pulse types, (b) long wearing and reliable, and (c) adaptable to remote handling. These advantages are gained where there is chemical compatibility, where "clean" streams are used, where vertical operation is employed, and where reasonable care has been used in the fabrication. Tolerance to foreign materials, and adaptability to horizontal operation, has not yet been evaluated.

Vertical Tank Circulation-Agitation System - A prototype of the vertical tank circulation agitation system for the new Reclamation Facility has been operated. The prototype consists of three parallel glass columns, each 6-inches in diameter and 15 feet high. The contents of the tanks are circulated with a centrifugal pump for agitation. A mixing time of less than three minutes was demonstrated on mixing a weak acid solution and caustic, using phenolphthalein indicator. In final phases of the testing simulated Recuplex CAF solution is being used. To approach plant conditions, 0.5 percent silica has been added.

WASTE TREATMENT

Process Waste Tank Cleanout

The study of process waste tank cleanout methods has been initiated by evaporating batches (up to 300 liters) of both Purex and Redox neutralized synthetic wastes to dryness. Strong, nearly impenetrable, cakes were produced in both cases. However, the cakes were readily slurried up by adding water and heating until a "rolling" boil occurred. This preliminary result indicates that hydraulic mining could be effective in tank [redacted]. However, sampling is required to discover the properties of the "hot" cakes in the tanks.

Batch Calcination

Small scale studies of the calcination of simulated high-level Purex type wastes by the batch process were continued. A total of 14 experiments were made in 3-inch diameter by 7-inch high stainless steel pots. Simulated acidic waste solutions for 10 of the studies contained only nitrates and sulfates of sodium, iron and aluminum. The four other studies also contained lead, nickel, chromium, potassium, acetate, phosphate, silicon dioxide and manganese dioxide in the minor concentrations that would be expected in the neutralized stored Purex waste or that would be added during the recovery of strontium from current Purex waste. The primary objective of the experiments was to better define the waste compositions which produce a calcine that forms a melt at 900 C or less. It has been reported previously that such melts form when the sulfate to salt nitrate mol ratio in the acidic, aqueous waste solution is greater than one and when the sodium to metal ion (iron plus aluminum plus chromium plus nickel) mol ratio is greater than 1.5 but less than 7.5 to 9.0. The new findings have indicated that there are some waste compositions within these limitations that do not form melts. This has been attributed to the presence of the minor constituents. For a given sulfate to salt nitrate ratio, the sodium to metal ion ratio must be lowered to form a melt when the minor constituents are also present.

Some molten solids erupted from the pot during the calcination of a feed with a sulfate to salt nitrate ratio of 1.4, the sodium to metal ion ratio of 8.0 and the minor constituents absent. The sulfate concentration was slightly greater than the stoichiometric sodium equivalent. The experiment was repeated with 40 percent more solution added to the pot. The pot did not erupt but the solids rose as a plug 1-3/4-inches out of the pot during the calcination step. Sectioning of the pot revealed dense, impervious solids above a layer of highly porous solids. It is postulated that the bottom solids were high in iron and aluminum sulfates. These sulfates started to decompose when the temperature rose above about 700 C. The reaction gases were unable to escape through the impervious layer so an internal pressure developed which was eventually relieved in the manner described above.

Another experiment was made with the acid, iron, aluminum and sodium concentrations the same as in the studies that erupted. The sulfate concentration was decreased so that its concentration was slightly less than one-half the sodium concentration. The sulfate to salt nitrate ratio was 1.325. No unusual occurrence was observed.

Previous runs had been made both with and without melt formation using less sodium than the stoichiometric sulfate equivalent. Possibly an excess of sodium is required only with a waste having a composition near the limit of the melt formation region.

The effect of phosphate addition on melt formation is of interest because of the potentially greater latitude offered in adjusting either the combined underground or the current Purex waste so that melts form without sulfate decomposition. One such experiment was made. The sulfate to salt nitrate ratio was 0.76 and the sulfate plus phosphate to salt nitrate ratio was 1.0. The sodium to metal iron ratio was 3.6. Post calcination inspection showed that partial melting occurred. A portion of the melt region had a glassy appearance.

Storage Problems

An analytical solution to the one-dimensional Poisson's equation for temperature distributions in self-heating annuli and cylinders has been derived. The solution

assumes constant thermal conductivities and volumetric heat generation rates. A dimensionless plot has been prepared to aid in the design optimization of annulus radii when all other parameters are pre-determined.

The temperature effect of a void inclusion within an annulus of self-heating material and near the outer edge is being numerically investigated.

Pot Calcination with Phosphoric Acid

An additional experiment with synthetic Purex 1WW was performed testing the Brookhaven scheme of calcination in a pot of phosphoric acid. This time the 3-inch stainless steel pot was immersed in a furnace rather than heated on a hot plate, and heating was carried to a final melt. As before, drying proceeded through a thick slurry stage, and there was considerable foaming. However, a compact melt was produced which had only about one-half the volume of the mixed oxides and sulfates produced by direct drying and calcination of Purex waste without phosphate. It would also be expected that the thermal conductivity of the phosphate melt should be higher than that of the sulfate solids. On the basis of these observations the scheme appears workable and apparently merits further study at a semi-works scale.

In other experiments, borate was compared to phosphate as an additive for rendering certain 1WW solids meltable (at temperatures < 900 C). These solids would correspond to one proposed scheme for working off the presently stored Purex tank wastes. The use of phosphate produced homogeneous melts whereas borate resulted in two phases, one mobile and the other either a solid or a viscous liquid. Phosphate thus appears to be the more promising additive for this application.

Observation Wells

There were no appreciable changes in ground water contamination patterns in the vicinity of the 200 Areas during the past month. The general decreasing trend in concentrations of radioisotopes in the ground water, attributable to radioactive decay and reductions in the quantities of radioactive materials cribbed, was most evident in samples from wells adjacent to active cribsites.

There are indications that radiocontaminants which originated at the 216-BY cribsite in 200 East Area, and were detected in Hot Semiworks monitoring wells several months ago, may now be appearing in monitoring wells just south of Purex plant. Movement of the waste in this direction is expected and probably accounts for increases in beta-emitter concentrations recently noted in wells west and southwest of the Purex Process Condensate Crib (216-A-5). Further movement will place the waste in the general path of Purex cribbed wastes which have moved to the southeast of 200 East Area. Since radioisotope concentrations in the ground water are of the same order of magnitude for both waste streams, the waste from the 216-BY cribsite will probably be indistinguishable from Purex wastes in monitoring wells southeast of 200 East Area.

A study was made of earth samples taken during well construction to evaluate the effect of the drilling and sampling operation on the character of the samples. The evaluation was made by comparing physical and chemical properties of samples from adjacent wells at two locations. In each case one of the wells was sampled by collecting material from the bailer used to clean crushed and churned-up rock fragments from the well, while the other well was sampled with a commercial core-barrel sampler.

The core-barrel collects in-place samples that are practically undisturbed by the drilling and sampling procedure. However, most of the Hanford soil samples have been obtained by the simple bailer technique. The samples were analyzed with regard to sand, silt, and clay-fraction percentages, pH, cation exchange capacity, and calcium carbonate content. The average difference between the two sets of samples was less than the standard deviation for all the characteristics studied. Thus, these data do not reveal a significant effect of sampling method on the earth material obtained and research utilizing samples taken by both methods should produce comparable results.

In cooperation with the drilling contractor, an eight-hour pumping test and a step-drawdown test were performed in well 299-E27-4, located about 1000 feet north of the Purex tank farm. This well is intended as an emergency water supply system for the Purex tank farm condensers. The test indicated that this well should be able to produce the required 100 gpm without difficulty. The water pumped was found to have a temperature of over 70 F which is about 10-15 F above normal ground water temperature. The higher temperature is ascribed to nearby disposal of thermally hot waste and the presence of underground tanks of boiling high level waste. No radioactive contamination was detected in the pumped ground water.

Disposal to Ground

Recommendations relative to the abandonment of the Purex organic waste crib (216-A-2) and location of a replacement crib were forwarded to the Chemical Processing Department. It was recommended that the existing and replacement facilities be utilized only to their specific retention capacities due to poor Co-60 and possibly Sr-90 removal by soil adsorption mechanisms. The existing crib has already received over 90 percent of its estimated specific retention capacity. The suggested location for the replacement facility is about 150 feet south of the existing organic waste crib.

A review was made of disposal needs arising with reactivation of the Hot Semiworks for the isotope recovery program. It was recommended that the limited amount of neutralized process condensate to be produced in this program (estimated at 200,000 gallons or 0.5 column volume) be discharged to the essentially unused 216-C-6 crib at the Semiworks. Samples of the waste are to be obtained for soil column testing soon after operations begin.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium Recovery Program

Purex Flowsheet Assistance - The Purex strontium-crude flowsheet was modified following production run No. 8 to incorporate changes deemed desirable on the basis of recent laboratory and hot-cell findings and because of the loss of one of the plant centrifuges (which necessitated a reduction in time cycle). The remaining long-cooled uranium was processed without feed clarification and the products from caustic-carbonate metathesis of the sulfate precipitate (runs 9 thru 14) pooled for oxalate by-product precipitation in two batches. Overall recovery (to the oxalate supernate) was about 60 percent with 150,000 curies of strontium-90 recovered. The strontium-90 concentration (43 curies/gal) was two-fold greater than the vault material and lead was very low (< 0.01 gm/l); however, cerium and zirconium-niobium content is high and may complicate purification. The material is being stored at Purex for concentration (by either evaporation or precipitation) and shipment to 325-A when Purex load-out facilities are completed.

Other laboratory and hot-cell experiments were aimed at developing a simple, reliable flowsheet for concentrating the strontium crude (either the above material or that currently in the 244-CR vault). Concentration is desirable from a shipping standpoint of fewer cask movements and to provide a more concentrated feed for the purification processes. Reduction of sodium and nitric acid concentration would also be most desirable. Laboratory experiments with synthetic feeds showed that high pH precipitation with either 1M Na_2CO_3 or a Na_2CO_3-NaOH mixture gave quantitative strontium precipitation, ferric hydroxide serving as a carrier. A hot-cell experiment with a liter of 244-CR vault material, however, gave only 58 percent recovery. Further hot-cell concentration experiments will use the F-13 concentrate.

Strontium Purification - Installation of the larger-scale equipment in A-Cell of the High Level Radiochemistry Facility was completed in mid-November. A cold run was started November 19, following calibration of tanks and probes. The run, which featured room temperature operation and EDTA (ethylene-diamine tetracetic acid) complexing of iron during ion exchange loading, has proceeded smoothly except for difficulties with the feed pump and piping system. Piping changes have been made which rectified this difficulty.

The mole ratio of iron to strontium in the vault material (data on F-13 not yet available) is 33 to 1. If this solution is loaded directly, the iron would saturate the ion exchange capacity of the resin and greatly reduce the amount of strontium which can be purified per run. Experiments in a small column showed that use of a stoichiometric quantity of EDTA at pH 2 to 4.5 will cause iron (and probably cerium) to pass through the column while permitting strontium to load. This use of EDTA was tested in the A-Cell run. A 218-gram batch of strontium, equivalent to 16,000 curies was absorbed on the first column without detectable breakthrough while little or none of the iron absorbed.

Other ion exchange experiments were conducted in support of the Hot Semiworks campaigns, in which it is proposed to use an ion exchange column following one cycle of solvent extraction to concentrate the product and achieve additional decontamination from cerium and zirconium-niobium. Strontium was found to load readily to a concentration of over 50 g/l of resin from a pH 2.5 synthetic solvent extraction eluate containing 1 M citrate, 0.4 M Na, 0.04 M Sr, 0.01 M Ca, and 0.001 M Ce. Elution with eight column volumes of 2 M $NaNO_3$ removed 95 percent of the strontium at an average concentration of 6.6 g/l. Higher concentrations should be realized with nitric acid elution.

Feed Preparation - Emphasis has been placed on processing a dilute feed representing a four-fold concentration of the "crude cut" material currently in the 244-CR vault. This feed solution would still be about one-tenth as concentrated in strontium as the feed solutions used in previous solvent extraction studies. The flowsheet currently under study involved first an extraction at relatively high pH (4 - 5) to extract strontium and some calcium. Acetate would then be added to provide buffering and complexing agents such as EDTA or HEDTA (n-hydroxyethylene diamine triacetic acid) added to complex iron and the rare earths to decrease extraction to these elements as well as to prevent precipitation of iron. The organic from the initial extraction may then be stripped and the resulting aqueous used as feed to a second cycle at low pH (2) to separate strontium and calcium. Alternately the organic phase may be fed to a partitioning column operating at low pH for this separation.

Feed solutions stable towards solids formation at pH's as high as 6 can be prepared from the four-fold concentrated crude cut solution. Typical feed solutions used in batch contact and mini-mixer-settler runs contained 0.5 M sodium acetate and 0.05 M EDTA or 0.25 M HEDTA. They were used at pH's from 4 to 5. Complexing of iron by EDTA and HEDTA is not rapid and some digestion time (one to two hours) may be required to assure solids-free solutions at pH's above four.

The effect of radiation on the feed solutions as well as the extractant is under study. Solutions simulating the concentrated feeds previously studied were subjected to gamma radiation in the 100-KE facility. In these cases, acetate or citrate was present as buffering agent -- neither EDTA nor HEDTA was present. The solutions were initially at pH four to two. After exposure to 8×10^8 R of gamma radiation, marked increases in pH (to 7 - 8.5) and extensive solids formation had occurred in all the solutions.

No visible change occurred in an organic extraction solution containing 0.4 M D2EHPA (di-2-ethyl hexyl phosphoric acid) and 0.15 M TBP in Shell E-2342 diluent when irradiated to a comparable exposure. Samples simulating the dilute feed now under study are being irradiated in the 100-KE facility.

Laboratory Solvent Extraction Studies - Batch contact studies were made using dilute feeds containing acetate and EDTA or HEDTA for aqueous and 0.4 M D2EHPA - 0.2 M TBP - Shell E-2342 as organic. Aqueous to organic volume ratio was five and initial feed pH was from four to five. Changes in pH from initial to equilibrium values were small (0.5). Distribution ratios obtained indicated good extraction of strontium. Cerium extraction was reduced by both EDTA and HEDTA although more by EDTA at any given concentration. Distribution coefficients for europium were lower than for the cerium as spiked; again, EDTA was more effective than HEDTA in reducing the extraction.

Three mini-mixer-settler runs have been made using the dilute feed. In all cases, the extractant was 0.4 M D2EHPA - 0.2 M TBP - Shell E-2342 and feed to scrub to organic flow ratios were 1.9/0.075/0.39. Feed solutions varied in acetate concentration (0.25 - 0.4 M), initial pH (4.0 - 4.7) and in the use of EDTA or HEDTA as complexing agent. Scrub solutions were sodium acetate - sodium nitrate solutions at pH 3.8 or 9.0. Data from these runs show good extraction of strontium; excellent separation of iron, ruthenium and zirconium-niobium (not detected in the organic) and some separation of cerium (DF = 6.5 - 13). Barium tended to divide more or less evenly between the two phases. Calcium data are not yet available.

Several runs, under solution composition and flow ratio conditions similar to those for the mini runs, have been made in a miniature pulse column. Operation was good at volume velocities up to 300 gal.(hr)(sq.ft). These runs confirmed the good strontium recovery and partial cerium decontamination observed in the mini runs.

Preliminary batch contacts were made to test the feasibility of removing strontium from an organic stream (A-column product) without removing other constituents. In these, organic streams from A-column runs were contacted with equal volumes of either 1.0 M citric acid or 1.0 M tartaric acid. Equilibrium pH in both cases was about two. Distribution coefficients (E_a^o) were 0.1 or less for strontium and five to seven for calcium and cerium. Partitioning of strontium appears feasible and the data are consistent with pilot plant information described below. Flowsheets designed to achieve partitioning are to be tested in the miniature pulse column using radioactively traced feeds.

Pilot Plant Solvent Extraction Studies - Pilot plant studies to demonstrate the recovery of strontium-90 from Purex 1WW "crude cut" by pulse column solvent extraction techniques were continued. Information gained from the laboratory studies described above has been used in these studies. Primary emphasis was on the extraction of strontium from HEDTA complexed feeds at pH's ranging from 4 to 6, using 0.4 M D2EHPA - 0.2 M TBP in Shell E-2342 as the solvent. The strontium was stripped from the solvent with either nitric acid, citric acid, or tartaric acid. The latter two stripping agents permitted operation at pH's favorable for partitioning strontium from calcium and rare earths. Highlights of the runs were as follows:

1. Strontium recoveries were greater than 90 percent in extraction runs with either top or bottom interface operations and using up to a 50 percent excess HEDTA in the feed. The addition of HEDTA may also have provided some partitioning from calcium; the calcium reported in the product ranged from 50 to 90 percent of that in the feed.

2. Dilution of the feed ten-fold (from 1.6 g Sr/l to 0.16 g Sr/l) did not affect the strontium recovery at an approximately constant solvent loading when the same sodium nitrate and acetate concentrations were maintained in the aqueous feed.

3. The solvent could be used in either the sodium or acidic form without affecting strontium extraction or column performance. The pH of the waste in the latter case was typically about 4 with the dilute feed.

4. The flooding capacity of the extraction section with the dilute feed was in excess of 1200 gal/(hr)(sq.ft) with either top or bottom interface. Maximum capacity with bottom interface was about 70 to 80 percent of the top interface capacity.

5. Improved scrub section stability was obtained using 1 M $NaNO_3$ in place of 0.2 M sodium acetate plus acetic acid.

6. With HEDTA present, the acetate concentration in the feed could be reduced to at least 0.5 M at pH 4 to 5 without iron precipitation. Addition of HEDTA to a pH 4 feed in which the iron had precipitated dissolved the precipitate within a few hours.

7. Complete stripping of the strontium and calcium in the solvent was obtained using 2 M HNO_3 at an aqueous/organic flow ratio of 0.1. The column capacity was in excess of 1000 gal./(hr)(sq.ft).

8. Calcium partitioning, together with pH control, was demonstrated in the stripping column using either 1.5 M citric acid or 1 M tartaric acid as the stripping solution at 650 gal./(hr)(sq.ft) throughput. The calcium DF with 1.5 M citric acid (A/O = 0.5) was 2 to 2.5, and with 1 M tartaric acid (A/O = 0.25) was 5 to 6. The aqueous phase pH in both runs ranged from about 1.7 at the top of the column to 2.1 at the bottom.

A flowsheet based on the above results has been prepared for review and integrated demonstration. Three major operations are involved, i.e., extraction of the butted and complexed "crude cut" in a typical compound pulse column, selective stripping or partition in a simple pulse column, and terminal ion exchange purification - concentration.

Precipitation and Filtration of Strontium Carbonate - Of several methods tried for precipitating strontium carbonate from dilute strontium nitrate solutions, two produced a product having a satisfactory particle size and filtration characteristics. One method uses carbon dioxide and ammonia as the precipitating agent. The other involves the use of sodium or potassium bicarbonate as the precipitating agent. Previous tests have shown that filter aid is required for the successful filtration of strontium carbonate which has been precipitated by the addition of sodium carbonate to strontium nitrate solution. The particle size of the product precipitated with bicarbonate is greater than 40-50 microns and filters successfully without filter aid on a "Type J Rigimesh" filter screen.

Calcination of Strontium Nitrate - Strontium oxide prepared by calcination of strontium nitrate has been proposed as a terminal product in the strontium recovery process. Short duration evaluation tests were made to screen potential materials of construction for the calciner by immersing coupons in molten strontium nitrate (not heat transfer conditions). Out of a large number of materials tested, only nickel, Hastelloy C, Monel, Inconel, Hastelloy D and Hastelloy B had corrosion rates less than 10 mils/mo when exposed to calcining strontium nitrate at 600 C.

Strontium nitrate has been successfully calcined in an agitated heated stainless steel pot. However, corrosion of the pot introduced as much as 2 percent corrosion products into the resultant strontium oxide. The magnitude of corrosion rates under heat transfer and calcining conditions for the four following materials in contact with calcining $Sr(NO_3)_2$ were:

304-L stainless steel	0.5 inch per month
Commercially pure nickel	0.5 inch per month
Hastelloy B	0.1 inch per month
Hastelloy F	0.1 inch per month

Further tests are planned with other materials of construction, and different calcining techniques.

Analysis of Calcium and Barium in Purex Essential Materials - Analytical methods for determining calcium and barium in Purex essential materials were required in tracing the source of these materials in the crude strontium product. Flame photometry was used to detect both metals when separated from sodium and other interferences. Calcium was purified by coprecipitation with lanthanum fluoride. Afterward, lanthanum was removed by hydroxide precipitation. Recoveries of added, known amounts of calcium were 60 to 100 percent. Coprecipitations with magnesium carbonate, lead carbonate, and lead oxalate were all unsatisfactory. Although not yet widely applied, ion exchange afforded satisfactory barium purification and an alternate for calcium. Specifically, calcium and barium were together loaded on Dowex 50 cation exchange resin, washed free of sodium with tenth normal hydrochloric acid, and eluted with six normal hydrochloric acid. Recoveries of added, known amounts of calcium were 75 to 80 percent; barium recoveries were 100 percent.

Radiostrontium Analysis - Application of ion exchange techniques improved the precision of Sr-89 and Sr-90 measurements about 2.5 times and reduced cost about 2.5 times from previous methods. In the application, strontium in miscellaneous acidic samples was loaded on Dowex 50. Impurities were removed by washing with 0.8 M α-hydroxyisobutyric acid and 0.4 M nitric acid. For determining Sr-89 and Sr-90 the strontium was eluted with 8 M nitric acid, dried on a stainless steel dish, and beta counted. For determining Sr-90, impurities were removed and the purified strontium was left on the resin for three days. A second impurity elution was made with 0.25 M

α hydroxyisobutyric acid. That eluate contained only the three days' growth of Y-90. Its beta counting rate permitted Sr-90 calculation.

Analysis of Calcium, Barium and Cerium in Pilot Plant Solutions - Since the large amounts of sodium and nitrate in strontium recovery solutions interfere with direct determinations of calcium, barium, and cerium, and since complexing agents like HEDTA make quantitative separation of trace elements very difficult, several techniques are under study for assay by emission spectrograph or flame photometer methods.

Strontium Shipment - It has been proposed to modify the cerium filter cask for strontium product shipment by means of an annular insert which would contain about 1-1/2 cubic feet of Decalso. Experiments showed that the scheme is entirely practical for High Level Radiochemistry purified product, which can be loaded onto the bed either from a dilute nitric acid solution or directly from the EDTA containing column eluate. Capacity of the cask under those conditions could be at least 70,000 curies of strontium-90. For strontium crude the situation appears much less favorable. A synthetic crude plugged a Decalso bed immediately due to precipitation of ferric hydroxide. Pre-treatment of the bed with acid to convert the Decalso to the hydrogen cycle eliminated the iron precipitation, but strontium broke through in the first column volume. Use of EDTA and Versene Fe-3 Specific to retain iron in solution show promise, and strontium capacity studies are being made with these reagents.

In other experiments, the absorption coefficient, KD, of strontium onto Decalso was measured from nitric acid, sodium nitrate, and ammonium nitrate solutions as a function of electrolyte concentration. KD has a value of about 10,000 at very low concentrations of strontium and electrolyte. This decreases steeply to values of 10 to 100 at a few tenths molar nitrate and then more gradually to values of 0.1 to 1 at 4 M electrolyte. Similar values were obtained from sodium nitrate and ammonium nitrate solutions but those from nitric acid were a factor of ten lower. Thus, nitric acid should be a more effective elutriant than sodium nitrate or ammonium nitrate, while loading should work better from the salt solutions.

Strontium Bearing Solids - The contents of the 244-CR vault were heated to about 50 C, stirred, and a sample taken after addition of the product of production run No. 8. The sample was examined in the laboratory and found to contain a small amount of white, crystalline precipitate. The precipitate was removed by filtration, washed, dissolved in hot 8 M HNO_3, and analyzed. It was found to contain more lead and strontium but less cerium and zirconium-niobium than the bulk of the sample. On the basis of these observations, the solids are believed to represent coprecipitation of strontium on lead sulfate. This precipitate may account for 5 to 25 percent of the total strontium, depending on the extent to which the sample is representative, and could explain the strontium "plating" phenomena which has been postulated in the plant.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

X-Ray Absorption Edge Spectrometry

In connection with analytical needs in current research programs, a brief study has been made of absorption edge X-ray spectrometry. This method entails measuring the absorption of a monochromatic X-ray beam (obtained with the aid of collimators and an analyzing crystal) on both sides of a major absorption edge of the element to be determined. Virtually all interferences can be eliminated by simply making the measurements at wave lengths narrowly separated from the absorption edge. The continuous variation in absorption by elements not having an absorption edge in the wave length

interval covered will be small and the amount of material having an absorption edge in this interval can be readily evaluated from the discontinuous increase in absorption as the wave length of the incident X-ray beam is decreased. Thus, samples of widely variable composition and in different matrices can be analyzed for the same element by this technique without additional calibration.

The small correction for absorption in the matrix can be eliminated entirely by making two measurements on each side of the absorption edge. Then a straight line extrapolation can be made in a plot of log I_o/I vs. wave length (or vs. the Bragg angle) to the exact wave length of the absorption edge and thereby avoid any necessity for correcting the measurement for changes in absorption by the matrix.

The method was briefly tested for determination of lead and bromine in the same sample. Despite the fact that the measurements were simply taken off instrument scans, the absorption jump was quite constant over substantial composition intervals.

Limitations in the method include the fact that the count rates must be handled as logarithmic functions, and it is necessary to accumulate about 10^6 counts to achieve good precision. Likewise, since the absorption edges for the light elements are at long wave lengths, severe experimental problems are encountered with these. The optimum cell length is approximately given by 2.56 divided by the mean total mass absorption coefficient for all the elements in the X-ray beam. Design of cells which do not absorb essentially all of the soft incident X-ray beam becomes quite difficult for the rare earth elements (L_{III} edges) and for elements lighter than Cr (K edges).

Analysis of Radiocerium in Huge Amounts of Other Radioactivity

When Ce-144 represents only a trace of the total radioactivity, multichannel energy spectrometry must be preceded by chemical purification of the cerium. Application of the new D2EHPA liquid-liquid extraction method reduced the cost of the separation three-fold. Three-fourths molar D2EHPA in n-heptane extracted over 90 percent of the Ce-IV from 10 molar nitric acid - molar potassium bromate solution. Three percent hydrogen peroxide stripped the cerium from the organic phase. The D2EHPA method also gave better yield and decontamination than former methods.

EQUIPMENT AND MATERIALS

Elkem Solenoid Valve

An Elkem solenoid valve with a plastic (believed to be polyethylene) body and a tantalum seat has been operated smoothly for over 150,000 cycles at 900 cycles per hour closing against water at 32 psig. The apparent difference between this valve and previously tested Elkem valves is in the body material and in the use of a 48 volt DC coil instead of a 120 volt AC coil. The earlier version failed because of electrical burnout of the coil.

Magnetic Pulser

An 1.55-inch magnetic pulser has operated for 500 hours and 1.2×10^6 cycles without a breakdown. The operating characteristics have been 2-inch amplitude, 40 cycles per minute, and 10 psig peak pressure. Observations indicate that the amplitude can be varied from 0 to 2 inches - for frequencies from 0 to 100 cycles per minute, by varying the power supplied to the coils.

Corrosion of 304-L Stainless Steel in HNO_3-HF-$Al(NO_3)_3$ Solutions

Corrosion rates observed for 304-L stainless steel in boiling 6 M HNO_3 - 0.01 M HF containing aluminum nitrate at Al/F mole ratios of 0,1,2,4,5,6 and 8 were 3.8, 2.4, 5.5, 0.5, 0.3, 0.3 and 0.2 mils/mo, respectively. In the absence of any fluoride, 304-L corrodes at about 0.14 mils/mo in boiling 6 M HNO_3. An Al/F mole ratio of four or more is required for effective protection of 304-L in boiling 6 M HNO_3. Further tests in 8 M HNO_3 - 0.01 M HF-$Al(NO_3)_3$ solutions are in progress. The data are desired in connection with the use of fluoride in Purex ion exchange procedures.

Corrosion of Waukesha 23 and 88 Alloys in Purex 1WW

Samples of Waukesha alloys 23 and 88 (steels) were exposed at room temperature to simulated Purex 1WW (at 6 M HNO_3) to determine their suitability as valves or in metering instruments. Alloy 23 corroded catastrophically (4 in/mo.) in the solution. Alloy 88 corroded at about 2 mils/mo. and in the solution at boiling, at about 50 mils/mo. After two days exposure, preferential attack was evident -- an apparent leaching out of some phase of the alloy.

Ceramics for Fused Chloride Baths

A special gas-tight zirconia crucible (purchased from the Zirconia Corporation of America) was permeable to a sodium chloride-potassium chloride-barium chloride solution at 800 C after only 50 hours of use.

PROCESS CONTROL DEVELOPMENT

C-Column Test Facilities and Studies

Twelve runs were made on the C-column test facilities during the month. Among these were runs similar to the one described last month, to determine column stability. Standard deviations in mid-column aqueous uranium concentrations of 0.35, 0.22, and 0.63 gram/liter at a nominal value of 75 grams/liter were obtained for 0.70, 1.06, and 2.50-hour periods, respectively. The remaining runs were carried out to determine the repeatability of column conditions, and to evaluate uranium concentration as a function of radial position of the sampling probe. Data from these runs are now being processed and analyzed.

Three Foxboro Electronic Consotrol Instrumentation (ECS) control systems were installed in the 1C column facility for evaluation. Two are temperature control systems, utilizing resistance-type temperature detectors and pneumatically operated steam valves. The third system controls the interface position of the column, utilizing a 0-50MV signal from a capacitance-type interface detector. The three instrument systems are all solid state electronic components with the exception of the conversion of electric to pneumatic signals for the operation of the final control elements. Initial operation has been satisfactory.

The debugging of the new Data Scanning Programmer was completed this month. All necessary wiring changes in the 321 Building racks were made and checked out so that data scanning can now be done with either the old or new programmer. Operation with the new programmer has begun.

Calciner Furnace Control System

Synchronization of the prototype programmer for finish-section shell temperature set-point with the existing programmer for feed-section furnace power has been accomplished. The existing power programmer servo is not in motion during the first phase of startup. During this period the finish-section temperature controller set-point is programmed from a synchronous-motor-driven cam cut to match the present shell-temperature time curve. During the second and third stages of startup, the temperature controller set-point is programmed from the existing power programmer servo. Use of this system will provide precise synchronism of the finish and feed section shell temperatures during startup and shutdown.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

A new DC tachometer and high range (0 to 10,000 psig) pressure transducer have been used to make velocity and pressure measurements in program-closing studies on the hydraulic Non-Production Fuels shear. The data were recorded on a Sanborn Recorder. Because of the limited frequency response of the Sanborn, a Hughes Memo Scope was also employed to determine whether the Sanborn adequately responds to the pressure and velocity waves. Preliminary conclusions are that some of the vibratory phenomena are recorded correctly by the Sanborn, but that in most cases sharp step changes are missed.

Under no load conditions the steady state velocity of the shear ranges from 40 in/sec at 500 psig operating pressure to 90 in/sec at 2000 psig. The maximum hydraulic pressure developed at the end of stroke, when the blade hit the stop, ranged from 1100 psig at 500 psig operating pressure to 3700 psig at 200 psig. The hydraulic pressures developed in cutting one-inch Schedule 160 stainless steel (304-L) pipe were 1900, 1800, and 1700 psig, when the striking velocity of the shear blade was 79, 85, and 90 in/sec. The momentum of the shear blade increases with the increased velocity; therefore, less hydraulic pressure is required to cut the work piece.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Continuous Ion Exchange Contactor Development - Jiggler Contactor

Operational pressure drop data for hydraulic analysis were secured for the adsorption-scrub column. Process flow rates were: feed - 45 gal/(hr)(sq.ft); scrub - 30 gal/(hr)(sq.ft); and resin - no flow of 20-50 mesh. Adsorption section pressure drops ranged from 3 to 7 psi/ft and scrub section pressure drops from 1 to 5 psi/ft under varying pulsing conditions.

Investigations of the elution column indicate that the elutant is still being drawn down into the adsorption section during the suction phase of the pulse. Tests to increase the supply rate capabilities of the elution scrub and to determine the feasibility of further separating the "A" and "C" Columns are in progress.

Salt Cycle Process

Hot Cell Experiment - The first test of the current Salt Cycle Process concept with

irradiated feed was completed during the month. Feed for this experiment consisted of 440 grams of UO_2 (initially 1.6 a/o U-235) which had been irradiated to ca. 1000 MWD/T and cooled ca. 18 months. No analytical data are yet available on the products from this run. Qualitative observations of possible interest include the following:

1. The clad separation step, in which the fuel was freed from the stainless steel cladding by sawing the (approximate 0.5 inch diameter) fuel rod into one-inch lengths and heating in air at ca. 450 C to convert the UO_2 to U_3O_8 and thereby pulverize it, proceeded smoothly although there was some indication that the irradiated material oxidized more slowly than had unirradiated materials used in cold runs. Weight change and visual inspection of the cladding segments after this operation indicated that no more than a negligible amount of UO_2 was retained with the cladding. Likewise there was no evidence of any significant "dusting" in this operation. The technique used for this operation may be worthy of consideration for larger scale work as well. The stainless steel canister in which the one-inch fuel rod segments were supported vertically on a wire grid bottom was lowered completely inside the fused silica dissolver vessel and this vessel covered with a loosely-fitting lid. Air was drawn into the dissolver vessel round this lid, up through the canister and out through the canister support tubing and a scrubbing system. The canister was subjected to continual (mild) vibration during this operation so that the powder was shaken loose as it formed and dropped onto the surface of a solid cake of NaCl-KCl in the dissolver vessel. As the weight change indicated the powder removal was nearing completion the furnace temperature was raised to melt the salt and allow the uranium oxide powder to sink to the bottom of the dissolver vessel before the assembly was opened.

2. Dissolution of the oxide into molten NaCl-KCl was accomplished by sparging the solution with both chlorine and hydrogen chloride and likewise proceeded smoothly. Accumulation of radioactive material (which proved to be predominantly Sb-125) on the filters in the cell exhaust system was noted during this operation. It is not clear whether this material survived passage through the in-cell off-gas scrubbing equipment or whether it may have escaped to the cell proper and thence to the filters during brief periods when the hood over the equipment was removed for manipulations. The volatilized material was apparently efficiently trapped by the cell filter system since there was no evidence of radioactivity in the exhaust duct downstream from the filters.

3. Qualitatively the four electrodepositions which were made appeared to duplicate performance seen in cold runs. The first deposition sought to remove ca. 100 grams of uranium as UO_2 free of plutonium and was made on a graphite cathode and in the presence of a chlorine environment. The UO_2 deposit was, as expected, smooth, dense, and tightly adherent. Following this deposition the salt showed the green color characteristic of uranium(IV), which is expected to form under these conditions.

Following this "By-product Deposition," two consecutive "Product Depositions" were made with a platinum-clad cathode and with air sweeping over the top of the melt. The UO_2 deposits in both cases were the porous, "dendritic" types of deposit previously seen in cold runs under these conditions. Finally, the UO_2 (supposedly free of plutonium) which had been deposited as a "by-product" was oxidized and re-dissolved in the melt and a third "product" deposition made under the above conditions.

A composite sample of about 230 grams of UO_2 was washed, dried and reduced in a mixture of N_2 and H_2. When the reduced material proved to have a "pour" density of only ca. 4 g/cc it was manually crushed, an operation which sufficed to increase its pour density to ca. 5.5 g/cc. The crushed material was then transmitted to the Ceramic Fuels Development Operation for testing its compaction ability in a remotized vibratory compactor.

Studies of $KCl-PbCl_2$ System - Addition of 0.5 mole percent TlCl to the 52.7 mole percent $PbCl_2$-47.3 mole percent KCl eutectic increased the rate of dissolution of U_3O_8 by chlorine by a factor of ca. 6. Electrolysis of a $PbCl_2$-KCl-UO_2Cl_2-0.5 m/o TlCl solution produced a crystalline UO_2 deposit quite similar in appearance to that obtained in the absence of TlCl. Analysis of the UO_2 deposit obtained showed 500 ppm Pb, 500 ppm K, 20 ppm Tl, and an O/U ratio of 2.027. An attempt to subline the impurities out at 500 C under 10^{-5} mm Hg was unsuccessful, giving no significant change in impurity content.

Behavior of Plutonium in the Salt Cycle Systems - The X-ray diffraction pattern of the solid phase precipitated when a solution of NaCl-KCl-$PuCl_3$ is sparged with air verifies that the precipitated product is PuO_2. All the lines in the PuO_2 pattern are present. Since the precipitate was not exposed to any aqueous washing operations, sodium chloride and potassium chlorides were present as impurities. The stronger diffraction lines of these compounds account for the remaining lines in the diffraction pattern.

Behavior of Lanthanum in the Salt Cycle System - In preparation for study of the behavior of rare earth fission products in the Salt Cycle System, some exploratory work has been done with lanthanum. Lanthanum oxide is rather readily dissolved into NaCl-KCl at 700 C by treatment with chlorine gas. In this manner 4 grams of La_2O_3 were dissolved in 20 grams of molten NaCl-KCl. Sparging this solution with oxygen then resulted in precipitation of 14 percent of the lanthanum in one hour and this had increased to 17 percent in three hours.

The X-ray diffraction pattern of the solid phase revealed a cubic lattice which could not be identified with the diffraction patterns for either La_2O_3 or LaOCl. The precipitate likewise dissolved only very slowly in hot concentrated acids and likewise resisted dissolution in molten potassium persulfate.

Further work showed that solid La_2O_3 when digested with molten NaCl-KCl at 700 C is partially converted to LaOCl in three hours. Solid lanthanum oxychloride (prepared by igniting $LaCl_3 \cdot 7\ H_2O$ at 450 C) when digested under molten NaCl-KCl at 700 C with agitation via an argon sparge is converted to the extent of about ten percent in three hours to the unknown insoluble compound. However, heating solid LaOCl at 700 C under helium in the absence of the molten salt solution produced no change.

Chemical analysis of the unknown solid compound disclosed a lanthanum content of 76.9 w/o but no satisfactory analyses for chlorine and oxygen were obtained. The measured lanthanum content suggests the formula $La_5O_6Cl_3$ or $La_2O_3 \cdot 3LaOCl$. This formula appears compatible with the experimental evidence in that the reaction

$$3\ LaOCl \longrightarrow La_2O_3 + LaCl_3$$

could account for the formation of an insoluble material containing both La_2O_3 and LaOCl in the absence of oxygen (in keeping with the experiment utilizing an argon sparge).

Pilot Plant Studies - A 1/2-inch x 1/2-inch x 2-inch graphite cathode was inserted into a 20-liter salt bath with a large anode on each side to determine the thickness of UO_2 deposits attainable by electrolysis of UO_2Cl_2 in equimolar NaCl-KCl. The electrolysis was carried out over a 20-hour period at 710 C and at current densities and voltages approximating those previously reported in pilot plant runs. It was terminated by air corrosion of the cathode at the bath surface. The UO_2 deposit, a porous structure of needle-like and plate-like crystals, retained the square cross-section of the electrode. The deposit was 1/2-inch thick near the bath surface but decreased gradually as the depth increased. The porous structure, in contrast to a high-density, sheet-like deposit obtained in pilot plant runs, is apparently due to the lower concentration of chlorine produced at the anode in the system, which appears inadequate to redissolve the UO_2 dendrites as they are formed.

Previously reported carbon impurities of 150 ppm appear to be typical only of the large agglomerates which are formed by breakup of the sheet of UO_2 deposited on the electrode. An overall average of 1000 ppm carbon was obtained in recent runs, although carbon fines caused high variability from batch to batch. The fines were apparently formed from air corrosion of the electrode at the bath interface and from carbon adhering to the back of the deposit when it was removed from the electrode. Attempts to remove the carbon by extraction with kerosene or to prevent corrosion by inert gas blankets have not been successful to date.

In an effort to reduce the high carbon content of electrolytic UO_2, several metals were tested as possible replacements for the graphite cathode. Platinum which had originally been suggested for this purpose proved unsatisfactory during a pilot unit run because of extreme interface attack. Metals tested on a small scale (in order of decreasing corrosion resistance) were Hastelloy D, Nichrome, Hastelloy N, Hastelloy X and Hastelloy R-235.

The last three metals were found to be completely unsatisfactory for the same reason as platinum, i,e., high interface corrosion. Nichrome exhibited minor interface corrosion and is to be tested further. Hastelloy D did not corrode selectively at the interface and had good general corrosion resistance. During an initial test the corrosion rate was approximately 200 mils/month but in subsequent tests with the same electrode it decreased to about 100 mils/month. Further evaluation of Hastelloy D as a cathode material is planned on a pilot plant scale.

Uninsulated quartz gas lift tubes were tested for possible application to recirculate molten salt. In a preliminary test using a 1/4-inch ID tube, recirculation failed because of salt freezing. With a 3/4-inch ID tube, however, considerable recirculation was obtained at 66.6 percent submergence (10-inch lift - 20-inch depth).

Salt Cycle Materials of Construction - During six-hour exposures to HCl-sparged equimolar potassium chloride-sodium chloride melt at 750-800 C, samples of Alnico-2, -3, and -3B corroded at rates of 36, 36, and 29 mils/mo., respectively. Some accelerated attack at the melt-vapor interface occurred on the Alnico-2 and -3B samples. During longer exposures (71 hours) to the sparged melt at 750-775 C, the Alnico-2 sample corroded at 50 mils/mo., again with some accelerated attack at the interface and in the vapor phase. The Alnico-3B sample corroded at 9 mils/mo. with some pitting beneath a scale which formed just above the interface level. This is the most promising corrosion behavior observed to date for any metallic material in this system.

RADIOACTIVE RESIDUE PROCESSING

Ball Mill Waste Concentrator and Calciner

An induction-heated ball mill was developed as a hydrolyzer for cerium zinc hexacyanoferrate(II) as part of the fission product packaging prototype. The feasibility of using this hydrolyzer as an aqueous waste concentrator and calciner was explored. The apparatus concentrated successfully simulated Purex low-acid waste to the point of slurry formation. However, the apparatus did not perform successfully as a dryer or as a calciner because of solids agglomeration. Partial calcination was achieved during continuous operation at temperatures of 600 to 700 C but the residue stuck to the walls of the rotor and to the agitator elements (3/4-inch cubes of stainless steel). No additional work is planned.

Radiant Heat Spray Calcination

Efforts for the month have been concentrated on (1) determining the effect of feed dilution on particle size, (2) calciner runs with a proposed feed which corresponds to blending underground stored waste with current waste, (3) evaluating refractory cloth filters with blow-back, and (4) corrosion studies on materials of construction and on non-galling alloys for use in valves.

Several runs were made with an acidic Purex 1WW feed ranging from full strength to a 1:10 dilution. It was expected that particle size would decrease with dilution, due to smaller solids content in each spray droplet; however, such was not the case. Feed concentration seemed to have very little effect on particle size of the powder produced. Therefore, a plant spray calciner would be able to handle unconcentrated waste as readily as concentrated, although the size and capacity of the unit would need to be greater to accommodate the larger volume of dilute waste.

Two runs were made with a feed simulating that obtained if Purex wastes were blended with stored wastes to test spray calciner operability. The feed calcined without difficulty except for some caking in the nozzle (which may not have been cooled adequately). The product tended to cake on the cloth filters and came off in hard lumps. The powder contained 3.8 percent nitrate and 3.0 percent sulfate. Heating some of the lumps to 800 C in a crucible gave only superficial melting. Use of sugar and other additives could improve powder characteristics and meltability from this feed.

The removal of solids from calciner off-gas continues to be a problem. A series of rigid filters including both sintered stainless steel and ceramic filters mounted and gasketed in several ways have been in simultaneous use for some time. The unit was dismantled and inspected. One ceramic filter had cracked, and several showed some slight evidence of blister build-up near the Durabla gaskets, indicating some leakage. There was evidence that some solids had passed all of the filters, although the porous stainless steel allowed the least leakage. The main difficulty with the rigid elements is a build-up of powder on the surface of the filter. This amounted to 1/8 to 1/4-inch, occurred in layers, and causes a high pressure drop. Blow-back removes only a portion of this cake.

Two improvised Fiberflax (aluminum silicate cloth) filter elements were used in the runs with blended waste. Pressure drop was only one-fifth that of the rigid filters, and the flexibility of the cloth allowed the blow-back cycle to remove even the hard, adherent cake (which would have plugged a rigid filter). A new filter section has been designed to accommodate ceramic cloth filters.

Mineral Reactions

The cesium-selectivity of clinoptilolite could be utilized to reduce the specific gravity of wastes stored in Purex tanks by separating the sodium from fission products in the supernatant solution. The sodium nitrate solution could then probably be disposed to the ground. The cesium could be eluted from the mineral with an ammonium salt and returned to the tank with considerable improvement in available storage capacity. If the column effluent could not be cribbed it could be stored in non-boiling tanks such as those used for coating waste. The eluate from the mineral column could be either returned to the tank or possibly fed to a calciner. The ammonium salt would decompose in a calciner reducing the calcined product volume. If ammonium nitrate proved too unstable for storage or calcination another ammonium salt could be used or another cation, such as potassium, used for eluting cesium.

Clinoptilolite elution experiments with 10 M NH_4NO_3 resulted in the removal of 97 percent of the adsorbed cesium in two column volumes. Attempts to elute cesium from clinoptilolite with ammonium hydroxide were not so successful, probably because of its lower ammonium ion concentration. These elution experiments were performed with flow rates of 50 gal/(hr)(sq.ft), using clinoptilolite loaded with cesium from synthetic high level waste. Similar elution experiments for radiostrontium on clinoptilolite indicated that about 30 percent is tenaciously held in the bed, apparently by some mechanism other than ion exchange.

Laboratory studies in the fixation of radioisotopes from high level wastes on clinoptilolite indicated poor retention of ruthenium but this was the only prominent radioisotope not removed by the mineral. Research is underway to seek scavenging or mine bed reactions for immobilizing ruthenium from neutralized wastes but this is not easily accomplished without pH adjustment or reducing conditions. The possibility of electrolytic removal of ruthenium was under study. Elsewhere the electrodeposition of ruthenium from alkaline wastes with decontamination factors greater than 100 has been demonstrated; such a process might also permit reduction of the nitrates to nitrogen oxides. This may be an advantageous way to avoid discharge of massive quantities of nitrates to the environs.

Laboratory experiments were conducted to determine the effect of phosphate addition on the removal of strontium from Purex boiling-tank condensate by a clinoptilolite bed. The addition of up to 0.01 M phosphate ion had no effect on the observed strontium removals. The fraction of radiostrontium which cannot be removed by ion exchange remained unaffected by this treatment. This strontium fraction is believed to be associated with an organic emulsion in the condensate.

Experiments with shallow beds of iron granules resulted in uptake of Zr-95 - Nb-95 similar to that found for ruthenium. The rate of uptake was greatest at pH 5 and 8 and lowest at pH 11, corresponding to iron oxidation rates. At pH 2 zirconium-niobium uptake was somewhat lower than at pH 5 but was still appreciable. Unlike ruthenium it is not probable that zirconium plates out in the elemental state at this lower pH, but is believed to be reduced by the hydrogen generated on the iron surface to a less reactive form that deposits on the bed.

Condensate Streams

In Pilot Run 11, approximately 700 gallons of Purex Tank Farm condensate was passed through activated carbon at a flow of about 1 gpm/sq.ft. followed by passage through

clinoptilolite at a flow rate of 4 gpm/sq.ft. Passage of the radioactive waste through the carbon was effective in removing butyl phosphates to less than 0.1 ppm (DF > 600). The treatment was less effective for removal of hydrocarbon diluent, the effluent concentration increasing from about 0.2 ppm (DF ~ 150) early in the run to 3.0 ppm (DF ~ 10) at the end of the run. While the feed appeared to be a homogeneous cloudy oil-in-water emulsion, distinct particles were visible suspended in the carbon column effluent. These particles were not effectively filtered by the mineral bed but they tended to settle out in the system, periodically breaking loose and floating as a sludge on top of the aqueous effluent. This sludge had considerable radioactivity associated with it, the primary gamma emitters being Zr-95, Nb-95, and Ce-144.

The strontium decontamination factor across the carbon column was about 6 and the decontamination factor across the clinoptilolite was about 10 for an overall decontamination factor of about 60 during most of the run. Cesium was not removed by the carbon but a decontamination factor of about 500 was measured across the clinoptilolite during the early part of the run. Addition of 100 ppm phosphate ion in the form of the trisodium salt to the clinoptilolite feed during part of the run did not change the decontamination for either strontium or cesium.

PRTR Waste Disposal

HW-67514, "Predicted Characteristics of PRTR Liquid Effluents," was issued. The report presents estimates of radioisotope concentrations in PRTR single-pass shield coolant streams resulting from activation of impurities in the water and corrosion of activated piping. It was estimated that discharge of these effluents to the river will result in an almost unmeasurable increase in the potential internal exposures of downstream water consumers and will be a very small fraction of the limits specified in Hanford Radiation Protection Standards.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

The lowermost sand and gravel bed of the lower Ringold "blue clays" was shown by wells recently completed on Project CAH-885 to thin to the northeast, east, southeast and south and to grade into silts and sands. The bed there also is confined between relatively impermeable basalts beneath it and silts and clays above it. Beneath 200 East Area this bed lies at the water table. Its high permeability there, compared to the rest of the Ringold sediments, offers a means by which waste waters may move to depth into the basin southeast of 200 East Area. Movement out of the basin, if the wastes ever enter it, is almost certainly precluded by the fine-grained sediments in that bed nearer the Columbia River and by the confining higher and lower strata. If the wastes settled by gravity forces, they would have to overcome those forces to rise up to more than 500 feet in order to enter the Columbia River.

Progress was made in the construction of a mathematical model for saturated flow in the plane of symmetry of a ground water mound. With assistance from personnel in Operations Research and Synthesis, the equation form of the complex potential distribution was obtained and one solution obtained by means of an integral evaluation. A major difficulty faced in the process of solving this flow problem is the uncertainty in the shape of the water table. The procedure developed for attacking the problem gives the conformation of the water table during the solution of the flow problem.

A better system of constraints must be derived to avoid instability in the computer solution for the imbibing case of partially saturated flow. The system derived earlier for this application is unsatisfactory because the input constraints are very sensitive and difficult to estimate. The difficulty arises from the non-linearity of the partial differential equations that must be solved.

A study was made of the relative influence of several system variables on the flow patterns beneath cribs. This work is preliminary to an attempt at a detailed analysis of the flow from specific Hanford cribs and swamps. The variables studied were the size of the crib, the depth of the water table, the relationship between soil moisture content and conductivity, and the degree of inhomogeneity of the soil as expressed by the ratio of horizontal to vertical permeability. The experiment involved comparing the numerical solutions of mathematical models for which contrasting values were selected for each variable in turn. In general each of the design variables had a greater effect on the resulting flow pattern than was anticipated and none could be ignored.

Soil Chemistry and Geochemistry

Studies of mineral replacement reactions were extended to include several cation replacement reactions. An investigation was begun to ascertain principles governing the order and rate of such reactions. The reactions studied included the replacement of gypsum ($CaSO_4.2H_2O$) by barite ($BaSO_4$) and celestite ($SrSO_4$) and the replacement of calcite ($CaCO_3$) by strontianite ($SrCO_3$) and witherite ($BaCO_3$). Kinetic phase determinations were made with chromatographic columns and influents containing established concentrations of cations. The final products were identified from X-ray diffraction patterns.

The results of these experiments indicated that both the replacement order and relative replacement rate of each of these reactions is determined by the difference in solubility between the original column material and the final product. In systems where several replacement products were possible only the least soluble product formed. Thus, the same criterion of solubility governs both cation and anion replacement reactions.

Ground Waste Investigations

Laboratory experiments were completed to measure the adsorption by soil of radioisotopes from organic liquid used in the Purex process. The organic contained 30 percent TBP in a petroleum solvent. It is occasionally necessary to dispose of batches of this organic material by discharge to a special crib. The relative removal of radioisotopes from the solvent by soil was determined by equilibrium distribution experiments using actual samples of organic waste. The radioactive materials found in the waste for which soil adsorption was determined include ruthenium, strontium, cesium, iodine, cobalt, zirconium, plutonium, uranium, and rare earths. All of these materials were adsorbed by the soil except ruthenium, cobalt and iodine. The distribution coefficients for the adsorption by soil from the organic solvent were not greatly different from those commonly measured for aqueous systems.

Field Apparatus Development

Components for a sensitive pressure drop sensing element for orifice measurement of very low flows were assembled and tested. Measurement of vertical flows in 8-inch wells in the range of 40 to 1500 cc/min. is believed attainable with the device which will be field tested.

Micromeritics

Particle deposition in standard pipe of several diameters and lengths was calculated for several particle diameters and air flow rates. Data used were obtained in experiments performed earlier. Applied to currently used stack sampling lines, the results showed that most sample line installations would deposit a large fraction of particles larger than two microns in diameter on the pipe wall. For higher velocity streams in larger pipe sizes, even 2 μ particles might be lost to the walls. Re-entrainment after deposition of particles larger than 10 μ, for which only limited data are available, may result in more representative sampling for these sizes. Although in normal operations most of the radioactive material in plant effluents is believed to be associated with sub-micron particles, samples taken during emissions of larger particles are likely to be qualified due to non-representative particle sizes delivered to the collector.

Reactor Effluent Radioisotope Studies

Although the time required for the cooling water to pass through a reactor tube is too short for any significant fraction of most impurities to be activated, two radioisotopes are produced in this fashion in amounts greater than one percent of their total activity. These are Na-24 of which about 30 percent is produced in the water, and P-32 of which as much as 14 percent may be produced by fast neutron activation of sulfur impurities in the process water which pass directly through the reactor. In all other cases, most of the radioisotopes result from activation of the impurities adsorbed onto the reactor film and then desorbed. The P-32 from the sulfur not adsorbed from the water thus represents the minimum obtainable by eliminating any contribution from the reactor film. Further reduction of the P-32 would require reduction of sulfur in the process water. Some reduction can be obtained by using another acid and another flocculating agent rather than the presently used sulfuric acid and alum.

Pigments for Meteorological Studies

A search is in progress for two pigment materials of less than four microns diameter which would be suitable for dual pigment meteorological particle dispersion studies. In addition to size, and compatibility with dispersion methods, the pigment concentrations on collection filters should be capable of simple, yet very sensitive determination for each pigment in the presence of large quantities of the other. Fluorescent and phosphorescent zinc sulfide pigments are available which have been found to meet the analysis requirements, but the phosphorescent particles are much too large. On grinding, these pigments are found to lose much of their phosphorescence. Other fluorescent materials are being studied in combination with zinc sulfide which may produce the desired dual particle system.

Radiation Protection Studies

Comparative protection indices were measured for agar as a 0.1 percent solution and as a gel at a concentration of 0.4 percent. The values were 0.016 and 0.0004, respectively, indicating a decrease in the protection index of 1/40 in passing from the liquid state to the gel state. This interesting change in radical-scavenging properties upon forming the gel matrix may make agar a useful prototype for studying the effect of configuration on these properties in biological systems.

L. P. Bupp

LP Bupp:cf

Manager
Chemical Research and Development

[redacted]

BIOLOGY LABORATORY

A. ORGANIZATION AND PERSONNEL

During the month, D. E. Warner, Manager, Biological Analyses, resigned to accept a position with the AEC's Division of Compliance in Washington, D.C. R. F. Palmer of the Metabolism Operation was appointed his successor effective December 1, 1960.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

Concentrations of I^{131} in the thyroid glands of jack rabbits were approximately twice those observed one year ago. Values follow:

Location	Collection Date	μc/g Wet Thyroid Average	μc/g Wet Thyroid Maximum	Trend Factor
Wahluke Slope	Nov. 2	4×10^{-4}	5×10^{-4}	2
Prosser Barricade	Nov. 1	3×10^{-4}	5×10^{-4}	--
Rattlesnake Springs	Nov. 1	2×10^{-4}	5×10^{-4}	--

Columbia River Contamination

Fish

Whitefish were abundant and readily available to sportsmen at public fishing areas at Priest Rapids and Ringold which are immediately upstream and downstream from the Hanford Reservation. The October whitefish catch per unit effort of fishing at Ringold and Priest Rapids was one fish per man hour and one and one-half fish per man hour, respectively. This is about the average rate of fishing success during this season of the year.

Concentrations of gross beta emitters in whitefish collected from the Columbia River within the Hanford Reservation were approximately twice those observed one year ago. The annual upstream migration of whitefish brought fish from the Hanford Reservation into the Priest Rapids area where the average concentration of radioelements in flesh was about the same as those observed one year ago. The average concentration in the flesh of whitefish from Ringold increased to three times the average for November 1958. Only one fish was collected during November 1959; its radioactivity was within the range of values found during November 1960. The average concentration in samples from Priest Rapids was about the same as last year. Specific values for fish flesh follow:

Sample Type	Location	Collection Date	µc/g Wet Weight Average	Maximum
Whitefish flesh	Priest Rapids	Oct. 20	1×10^{-5}	3×10^{-5}
" "	Hanford	Oct. 12-17	2×10^{-3}	3×10^{-3}
" "	Ringold	Oct. 19	3×10^{-3}	6×10^{-3}
" "	McNary	Oct. 26	3×10^{-4}	3×10^{-4}
Minnows (entire)	Hanford	Oct. 18-28	2×10^{-2}	3×10^{-2}
" "	McNary	Oct. 26	3×10^{-3}	3×10^{-3}
Chislemouth flesh	Hanford	Oct. 18	5×10^{-3}	6×10^{-3}
" "	Burbank	Nov. 3	2×10^{-3}	3×10^{-3}
" "	McNary	Oct. 26	2×10^{-3}	3×10^{-3}
F.S. Sucker flesh	Burbank	Nov. 3	1×10^{-3}	4×10^{-3}
" " "	McNary	Oct. 26	1×10^{-3}	1×10^{-3}
C.S. Sucker flesh	Hanford	Oct. 18	4×10^{-3}	5×10^{-3}
" " "	Burbank	Nov. 3	3×10^{-4}	3×10^{-4}
" " "	McNary	Oct. 26	3×10^{-4}	4×10^{-4}
Squawfish flesh	Hanford	Oct. 12-28	8×10^{-4}	2×10^{-3}
Squawfish flesh	McNary	Oct. 26	2×10^{-4}	3×10^{-4}
Carp flesh	Hanford	Oct. 28	4×10^{-4}	6×10^{-4}
" "	McNary	Oct. 26	1×10^{-4}	1×10^{-4}
L.M. Bass flesh	Hanford	Oct. 18	2×10^{-3}	2×10^{-3}
Yellow Perch flesh	Hanford	Oct. 28	2×10^{-3}	2×10^{-3}
S.M. Bass flesh	Hanford	Oct. 18-28	1×10^{-3}	2×10^{-3}
Chub flesh	McNary	Oct. 26	3×10^{-4}	5×10^{-4}
Pumpkinseed flesh	McNary	Oct. 26	2×10^{-4}	2×10^{-4}
Black Catfish	McNary	Oct. 26	2×10^{-4}	2×10^{-4}
Channel Catfish flesh	McNary	Oct. 26	2×10^{-4}	4×10^{-4}

Comparison of values for 41 samples of fish flesh which were both counted for total beta activity and analyzed specifically for P^{32} by radiochemical analyses showed that the P^{32} contribution averaged 96 per cent of the total beta activity. This is within the same range reported in 1956 (HW-36074). Similar analyses of five bone samples indicated that P^{32} was responsible for more than 99 per cent of the total beta activity.

Waterfowl

Heads of 236 waterfowl were obtained from local sportsmen and scanned for gamma emitters during the month. As of December 1, a total of 391 heads have been scanned since this program began in October. Of all heads, 161 (41 per cent) measured above background levels of radioactivity, indicating that they had frequented the Columbia River in the environs of HAPO. Radioisotopic analyses showed P^{32} responsible for nearly all of the total radioactivity and for over 90 per cent of the beta radioactivity. For all heads, the average total beta was 6×10^{-4} µc/g. The maximum was 10^{-3} µc/g. Fifteen per cent of the heads contained total beta levels above 10^{-4} µc/g. Comparisons of samples from 21 ducks showed the P^{32} contained of the heads to be 1.1 (± 0.7) times that in the flesh from the breast.

Concentrations of total beta emitters in flesh of waterfowl taken from the Columbia River within the reservation were six to eight times greater than one year ago. Spec[illegible] values for their flesh were:

Sample Type	Collection Date	µc/g Wet Weight Average	Maximum
Merganser Flesh *	Nov. 1-3	4×10^{-3}	6×10^{-3}
River Ducks Flesh *	"	8×10^{-4}	5×10^{-3}
Diving Ducks Flesh *	"	2×10^{-4}	8×10^{-4}
Coots *	"	4×10^{-5}	8×10^{-5}

* Samples collected biannually.

Swamp Contamination

Concentrations of fission products in flesh of waterfowl were one-third to one-fifth those observed one year ago. Gamma spectrometer analyses showed this radioactivity was produced principally by Cs^{137}. Values follow:

Sample Type	Collection Date	μc/g Wet Material Average	Maximum
River Ducks flesh*	October 24	1×10^{-4}	3×10^{-4}
Coots flesh	"	6×10^{-5}	6×10^{-5}

* Samples collected biannually.

Fallout Contamination

Fission products occurred in rabbits from Hanford Reservation in the following amounts:

Sample Type	Collection Date	Total Beta μc/g Wet Material	Trend Factor
Feces	Nov. 1-3	1×10^{-5}	--
Bone	"	6×10^{-6}	--
Liver	"	5×10^{-6}	-2
Muscle	"	4×10^{-6}	-2

Salmon Spawning

Aerial surveys of spawning activity were completed. A total of 295 nests were observed during the fall. The area nearest the Priest Rapids Dam (Midway) was again of major relative importance, as it was in 1959, suggesting a partial barrier effect produced by the Dam.

Effect of Reactor Effluent on Aquatic Organisms

A test was started with chinook salmon eggs to determine the comparative toxicity of "straight" reactor effluent with that of effluent passed through a bed of aluminum turnings. No results are yet available. The test is being run at the 1706-KE laboratory and the eggs were obtained from the U. S. Fish and Wildlife Service.

C. columnaris

As river temperatures have declined during the last two months, likewise the recovery of columnaris from scrap fish and salmon has dropped off. Samplings were continued so that relative virulence of strains obtained at different times can be compared when test fish become available.

Columnaris organisms were inoculated into sterile river mud and held at room temperature, refrigerated, and frozen controlled temperatures. Survival at room temperature was greatest with essentially 100 per cent survival after eight days and 6 per cent survival after 22 days.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Zinc

A study of the long-term uptake and retention of Zn^{65} in rams will be initiated as soon as the whole-body monitor is ready. The purpose of this investigation will be to extend earlier observations concerning the rates of uptake and turnover of zinc in the major tissues, and to obtain direct measurements of the radiation dosimetry in rams after the daily administration of Zn^{65} for extended periods. Stable zinc concentrations in the rams' tissues will also be determined. Data on the stable zinc content in sheep is not available and will be needed for proper evaluation of the experimental results.

Another study is being considered for determining the uptake of Zn^{65} fed daily to mice or rats on varying levels of dietary zinc. These data are needed in order to resolve apparent contradictory results in several reports in literature.

Calcium

Experiments with plants planted with DNP suggest that there are two mechanisms in calcium uptake; one, an active process operative at low calcium concentrations and independent of water uptake; two, a passive process operative at higher calcium concentrations which appears to be associated with water uptake.

Water uptake by plants is depressed as the concentration of DNP in the root environment is increased. The nature of this effect is being further investigated since these results appear to be in direct contrast to the reports in the literature which show no effect of this principle on water uptake.

Strontium

Pilot studies on the excretion of Sr^{85} by trout indicated that approximately 6 per cent of the isotope injected I.V. appears in the urine within 22 hours, and 3 to 4 per cent appears in the intestine. By inference, excretion by the gills is in the range of 15 to 45 per cent.

Experiments were completed in which the small intestine of the rat was perfused in situ with solutions labeled with Sr^{90} and Ca^{45} and varying in total calcium content. The animals were sacrified immediately following perfusion, the small intestine removed and the remaining carcass assayed for Ca^{45} and Sr^{90}. The results which represent the average data from six animals at each point are shown below with standard deviation indicated.

Ca conc. in perfusate	Per cent "dose in total carcass		
	Sr^{85}	Ca^{45}	"O.R."
Ca-free	4.3 ± 0.6	14.9 ± 2.3	0.29 ± 0.04
1.0 mM	3.2 ± 0.6	7.3 ± 1.6	0.45 ± 0.04
5.0 mM	2.6 ± 0.3	4.8 ± 0.4	0.54 ± 0.06
25.0 mM	1.4 ± 0.1	2.2 ± 0.2	0.65 ± 0.04

These results bear out previous indications that the major site of discrimination between strontium and calcium is in the intestinal tract and that this discrimination varies with dietary calcium level. This is the first time, however, that such a conclusion could be drawn directly from the experimental data without the necessity for assumptions or calculations.

Strontium, Plutonium, and Radium

Between nine and twelve months have elapsed since the injection of miniature swine with Sr^{90}, Ra^{226}, or Pu^{239} in doses comparable to those found to cause death in dogs approximately 1500 days after injection at the University of Utah. Groups of three miniature swine were injected with either Sr^{90}, Ra^{226} or Pu^{239} at six weeks, six months or one year of age for a total of 27 animals. Radiographs taken at three-month intervals of a fore limb and a hind limb of each animal and of the controls revealed minimal damage with a possible "washing out" of the medullary canal and changes in the spongiosa. Analysis of damage as detected by the radiograms will depend upon progressive skeletal changes as noted in future radiographic examinations.

Radiograms of 70 of 116 miniature swine now being fed 1, 5, or 25 μc of Sr^{90} daily showed no evidence of damage. There will be a total of 126 animals in this study, 60 on one μc/day, 24 on 5 μc/day and 12 on 25 μc/day from dams previously fed the same levels, 12 of the original dams started at 9 months of age on 25 μc/day, and 18 controls. Six of the original dams of the 5 μc level have been scheduled to be rebred in order to provide information relative to the Sr^{90} body burden in the first and second litters of females started on radiostrontium as young adults. Three of the first generation offspring on the 25 μc level have farrowed litters of 7, 7, and 9 pigs, all of the offspring appearing to be normal. Three miniature swine have been started on daily feedings of 125 μc/day of Sr^{90} and bred in order to produce earlier observable damage in the offspring.

Work will soon be completed on the conversion of an existing recording micro-densitometer for use in film dosimetry studies with tissues. The densitometer may be used to scan film with an aperture equivalent to 50-200 microns in diameter and will be used initially to evaluate the gross dosimetry in the skeletons of the miniature swine fed daily amounts of Sr^{90}.

Studies of the relative binding of Sr^{90} and Ca^{45} by proteins in blood from ewes fed levels of dietary calcium up to six times the normal dietary values have been completed. The results will be available as soon as the final samples have reached Sr^{90}-Y^{90} equilibrium for radioanalysis.

Cesium

Previous studies have shown that a drying period increases the plant content of Cs^{137}. These measurements were made on plant parts and maximum rise was noted for stems. A possibility that some of this material was relocated to stems from other plant tissues was investigated by growing plants immediately in nutrient solutions containing Cs^{137} and subsequently transplanting to soil. Drying of the plants in this manner did not show any plant uptake of Cs^{137} in stem tissues. It thus seems that the effect of drying is truly one of increased total uptake of Cs^{137} by the plants.

Radioactive Particles

A study of the effects of particle size and total deposited dose on the behavior of inhaled plutonium dioxide in 48 beagle dogs was completed. Results are:

1. Greater pulmonary retention of plutonium was observed in dogs inhaling particles in the range of 1 μ than in those inhaling particles having mean diameters of 0.4 or 0.2 μ. Dogs inhaling the latter two sizes of particles excreted larger percentages in feces.

2. Dogs inhaling 0.2 μ particles excreted larger percentages of the total plutonium dose in urine by factors of up to 20 fold or more; e.g., 10 per cent in two weeks compared with 0.5 per cent by dogs inhaling larger particles.

3. Dogs inhaling 0.2 μ particles also showed greater percentages of plutonium translocated from sites of deposition in the respiratory tract and the gastrointestinal tract to other tissues. Translocated plutonium was not preferentially deposited in skeleton over other tissues.

4. For all particle sizes the pulmonary retention increased as the total dose was decreased.

5. For 0.2 μ particles only, the percentage of plutonium excreted in urine decreased as the dose was increased. This is consistent with the observation that the residence time of plutonium in lungs decreased as the dose was increased.

These results have important implications in the establishment of permissible limits and the interpretation of bioassay data.

Protective Agents

Two dogs exposed to 250 r whole-body X-radiation, then treated with erioglaucine, died within two weeks after exposure. Of three dogs treated with erioglaucine prior to X-radiation, one died after three weeks and two have survived one month. Pre-treatment with erioglaucine did not significantly modify the early radiation syndrome.

Studies still in progress indicate a remarkable effectiveness of cysteine in preventing acute irradiation effects from repeated exposure of the abdominal region. Of 12 rats exposed to 1000 r to the abdomen at semi-weekly intervals, each irradiation preceded by injection of 1 g of cysteine per kg body weight, 10 animals remain alive after a total accumulated dose of 17,000 r. Unprotected control animals were all dead after a total dose of 8,000 r, the median lethal dose being 4,000 r. In the case of repeated exposure of the whole body, at dose levels of 250 or 500 r semi-weekly, the protective effect of cysteine is much less evident. The accumulated dose to death being increased by only about 50 per cent with cysteine pre-treatment. Exposure of the protected abdominal irradiated animals is continuing with little gross evidence of damage.

C. Lectures

a. Papers Presented at Meetings

L. K. Bustad, "Paradoxical Responses to Low Levels of Irradiation," November 12, 1960, Northwest Sectional Meeting of the Society for Experimental Biology and Medicine, Portland, Oregon.

R. O. McClellan, "Zn-65 Metabolism in Sheep," November 12, 1960, Northwest Sectional Meeting of the Society for Experimental Biology and Medicine, Portland, Oregon.

J. R. McKenney, "Internal Dosimetry of Zn-65," November 12, 1960, Northwest Sectional Meeting of the Society for Experimental Biology and Medicine, Portland, Oregon.

R. C. Thompson, "The Effectiveness of DTPA in Removing Plutonium from the Pig," November 12, 1960, Northwest Sectional Meeting of the Society for Experimental Biology and Medicine, Portland, Oregon.

R. F. Foster, "Biological Considerations of Radioactive Wastes in Streams," November 15, 1960, Eighth Symposium on Water Pollution Research in the Northwest, Portland, Oregon.

R. F. Foster, "The Influence of Radiological Wastes on Water Quality," November 29, 1960, Conference on Water Quality in the Columbia Basin, Pullman, Washington.

b. Off-Site Seminars

L. K. Bustad, "Hanford Biology" at Men's Brotherhood meeting of First Christian Church, Sunnyside, 11/1/60.
W. C. Hanson, "Project Chariot", Richland Rod and Gun Club, Nov. 7, 1960.
V. G. Horstman, "Hanford Biology," at Biology class, Columbia High, Richland, November 30, 1960.

c. Seminars (Biology)

R. O. McClellan, "Metabolism of Zinc-65 in Sheep", November 9, 1960.

J. R. McKenney, "Internal Dosimetry of Zinc-65," November 9, 1960.

d. Seminars (other than Biology)

L. K. Bustad, "Radiation Biology," IPD Seminar in 100-D Area, November 18, 1960.

D. Publications

a. HW Publications

None

b. Open Literature

M. F. Sullivan, "PVP labelled with I^{131} as an Agent for the Diagnosis of Radiation Injury in Rats," International J. of Rad. Biol. 2 (4), 393-398 (1960).

Microbiological Studies

Leakage of ions from irradiated yeast cells was found to be almost completely unaffected by temperature. This seems to further indicate that this leakage phenomenon is primarily a diffusion process and not metabolically controlled.

Fish Embryos as Biological Dosimeters

Testing of a life support system for salmon eggs was begun with confinement of the eggs to a closed chamber and measurement on oxygen requirements.

Chariot Studies

Pre-processing for gamma emitters in all animal samples from Project Chariot site were completed.

Plant Ecology

Preliminary investigations were conducted to determine the feasibility of determining the role of terrestrial soil algae and associated microorganisms in retaining radioactive fallout in soil surface layers and the possible influence of x-irradiation upon chlorophyll production in terrestrial algae.

Manager
BIOLOGY LABORATORY

HA Kornberg:es

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - NOVEMBER, 1960

ORGANIZATION AND PERSONNEL

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

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

Analyses of the first sizable quantity of Quality Certification data are continuing. It has been found possible to express warp, TFC, and diameter change as functions of reactor variables, with the resulting equations providing very good fits. IBM programming is now in progress to compare observed with predicted values for all the fuel elements thus far measured. This will remove the effects of reactor variables and made it possible to make direct comparisons of fuel element quality (i.e., tendency to distort dimensionally). A document is being prepared jointly with IPD personnel summarizing these findings.

Optimization of Reactor Operations

A paper concerned with the determination of optimum supplemental crew sizes was prepared for presentation at the AEC sponsored meeting on "Quantitative Analyses of Atomic Energy Operations" held in Germantown, Maryland, on December 1 and 2, 1960.

Process Tube Leaks

Further activity in connection with the prediction of internal tube corrosion awaits completion of the IBM programming to test the proposed model on complete data from B reactor.

Z Plant Information Study

Coding for the GE-312 computer is 40 per cent complete. This structure is still subject to desk debugging plus IBM 7090 assembler varification. Mr. Hugh A. Torchia, programming consultant from the GE Computer Department, is scheduled to spend the week of December 5 here at HAPO to provide the necessary consultation to permit completion of the computer program.

System requirements have imposed a delay on the receipt of the computer at HAPO; the present delivery data is January 30, 1961. This will alleviate the pressures for vendor personnel clearances, plant installation preparation and programming.

Reliability Studies

Work continued on the problem of designing a testing program to determine reliability parameters of panellit gage switches.

Inventory Studies

Work continued on the construction of a mathematical model of a spare parts inventory with some more general features added to the original model in order to make [redacted] licable to general inventory situations also.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Data were analysed from the second experiment designed to locate optimum conditions for the canning of four inch I and E enriched fuel elements. The first experiment, utilizing three factors and the cuboctahedron design, indicated which part of the response curve should be more thoroughly investigated. Subsequently, one factor was held constant while the other two varied within a smaller region with a 3^2 design replicated. Results were very consistent between experiments, and an optimum set of conditions was located and recommended.

In experimental work concerned with evaluating means of bonding jackets to cores other than with the alsi process, the use of fluid pressure bonding is being investigated. There are several variables involved, notably, the temperature and pressure of the autoclave, and the time of autoclaving. In addition, there are factors which may be varied prior to the pressure bonding. An experiment was designed to evaluate the effects of these various factors and arrive at a tentative recommended set of conditions for larger scale production.

Total count data (a measure of the alsi bond integrity) are being analysed from the experiment designed primarily to determine the effects of core hydrogen on braze layer porosity. This experiment was designed after an initial experiment did not provide clear cut results, due largely to nonrandomness of residual errors. Core hydrogen is controlled by adjusting furnace pressures at Fernald.

In connection with evaluating the effects of variables associated with the nickel plating of fuel elements to inhibit corrosion, necessary sample sizes were computed to detect given differences between fuel elements with respect to incidence of cracking in the nickel plate.

Irradiation Processing Department

Further work was done in connection with providing nomographs for use in calculating panellit trip settings.

Work is continuing on the uniform corrosion model. A method has been developed which sidesteps the main difficulty in fitting the model to the data.

A formula for the estimation of effluent temperatures in terms of known process parameters was written in a style amenable to slide-rule calculations, and a detailed procedure for efficient computation was supplied.

Chemical Processing Department

Discussions on the statistical aspects of experimental design are still being held with personnel of the 234-5 Development Operation.

The consumer has indicated acceptance of the proposal to demonstrate compliance to specifications on a part-by-part basis as recommended during October.

Mathematical assistance in the form of solutions to the neutron diffusion equation in several simple geometries were supplied as an aid in shielding calculations.

Contract and Accounting Operation

Appropriate time periods for the new safety award plan were computed.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Reactor Studies

A regression analysis was initiated in connection with a study of decontamination of aqueous waste solutions. The purpose of the regression analysis is to derive a mathematical model to define (effluent radioisotope concentration)/(influent radioisotope concentration) as a function of influent pH, phosphate concentration, temperature, flow rate, calcite surface area, and strontium-85 concentration.

Corrosion Studies

Work continued on the analysis of Al-Ni-Fe alloy corrosion data from an experiment performed by Corrosion and Coatings Operation to determine the parabolic-linear corrosion relationships under different treatment conditions.

An analysis was performed which expressed hydrogen pick-up in zirconium samples as a function of time. Comparisons were also made between different alloys and sample preparation methods.

Chemical Development

Closed form solutions were obtained to a mathematical model used to describe the time and spatial behavior of concentrations in a long filter column in which diffusion, transport, and absorption mechanisms were present.

4000 Program

Swelling Studies

Analysis of data from photomicrographs of uranium samples is being made to determine the nature of the heterogeneity of pore distributions corresponding to different annealing times and temperatures.

Assistance was given in setting up an experiment to determine activation energies resulting from the reaction of certain gases with graphite.

Plutonium Recycle Program

The problem of filling a container with spherical particles in such a manner so as to obtain maximum density under certain restrictions on the number and magnitude of particle sizes is under investigation.

Assistance was provided in determining the number of fuel elements to leak test in groups such that the total number of tests required is minimized. Helium detection from a group of fuel elements means that at least one of the fuel elements in the group is leaking. Further testing on the elements within the group is then required. The number to test in each group is clearly dependent on the expected leak data.

Chemical Effluent Technology

Mathematical assistance was provided in obtaining closed form solutions to a partial differential equation and boundary value problem used to estimate the transmissibility and coefficient of storage from river level fluctuations.

Significant progress has been made toward obtaining the solution by the method of hodographs to the problem of determining the stream profiles of the gravity flow system which consists of a point source located above an inclined water table.

6000 Program

Biology

Work continued on the statistical analysis of data from an experiment to determine the effects of varying amounts of radiation on the sex ratio and other population parameters of Ephestia kuehniella Zeller (Mediterranean flour moth).

General

Instrumentation

An unclassified document discussing a method of estimating the joint confidence estimates for a multiple gamma-ray spectrum was issued. The technique is based on a modified Chi-square approach with the joint confidence estimates being determined by the marginal confidence intervals. Examples illustrating different conditions for a two component gamma-ray spectrum are worked out and discussed in this document.

Carl A. Bennett

Carl A. Bennett, Manager
Operations Research and Synthesis

CAB:mw

PROGRAMMING OPERATION
NOVEMBER 1960

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Computer Code Development. The "Uranium Cascade Cost" computer program was completed during November. The new code calculates the cost of uranium per gram of U-235 and, in addition, prints out the enrichment cost and feed cost portion of the total expense and the ratio of these quantities. A feature of the program is that the value of the tails may be non zero. To operate the code, three of the four cascade constants (i.e., price of natural uranium, cost of separative duty, the tails composition, the value of the tails) must be specified. The fourth will be calculated and the cost schedule generated.

The PUCK program has been undergoing microscopic debugging and general updating. This program is arranged in such a way that those sections which do a particular job or solve an equation are written as a sub-program or sub-routine and used in conjunction with a main program, in this case GPR.

The PUCK program computes the apparent worth of plutonium given a specific reactor and an economic environment. "Value" and "worth" as applied to plutonium are used to indicate value to users under the given economic conditions whereas per "price" is an arbitrarily assigned cost which is given datum used in the calculation to determine the apparent worth. The reactor is first treated as a single-pass uranium-fueled reactor and then as a self-sustaining plutonium-fueled reactor. The resultant reactor data are used in the economics sub-programs in which the economic environment is introduced. Two sets of fuel costs, recycle and once-through, are calculated in the economics sub-routines. PUCK sub-routines then determine the minimum fuel cost and make a simultaneous solution of once-through and recycle cost curves to determine the plutonium value under the given conditions.

GPR, a generalized plutonium recycle program, and in this case the main program of PUCK, is a generalized formulation of material and reactivity balance in plutonium recycle systems. The reactor data such as isotope concentrations, flux time, exposure, etc., that are calculated in GPR are relayed to the economics sub-routines which solve for the four components of the total fuel cost. These components are the out-of-reactor inventory charge, the in-reactor inventory charge, direct burnout charge and the fuel element fabricating and jacketing cost. These total costs are calculated for both once-through and recycle conditions.

It has been established that the total fuel costs are best considered at their minima. To consider cost at a given enrichment or some other criteria leads to confusion because the position of the once-through and recycle cost curves as a function of enrichment varies when reactor operation is changed from once-through to recycle. Therefore, PUCK has sub-programs that determine the minimum fuel cost. The minimizer sub-program can accomplish this quite accurately with as few as five enrichment points.

Using these minimized fuel costs, a sub-routine simultaneously solves the fuel cost as a function of the assigned plutonium price. The intersection of the recycle and once-through curves indicates the apparent worth of plutonium under the given conditions.

Since it would be impossible for a reactor operator to always operate at optimum conditions, PUCK also solves for a cost consisting of a minimum fuel cost plus 10 percent of the minimum fuel cost at an enrichment greater than that at minimum cost. In doing this, there are obtained four instead of two minimum costs (two recycle and two once-through) and four curves of fuel cost as a function of assigned plutonium price. Thus, in addition to the intersection of the recycle minimum and once-through minimum costs as a function of assigned plutonium value, intersections are also obtained with the recycle minimum and once-through above minimum, with a recycle above minimum and the once-through minimum, and with the recycle above minimum and the once-through above minimum. With these four intersections, the reactor operator is able to attain a range of apparent plutonium values and fuel costs when reactor operation is close to optimum.

Since current and future canning costs of plutonium-bearing fuels present the greatest uncertainty of the economic variables, PUCK calculates the data necessary to plot the plutonium value as a function of the difference between canning costs. This difference is referred to as "delta" and is defined as being equal to the cost of fabricating and jacketing a plutonium enriched element less the cost of jacketing a uranium enriched fuel element. A plot of plutonium values as a function of delta will indicate to the reactor operator at what difference in plutonium and uranium canning costs (delta) a change from recycle to once-through operation would be advantageous.

The latest version of PUCK (PUCK II) is being programmed to utilize the versatility and speed of the IBM-7090. PUCK II, though it does the calculation as explained above, will have further refinements.

The GPR program is being calibrated against the newer and more complete MELEAGER burnup program. In addition, PUCK II will insure that at least three enrichment points will be used in calculating the coefficients of any curve and that the exposure at one of these

enrichments will be greater than 7500 MWD/T. Also, to investigate minimum points of a curve more accurately, the program searches for an enrichment at which the exposure is less than 5000 MWD/T.

By the same method, it will be possible to specify a number of exposures at which the corresponding enrichments will be interpolated (or extrapolated) by the curve fitting sub-program. Using these interpolated enrichments the program will list the corresponding grams of each plutonium isotope available at given exposures. Heat ratios will be interpolated by the same curve-fitting process. The program will also be able to list the grams of plutonium available and the corresponding enrichments for a given set of exposures.

It is also planned for an additional sub-program to calculate the plutonium isotopic concentration at various designated time intervals. This is essential because the composition of recycled plutonium is highly sensitive to exposure history. The plutonium composition at equilibrium can be determined easily and has been used in the past by GPR to evaluate plutonium recycle. This is unreal because in many power reactors of interest it could take a 100 years or more to arrive at the equilibrium condition. A measure of the productivity of plutonium compositions resulting after 10, 20, 30 years of operation would be more meaningful. Correspondingly the length of time necessary to approach to within 95, 99 and 99.9% of the equilibrium composition of Pu-239, Pu-240, Pu-241 and Pu-242 would be useful. These compositions are extremely sensitive to the amount of plutonium lost or set aside between each cycle and the cycle length itself. In addition to the general desirability of working with accurate plutonium compositions, studies with the latest plutonium-242 cross sections indicate that for sake of accuracy it is essential to do so. As a consequence a PUCK subroutine to be known as "Rx" is being prepared. In addition to establishing plutonium compositions short of equilibrium this subroutine will easily maintain identification of the newest formed plutonium and the recycled material. Such identification of the plutonium was provided in the initial PUCK program but the Pu-242 cross sections used in the past did not indicate that this identification was worthwhile. Rx will simply facilitate determination of <u>when</u> the identification is worthwhile.

<u>Cycle Analysis.</u> A selected summary report of recent studies on stainless steel jacketing was prepared for presentation at the ANS meeting in San Francisco. The report emphasizes the strong interdependance of economically allowable parasitic material with reactor specific power, interest rates, jacket thickness, thermal to electrical efficiency, and reactor leakage. The effects are often compensative but in some data ranges are not. For this reason, a statistical analysis with interdependance evaluation is needed. The validity of the rapid survey methods used is demon-

strated by showing checks of ± 3% with experiment and more rigorous computations. Without the rapid analysis method an investigation of such scope would be economically prohibitive.

A set of thirty-six tabulations of plutonium isotopic compositions versus fuel exposures from zero to about five thousand MWD/T was prepared for statistical analysis. The data are from calculations on the IBM-709 using the Meleager Code, and represent the study of a wide range of reactor types. It is hoped that analysis of the data will result in relatively simple correlations of plutonium isotopic compositions versus exposure as a function of the variables used in the Meleager Code. Variables included in this study were concentration of U-235 in U-238, thermal utilization factor, and the moderator-to-fuel ratio.

High Exposure Plutonium. Information has been received that 1.8 kilograms of 31% Pu-240 Canadian plutonium will be provided for PRP use.

It is anticipated that ORNL will process kilogram quantities of 40% Pu-240 material for special studies in the PCTR.

2. SPECIFIC FUEL CYCLE ANALYSIS

A graded discharge version of the "QUICK" economics code has been debugged. With a few format changes it will be ready for the BWR study and other work.

The MELEAGER code has been put on the monitor system to save read-in time on the IBM-7090. The saving will be about three minutes per run. Programming probably averages 30 runs a month.

The "Russian Superheat Reactor" was analyzed to determine its fuel costs and the plutonium value. "MELEAGER", physics and "QUICK" economic analysis were applied to obtain fuel cost. "PUVE" will be used later to determine the plutonium value. Three values of initial K_{oo} were used so that a minimum fuel cost can be found. The physics code automatically recycles the plutonium that is generated from one batch to the next.

A calculation to determine the value of "ideal" plutonium is about two-thirds complete. This study examines the fact that the value of "ideal" plutonium can be based on the price of pure U-235 as determined by the uranium cascade and not the price of U-235 at enrichments equivalent to the plutonium enrichment under study.

The problem arises from the fact that estimates of the reactor value of plutonium are tied to the basic resource, uranium as processed through the cascade. Cascade enrichment of natural

uranium provides a uranium price schedule for U-235 compositions in U-238 from zero value cascade tails (approximately 0.3 wt. % U-238), to top product of essentially pure U-235. The cost per gram of U-235 is greater as the enrichment increases, in keeping with isotope separation theory. As a consequence, it costs more to burn a gram of U-235 starting from 3% U-235 than starting from 2% U-235. Plutonium burning does not have this characteristic when enriching U-238, and this is a major contribution to the value of plutonium as a thermal reactor fuel. In addition, plutonium takes advantage of the fact that current uranium price schedules define a composition of U-235 in U-238 that has zero value. To show the inherent ramifications of these differences many of the other characteristics that distinguish plutonium from U-235 must be ignored. Accordingly, one postulates a special "ideal plutonium" with all the properties of U-235 except that it is produced by neutron absorption in U-238 and can be chemically separated from U-238. The value of this "plutonium" will be determined as an alternative to U-235 enrichment of U-238 in thermal reactors. In this case U-235 will be valued in accordance with price schedules for U-235 in U-238.

An equation for the value of "ideal" plutonium is derived by assuming that the burnout costs in a reactor containing uranium only are the same as for the identical reactor containing a mixture of uranium and "ideal" plutonium if the fissile enrichments are the same. This equation will be a function of the total enrichment, the uranium portion of the U-Pu enrichment, the burnup fraction and the uranium cost (i.e., cascade cost).

The following table lists the results of this relationship for a one percent difference of final enrichment from initial enrichment for various initial enrichments and the corresponding U-235 price is $/gram from the present AEC price schedules.

VALUE OF IDEALIZED "PLUTONIUM"

Initial Enrichment Wt. % U-235 or "Plutonium"	Price $/gm U-235 By Present Price Schedules	"Plutonium" Value* From Equation
10	15.29	$ 16.70
5	13.96	16.24
4	13.39	16.06
3	12.50	15.50
2	11.00	14.42

*Plutonium is enriching pure U-238, not tails.

Notice that the "value" of "plutonium" is substantially greater than the value of U-235 in the initial mixes which is the value of U-235 or "plutonium" simply mixed with U-238 to this isotopic ratio and equated to the corresponding price from the current price schedule. This characteristic of plutonium to "make back" the separative work costs and the fact that the price schedules define a zero value composition enters in all plutonium value calculations wherein the value of plutonium is based on a uranium price schedule from the present cascade. HLO's and other sophisticated plutonium value analyses using electronic computers are arranged to automatically optimize on the equivalent uranium-235 feed composition.

It is apparent that higher plutonium values are achieved if one mixes this "special" plutonium with zero valued cascade tails since the U-235 in tails is free. What is not as obvious is that mixing this special "plutonium" with any cascade product above tails will yield higher plutonium values than the above table shows. And further, if the mixture is with U-235 compositions equal to or above zero value tails, the "plutonium" value is nearly, but not quite, the value of fully enriched U-235.

If the "ideal" plutonium is mixed with tails the plutonium value equation becomes particularly simple because in the present cost schedule, the value of tails and the derivative of the cost schedule at the tails composition are zero. For this situation the value of plutonium is very nearly a constant and is about equal to the value of U-235 in 98% enriched uranium.

B. OTHER ACTIVITIES

The work of the Plant Improvement Program Task Force was completed with the development of revised procedures for determining and supporting HAPO capital facility requirements.

Preliminary scoping of the Fuels Recycle Pilot Plant was concerned with coordination of chemical reprocessing and fuel element fabrication requirements involving highly radioactive recycled plutonium and uranium.

Assistance was provided in arranging 30 visits to HLO by 180 persons, including representatives from 7 foreign countries. Of special interest was a team of Euratom Research and Development board members, here to review progress in the Plutonium Recycle Program. Programming also coordinated HLO's activities in achieving public recognition of PRTR initial criticality.

JM Atwood

Acting Manager, Programming

JM Atwood:rd

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF NOVEMBER 1960

A. ORGANIZATION AND PERSONNEL

Effective November 1, 1960, R. C. Henle was promoted to the exempt roll and transferred from the Radiological Evaluation Working Group to Radiation Monitoring as Specialist - Radiological Defense. The force of the Radiation Protection Operation remained at a total of 135.

B. ACTIVITIES

The Plutonium Recycle Test Reactor attained its first initial criticality the morning of November 21. Further critical testing continued over several days with rising power levels up to 1000 watts. The primary circulation system is not completed, however, the initial testing is possible because the amount of heat generated does not require cooling. Other interim measures to permit safe operation with an incomplete plant include maximum power level trip at 1 kw with intended operation only up to 100 or 500 watts, aqueous effluent and ventilation exhaust instrumentation operating to give automatic annunciator alarm, and critical operation with the containment vessel closed with entry via the airlock. Radiation monitoring studies conducted simultaneously with the critical testing revealed no unexpected conditions. At 500 watts power, with the top shield of the reactor removed, the maximum dosage rate was 80 mrems/hour at the edge of the upper access opening. All of the leakage appeared to be fast neutrons, coming through the top and bottom primary shields which are not yet water filled. Film studies of the top face showed no significant leakage. The radiation background in the work area remained at 15 μc/hour throughout the critical testing.

The tritium concentration of the PRTR heavy water approximates 15 μc/ml average, a low enough content to require only nominal protection for the workers. Two cases of skin and breathing exposure to heavy water or its vapors have produced bioassay results showing one and two microcuries tritium per liter, which will yield only a few mrem of body dose in a four-week period.

Two cases of plutonium deposition were confirmed in November. The total number of deposition cases that have occurred at HAPO is 262 of which 192 are currently employed. Four radiation incidents occurred involving potential plutonium deposition. A J. A. Jones employee received high-level hand contamination in the 234-5 Building. Skin decontamination was complicated because of minor injuries. Whole Body Counter examination indicated less than 1000 d/m in the injury sites. Initial bioassay sampling indicated body deposition of less than 10 per cent of the maximum permissible body burden (mpbb). Three CPD employees in separate incidents were contaminated with plutonium. One employee received head and hand contamination as a result of plutonium nitrate dripping on his head. A small acid burn and decontamination required removing the hair from his head. Initial bioassay sampling results indicated positive, but minor, body deposition. Another employee received a plutonium contaminated minor injury as a result of a screw driver puncturing the hood gloves. Examination in the Whole Body Counter indicated the injury site to be essentially free of contamination. The third employee received hair and head contamination with plutonium oxide during the changing of a ruptured glove without respiratory protection. Nasal smears showed from 5,000 to 10,000 d/m. A series of bioassay samples will be necessary before meaningful estimates of the body deposited plutonium can be made.

An employee of the St. Regis Pulp and Paper Company, Tacoma, Washington, was examined in the Whole Body Counter at the request of AEC-HOO. Results of the examination were within the "normal" range detected in the 950 people counted to date during 1960.

The routine environmental monitoring vegetation sampling program was revised in accordance with past experience with the usefulness of the data. In essence, the sampling zones immediately surrounding the separations center remain on a weekly frequency while other on-project zones were placed on a fortnightly schedule. The off-project sampling zones were placed on a semiannual basis and include analyses for Sr^{89}, Sr^{90}, and P^{32}, in addition to current gamma scan radionuclides. The semiannual frequency calling for sampling in February and August is aimed at following trends over several years rather than over shorter time periods. The revisions will also assist in adjustment of man power usage for other environmental programs being developed.

Representatives of Radiation Protection Operation participated in Civil Effects Project 60.3 conducted at the Nevada Test Site. Civil Effects Project 60.3 provided point and broad source configurations for purposes of testing equipment for air-borne radiometric survey. Air-borne radiometric measurements were taken with HAPO equipment aboard the local AEC aircraft to facilitate making improvements in our monitoring system. The data have not been reduced to the point of reportability.

The redesigned jig for the calibration of badge film was installed and placed in operation. The new jig makes it possible to expose a complete set of calibration badge film from 30 to 10,000 mr simultaneously. Numerous checks were made with film and R meters to assure that the film holders are at the correct positions for the required exposures. Further checks were scheduled when newly calibrated R meters are received from the Bureau of Standards.

Functional performance testing of the automatic film densitometer system continued. The photo diodes originally programmed to interpret the film number matrix proved unsatisfactory and a new design utilizing solar cells was assembled. The badge processing machine received "tune-up" service after approximately two years of operation. Modifications to adapt this machine to processing of the next Hanford badge were studied.

Prototype stainless steel containers to provide fire and corrosion proofing for the Hurst criticality dosimeter system are being fabricated. Test to assure that this system can be assembled without heating the threshold foils above about 100° F. are in progress.

Study of various neutron monitoring systems utilizing indium, gold, and cadmium foils has shown promise as a replacement for the Hurst criticality dosimeter system. The systems under study offer the advantages of simplified interpretation requiring rather economical and readily available equipment and do not present contamination problems in the event of fire or corrosion damage. Increased time to recover the foils and complete the interpretation is also obtained due to the relatively longer half life of the foils. Performance studies of these systems are continuing as positive ion accelerator time is made available.

Experimental studies indicate that a 70 mil plastic filter, a beta equivalent filter composed of 10 mils of 2S aluminum and 45 mils of plastic and the open window area will permit the discrimination between beta and low energy gamma exposures in a film dosimeter. The filters are also essentially gamma-response-equivalent from 60 Kev to 2 Mev. Final evaluation of the dosimetry system is in progress with prototype personnel dosimeters receiving actual plutonium exposures at the 234-5 Building. Following these exposures a uranium beta exposure will be added by the Calibrations Operation before final exposure evaluations are attempted.

Fluorods, glass rod dosimeters, have been received from Oak Ridge National Laboratory for inter-comparison. The HAPO dosimeter and calibration indicated 13 rods had received a dose of 58 r $\pm$ 2 r and 12 had received a dose of less than 5 r $\pm$ 3 r. The actual doses given to the rods at Oak Ridge were 13 rods at 55 r and the rest were blanks. HAPO has sent 25 Co^{60} irradiated fluorods and five blanks to Oak Ridge for dose evaluation. Fluorod exchange with Los Alamos is also planned.

Some initial studies of silicon diodes and a silicon surface barrier diode have been completed. Forward current measurements at constant voltage and temperature were observed before and after irradiation doses of approximately 10 and 80 rems of fast neutrons from a PuF_4 source. After a 10 rem dose, the forward current dropped by about 60 per cent for the surface barrier diode and about 20 per cent for a Hughes silicon p-n junction diode. After a total of 80 rems, the forward current dropped an additional five per cent for the surface barrier diode and 16 per cent for the Hughes diode.

The Reactor Engineering Development Operation was given information concerning possible noble gas monitors for the gaseous effluent released from the PRTR facility. NPR stack monitoring equipment design was also discussed with the CE&U Design Development. Consultations continued on the design of the Fuel Recycle Pilot Plant.

L. G. Faust and E. C. Watson attended the Working Committee on High Exposure Plutonium Handling meeting at Rocky Flats on November 15 and 16. The latest information on this subject was presented at the meeting. The final report of the committee is being prepared (at Rocky Flats) for documentation and submission to the AEC. The committee will remain active but on a less formal basis.

The performance testing of the portable 256-channel analyzer is now nearly complete. The program for the month of December calls for spectra studies of a PRTR fuel element and observations of the Calibration K fluorescent X-ray source spectra. The K fluorescent X-ray spectra will then be compared with typical spectra in the 234-5 Building to confirm low energy personnel dosimeter calibration procedures.

On November 17, R. L. Junkins returned to Vienna, Austria, as the U. S. Representative to the International Atomic Energy Agency sponsored Panel discussion on the topic of "Radioactive Waste Disposal Into Fresh Waters".

C. EMPLOYEE RELATIONS

Three suggestions were submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to 35. There were no suggestions evaluated and rejected. One suggestion was adopted with an award of $10. Eight suggestions submitted by RPO personnel are pending evaluation.

There were five medical treatment injuries during the month for a frequency of 2.41. One security violation occurred during November bringing the year-to-date total for RPO to two.

Radiation protection training included: One 90-minute orientation talk to Plutonium Metallurgy personnel; PRTR-assigned personnel attended a training course on the use of the BF_3 double moderator as applied to critical and power tests; a discussion to construction personnel on the administration of film badges at the PRTR site; and one session on the operation of the scintillation monitors for 614 Buildings.

D. SIGNIFICANT REPORTS

HW-67197 "Effect of Plutonium-241 on the MPC and MPBB for Expected Isotopic Mixtures of Plutonium" by L. C. Rouse.

HW-67426 "Significance of the Plutonium-241 Buildup in PRTR Fuel in Respect to Air-borne Plutonium Contamination" by J. R. Bovingdon.

HW-67439 "Analysis of Radiological Data for the Month of October, 1960" by R. L. Junkins.

HW-67642 "Monthly Report - November 1960, Radiation Monitoring Operation" by A. J. Stevens.

Undoc. "Trip Report - Review of the First Year's Experience with the Hurst Dosimeter System" by C. M. Unruh.

W. V. Baumgartner and J. K. Soldat presented talks entitled "The Safe and Proper Handling of Radionuclides not Requiring a Specific A.E.C. License" to the Oregon State Science Teachers Association at Eugene, Oregon, and LaGrande, Oregon, respectively.

R. L. Junkins presented a talk before the Eighth Symposium on Water Pollution Research in the Northwest which was held in Portland, Oregon, on November 15. The subject of the talk was "Methods of Waste Disposal".

ENVIRONMENTAL MONITORING - RESULTS - (Mid-October 1960 - Mid-November 1960)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.8	% MPC_w-GI*
Separations Areas	Gross Beta	1.3×10^{-7}	µc/cc
Pasco	Isotopic	6.0	% MPC_w-GI**
Kennewick	Isotopic	< 1.0	% MPC_w-GI**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	3.0×10^{-9}***	µc/cc
100-F Area	Isotopic	2.3	% MPC_w-GI*
Hanford	Isotopic	2.5	% MPC_w-GI*
Pasco	Isotopic	18	% MPC_w-GI**
McNary Dam	Gross Beta	1.3×10^{-6}	µc/cc
Vancouver, Washington	Isotopic	< 0.6	% MPC_w-GI**
Atmosphere			
I^{131} Separations Areas	I^{131}	1.3×10^{-13}	µc/cc
I^{131} Separations Stacks	I^{131}	0.8	Combined curies/day
Active Particles - Project	--	1.6	ptle/100 m^3
Active Particles - Environs	--	0.1	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	2.0×10^{-6}	µc/g
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Eastern Washington and Oregon	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Fission Products less I^{131} - Wash. and Ore.	Gamma Emitters	$< 1.0 \times 10^{-5}$	µc/g

* The % MPC_w is the percent of the maximum permissible limit for occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

** The % MPC_w-GI is the percent of the maximum permissible concentrations for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

*** This location is now sampled quarterly. The most recent result is tabled.

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
November	0	0
1960 to Date	1	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
November	5,538	4	3	0
1960 to Date	151,422	2,330	47	12

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	mr(s
November	22,134	1,938	204	77	81	10.18	19.2
1960 to Date	134,306	11,140	1,858	491	658	11.31	17.91

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
November	1,155	0	0	0	8
1960 to Date	14,921	3	0	0	64
Fast Neutron					
November	189	20	1	0	8
1960 to Date	2,020	183	69	0	29

Whole Body Counter

	Male	Female	November	1960 to Date
GE Employees				
Routine	69	6	75	821
Special	6	0	6	59
Terminal	0	0	0	1
Nonemployees	1	0	1	56
Pre-employment	0	0	0	10
Total	76	6	82	947

Bioassay

	November	1960 to Date
Confirmed Plutonium Deposition Cases	2	18*
Plutonium: Samples Assayed	823	7,303
Results above 2.2×10^{-8} µc/sample	44	443
Fission Products: Samples Assayed	891	7,287
Results above 3.1×10^{-5} µc FP/sample	0	34
Uranium: Samples Assayed	285	2,971

*Bringing the total number of plutonium deposition cases which have occurred at Hanford to 262.

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples	Following Period of No Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples
Fuels Preparation	338	13	67	41	3.9	66
Fuels Preparation*	0	0	0	0	0	0
Hanford Laboratories	27	6.9	33	8.6	2.9	29
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	20	4.8	35	27	4.4	35
Chemical Processing*	47	16	7	8.5	4.4	6
Special Incidents	35	27	3	0	0	0
Random	0.9	0.7	4	0	0	0

*Samples taken prior to and after a specific job during work week.

	November	1960 to Date
Thyroid Checks		
Checks Taken	0	179
Checks above Detection Limit	0	5
Hand Checks		
Checks Taken - Alpha	32,508	351,869
- Beta-gamma	48,511	495,034
Skin Contamination		
Plutonium	24	255
Fission Products	32	418
Uranium	0	39

CALIBRATIONS

	Number of Units Calibrated November	1960 to Date
Portable Instruments		
CP Meter	1,008	10,128
Juno	272	3,136
GM	889	8,660
Other	214	1,989
Audits	55	55
Total	2,438	23,968
Personnel Meters		
Badge Film	984	13,534
Pencils	-	1,912
Other	245	4,306
Total	1,229	19,752
Miscellaneous Special Services	1,019	6,769
Total Number of Calibrations	4,686	50,489

AR Keene
Manager
Radiation Protection

AR Keene:kc

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - NOVEMBER, 1960

GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 1.56, which is considerably below average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 19,152 hours. This includes 13,513 hours performed in the Technical Shops, 3,700 hours assigned to Minor Construction, 435 hours assigned to other project shops and 1,504 hours assigned to off-site vendors. Total shop backlog is 18,533 hours, of which 60% is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 5.6% (941 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	5,454	28.5%
Irradiation Processing Department	674	3.5%
Chemical Processing Department	837	4.4%
Hanford Laboratories Operation	12,032	62.8%
Construction Engineering & Utilities	18	.1%
Miscellaneous	137	.7%

Requests for emergency service decreased, slightly, requiring an overtime rate of 5.6% versus 5.9% the previous month. The majority of requests emanated from the PRTR, Hanford Laboratories and from the Finished Products Operation, Chemical Processing Department.

Appropriation Requests for shop equipment totaling $65,900 were returned approved. Purchase requisitions for all items have been prepared and forwarded to the Purchasing Operation.

RADIOGRAPHIC TESTING OPERATION

A total of 3,691 tests were made of which 836 were radiographic (including x-ray and gamma-ray) and 2,855 were supplementary tests. Out of a total of 2,891 man-hours, 627 (21.7%) were used in connection with radiographic tests, and 2,264 (78.3%) were used on supplementary tests. The supplementary test work included: borescoping; eddy current; magnetic particle; penetrant (fluorescent O.D. and I.D.); stress analysis; surface treatment (pickling, steam detergent cleaning, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements).

The number of pieces handled this month totaled 2,817 items. The feet of material represented by these items amounted to 31,624 feet. Work on tubular components continued to account for a large percentage of the footage of material tested; the work includes both fuel element sheath tubes and reactor process tubes.

Work was done for 19 organizational components representing most of the operating departments and service organizations. A total of 36 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 47 different occasions for advise and information on general testing and applications for other than the jobs tabulated in Part - II Testing Statistics.

Additional NPR process tubes have been received including 31 on the production order. Considerable experience has been gained in the pickling of the full size NPR process tubes. Twelve tubes have been processed.

Forced rinsing through locking seals on the end of the tubes are used to assure positive rinsing. Tubes pickled to date include rejects and those being conditioned for excessive penetrant indications. The work has served excellently to establish procedures and for training opportunities for Kaiser Engineers craftsmen.

Autoclaving has not proceeded as successfully. On the second tube autoclaved, a combination of bad draining and relatively high blow down temperature had left a stain on the inside surface of the tube. It may be possible through use of a lower temperature to make the stain removable by wiping.

Testing of the tubes on the development order is proceeding routinely. The black light borescope stand for fluorescent penetrant testing has been installed and is in operation.

A new stress analysis program has been started for the 105-KE reactor. As in similar work done for some of the other reactors, main concern is with the risers and crossheaders on the rear face.

Zircaloy sheath tube testing continues at a high, sustained effort. Additional test requirements, utilizing white light borescoping for inside surface imprefections have greatly increased the testing time and makes schedules difficult to meet. The equipment acquisition and facilities modification for the consolidated sheath tube testing area in the 314 Building is proceeding. All of the equipment connected with the 306 laboratory has been activated and is operational.

A very profitable on-site training course on Magnetic Particle Testing was conducted by the Magnaflux Corporation. Utilizing the new 306 Testing Laboratory, thirteen employees participated (one from Fuels Fabrication, R&F R&D). Contracting for the presentation of such courses has proved to be an effective way of achieving high quality instruction for a large number of personnel.

Part II - Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces
CPD	113	132	10
FPD	49	22	26
HLO	3,172	29,965	2,692
IPD	269	1,418	80
JA Jones	88	87	9
Total	3,691	31,624	2,817

CONSTRUCTION OPERATION

There were 49 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $189,885. Ninety-four new orders, 7 supplements and adjustments for underruns amounted to $85,518. Expenditures during the month on HLO work were $115,307. Total J. A. Jones backlog at month's end was $160,096.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of mo.	48	$ 184,030	1	$ 5,855
Issued during the mo. (Inc.Sup.& Adm.)	94	85,518	0	0
J.A. Jones Expenditures during mo. (Inc. C.O. Costs)		114,267		1,040
Balance at month's end	75	155,281	1	4,815
Orders closed during month	67	116,265*	0	0*

* Face Value of Orders Closed

FACILITIES ENGINEERING OPERATION

Projects

There were 13 authorized projects at month's end with total authorized funds of $2,814,000. The total estimated cost of these projects is $4,739,000. The balance between expenditures to date and total estimated cost is $3,350,000.

The following summarizes the status of HLO project activity:

Number of authorized projects at month's end	13
Number of new projects authorized during the month	0
Projects completed during the month	0
New project proposals submitted to AEC during month:	2
CGH-916 Fuels Recycle Pilot Plant	
CAH-917 Atmospheric Physics - Field Service Center	
New projects awaiting AEC approval:	5
CGH-832 Full Scale Physical Constants Test Reactor	
CGH-902 Uranium Scrap Burning Facility	
CAH-914 Rattlesnake Springs Radioecology Facility	
CGH-916 Fuels Recycle Pilot Plant	
CAH-917 Atmospheric Physics - Field Service Center	

Note - Proposals complete or nearing completion are as follows:

Second Whole Body Counter Cell Addition - 747 Building
314 Building Ventilation System
Uranium Oxide Development Laboratory

Also, Project CGH-874, Consolidation of Plutonium Metallurgy Facility, has been revised and is awaiting final HLO approval.

The attached project report contains details of individual project work.

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals. Some items of work have been deferred because of shortage of capital funds.

Title	Status
Pressure Vessel and Piping Systems - Engineering & Inspection Service	This is a continuing work program on HLO vessels, pressure systems and related safety devices. Engineering work not only consists of periodic inspection and engineering evaluations of plant pressure systems but also includes services to R&D components having process devices subjected to high pressures and temperatures. Code compliance work is being performed 1) PRTR Systems; 2) Irradiation Studies Loop; and, 3) Breakaway Corrosion Loop.

Title	Status
Glove Boxes, 325 Building	Work completed.
"Split-half" Machine for Critical Mass Studies	Design of machine and safety rods nearing completion.
Improvement to Animal Waste Disposal System	Work on conveyor completed. The sludge pump was received in damaged condition and returned to Vendor.
Horizontal Control Rod and Drive for Tamper Tank (Critical Mass)	Design work is substantially complete. Materials are being ordered.
Basement Access Enclosure - 325 Bldg.	Construction work is proceeding.
Special Laboratory Air Conditioning 222-U Building	Work stopped pending availability of funds.
Misc. Animal Quarters & Pasture 100-F	Pasture completed. Work on exercise pens deferred. Additional dog pens and alteration to existing pens is 90% complete.
Canopy Design - 100-F	Work complete.
Design special beryllium dust filters - 306 Building	Design complete. Fabrication and installation work has been initiated.
Intercom System - 231-Z Building	Work stopped pending customer decision of need.
Waste Treatment Demonstration Facility - 271-CR	Conceptual work in progress.
Material Handling System - 308 Building, 2nd Floor	Work started.
Fall-Out Shelter Study	Study complete.
Fuel Element Assembly Room - Basement Mezzanine, 325 Building	Plans have been developed and construction work has started.
Electrical Modifications - 3702	Material on order.

Drafting and Design Services

Work load in central drafting room (3706) is very heavy. Branch offices in 306 and 308 Building have steady work loads with heavy backlog in 308 office.

Major design and drafting work in progress includes the following:

1. High Level Utility Cell - 327 Bldg. - Special Tools (60% complete).
2. PRF Critical Facility - Detail of in-cell piping, ventilation, instrumentation and electrical work (18 dwgs. - 90% complete).
3. Physical and Mechanical Properties Test Cell - 327 Bldg. - Special equipment design (35 dwgs. - 70% complete).
4. Structural Materials Irradiation Test Facility - design - (25 dwgs. required - 40% complete).
5. Strontium Purification Project - Work approx. 90% complete.
6. Fuel Element Wire Wrapping Machine (12 dwgs. required - essentially complete).
7. Split-half mechanism, Critical Mass Laboratory.
8. Thermal precipitator - (5 dwgs. required, 40% complete).
9. Breakaway Corrosion Loop - Approximately 40% complete).
10. Critical Facility - approximately 20 dwgs. required - estimated 35% complete.
11. Stress Rupture Facility - Estimated 95% complete.
12. Fuels Recycle Pilot Plant - conceptual work in progress.
13. Length Measurement Telescope - Approximately 15% complete.
14. Test Loop for 305 Bldg. Reactor - Preliminary work started.
15. Ultrasonic Transducer - Bridge & Track - Preliminary work started.

In addition to the above work, miscellaneous small design-drafting jobs are in progress.

Approximately 140 drawings including sketches, work sheets, and formal drawings were completed during the month of November.

Plant Maintenance and Operation

October costs were $132,020. Expenditures are within 0.2% of predicted. Maintenance, janitor service and power operators are running slightly less than forecast; while utilities are running slightly above.

Miscellaneous

Approximately 27,700 square feet of prints were reproduced during the month.

The total estimated value of the 33 requisitions issued during the month was $48,000. The majority of this procurement activity is for approved HLO projects.

Painting was started in 321 Building.

Pump House No. 3 (near 329 Building) work is nearing completion.

Further studies have been made in 308 Building running the exhaust fans with the supply fans off, with the supply dampers opened. This arrangement kept the building negative pressure from being excessive. The emergency exhaust fan for the hoods only was inadequate to clear the test smoke from the rooms.

Buildings 231-Z and 3702 are being reroofed.

The old vacuum pump room in 314 Building has been removed to make room for Radiographic Testing.

The staircase to the second floor of 314 Building has been rearranged to provide space for a shop.

TECHNICAL INFORMATION OPERATION

An audit of Technical Information by the Accounting Operation was completed at mid-month and a report submitted to the Manager of Finance, HLO. Recommendations were made concerning the follow-up on the Quarterly Inventory of Classified Documents, the accountability for engineering drawings in classified documents, the circulation and follow-up of book charge-outs. The report also recommended (1) that the Somat pulping machine be excessed and (2) that Files begin to put away their daily work at 3:55 p.m. All recommendations are being acted upon and will be reported as completed.

A new procedure for follow-up of deliquent Quarterly Inventories was made effective this month. As recommended by Auditing, Accounting Operations, Classified Files will advise Security Audit and Investigation of all custodians who have not returned their inventories one week after mailing so that necessary steps can be taken by Security to determine that the delay is not due to a document being misplaced.

The Purex Technical Manual was reviewed for declassification. The deletions required for declassification were marked and the manual was sent to a Responsible Reviewer for concurrence. The manual will be submitted to the AEC's Declassification Branch for formal declassification after which it will be made available to the Eurochemic Exchange Program.

Revisions were formally proposed to HOO for Topic 201.7.2 of the Hanford Classification Guide which covers interdepartmental transfers of fuel elements. Because classification of the records for a single transaction appears to be unjustified, revisions which more clearly identify the sensitive and non-sensitive areas of information were proposed.

An innovation in reference service was begun this month by including brief book reviews by reference specialists in "What's New in the Library?" Titles selected for review are chosen on the basis of their plant-wide interest, unique presentation, etc. First reviews covered (1) "Management of Nuclear Materials", a long-awaited book and a first of its kind devoted to the accountability of special and source nuclear material and (2) "Chemistry for Engineers".

The microfilming program is proceeding steadily, with 3906 documents microfilmed during the month. A second auto-scan microfilm reader has been ordered and should be on hand shortly. This is badly needed in the 300 Area Files for the use of technical people who must now use the microfilmed reports in their work.

Work Volume Statistics

	October	November
Document Distribution and Files		
Documents routed and discharged (copies)	16,100	17,443
Documents issued (copies)	14,281	12,925
Documents sent off-site (copies)	8,257	6,494
Document reserves filled (copies)	641	476
Documents picked up and delivered	18,229	18,206
Document Accountability		
Holders of classified documents whose files were inventoried	627	285
Documents inventoried in Files (copies)	0	--
Documents destroyed or retired (copies)	6,055	9,159
Documents revised (copies)	1,398	1,438
Documents pulled and documents filed (copies)	12,010	12,081
Documents reclassified	731	416
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	210,390	210,142
Reference and Publication		
Books cataloged (new titles)	49	129
Books added to the collection (volumes)	205	285
Ready reference questions answered by professional staff	205	210
Literature searches by professional staff	68	70
Reports abstracted (titles)	260	224
Formal reports prepared (titles)	16	9
Off-site requests for HAPO reports (copies)	299	179
Reports released to CAP (titles)	43	35

Library Acquisitions and Circulation	October	November
Books ordered (volumes)	297	255
Periodicals ordered	29	322
Books circulated (volumes)	1,777	1,538
Periodicals circulated (issues)	3,353	3,223
Inter-Library loans	79	71
Films borrowed or rented	5	5
Industrial film showings	51	50
Bound periodicals added to the collection	62	62

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind.Med.	Total
No. of books	30,233	8,549	1,695	2,024	42,710
No. of bound periodicals	113	9	1,696	1	16,137
	30,555	8,558	3,391	2,025	58,847

Classification and Declassification	October	November
Documents, including drawings and photographs reviewed for downgrading or declassification	497	8
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	24	34
Documents submitted to Declassification Branch, Oak Ridge	227	4

Manager,
Laboratory Auxiliaries

JL Boyd:jw

SEMI-MONTHLY PROJECT STATUS REPORT H-10

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CG-731	Critical Mass Laboratory	58-b-4

AUTHORIZED FUNDS				
$ 1,000,000	DESIGN $ 142,000	AEC $ -0-	COMMIT'S. TO 11-20-60	$ 992,000
	CONST. $ 858,000	GE $ 1,000,000	ESTIMATED TOTAL COST	$ 992,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 5-22-58	DESIGN ---		DESIGN 2-26-59*	
	CONST. 6-4-59	CONST. 6-30-60		CONST. 6-30-60	

ENGINEER

FEO - DS Jackson

Project Engineer - DL Ballard, CE&UO

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE Howard S. Wright Const. Co.		2950
COST PLUS FIXED FEE J. A. Jones	8	
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE			
CONST.	100	100	100
PF			
CPFF	14	100	100**
FP	86	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a laboratory for performing critical mass studies of Pu solutions and precipitates and involves the construction of a new structure in the 200 E Area.

Installation of reactor control components is continuing. A work order has been issued to J. A. Jones Company for modification of process lines to eliminate possible future contamination problems. Plant Forces are progressing on start-up items.

* Phase I only. Phase II was completed 3-31-60.
** Complete with exceptions noted on Physical Completion Notice.

PROJ. NO.	TITLE	FUNDING
CA-744	Metallurgical Development Facility, 306 Building Addition	58-b-4

AUTHORIZED FUNDS				
$ 2,685,000	DESIGN $ 137,200	AEC $ 1,366,000	COMMIT'S. TO 10-30-60	$ 2,581,449
	CONST. $ 2,547,000	GE $ 1,319,000	ESTIMATED TOTAL COST	$ 2,670,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 6-30-58	DESIGN ---		DESIGN 9-30-59	
	CONST. 3-20-59	CONST. 9-1-60		CONST. 9-1-60	

ENGINEER

FEO - KA Clark

Project Engineer - JT Hall

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		10,600
COST PLUS FIXED FEE		2,500
PLANT FORCES		200
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		260
GE FIELD ENGINEER		425

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	100	100
PF	2	100	100
CPFF	42	100	100
FP	56	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide increased capacity for an expanding reactor fuels research and development program and involves an addition to the 306 Building.
Lump Sum Contract exceptions have been completed. The Cash-Stacon valves in the H & V preheat control system are malfunctioning. The vendor has been asked to correct the condition.
Start-up work by Plant Forces has been lagging. Recent conferences with FPD Maintenance Management brought a promise of their completion by 12-31-60.

SEMI-MONTHLY PROJECT STATUS REPORT H-11

MANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CG-785	In-Reactor Studies Equipment - 105 KW	0290

AUTHORIZED FUNDS					
$ 325,000	DESIGN $ 44,000	AEC $	COMMIT'S. TO 11-20-60	$ 264,360
	CONST. $ 281,000	GE $ 325,000	ESTIMATED TOTAL COST	$ 325,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 1-5-59	DESIGN		DESIGN 12-30-60	
	CONST. 3-22-60	CONST. 12-31-60		CONST. 3-1-61*	

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES	4	1075
ARCHITECT-ENGINEER	.5	700
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	99	99
AE			
GE	100	99	99
CONST.	100	93*	93
PF	100	93*	93
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a research and development facility to permit instantaneous measurement of physical properties of materials under dynamic in-reactor and simultaneous ex-reactor conditions.

The remaining Acceptance Test Procedures have been issued and testing is in progress. Procurement for the helium conservation modification is underway.

* Based on revised schedule submitted to the Commission for approval.

PROJ. NO.	TITLE	FUNDING
CGH-805	High Temperature Tensile Testing Cell - 327 Building	0290

AUTHORIZED FUNDS					
$ 170,000	DESIGN $ 20,400	AEC $ ---	COMMIT'S. TO 11-20-60	$ 155,129
	CONST. $ 149,600	GE $ 170,000	ESTIMATED TOTAL COST	$ 170,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 8-26-58	DESIGN ---		DESIGN 6-15-59	
	CONST. 9-14-60	CONST. 4-1-61		CONST. 4-1-61	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	3	160
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		280
GE FIELD ENGINEER	.2	15

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	49	20
PF	2	0	0
CPFF	35	50	40
FP			
Mat'l	63	50	10

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides equipment for performing room and high temperature tensile tests on highly irradiated materials and involves the installation of a cell in 327 Building.

Progress has been delayed because of late delivery of cell castings. This condition will be corrected by the end of the next reporting period. The manipulator and all cell castings are expected to be shipped by the vendors by 12-9-60.

SEMI-MONTHLY PROJECT STATUS REPORT H-12

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CGH-819	Increased Laboratory Waste Facilities - 300 Area	60-1

AUTHORIZED FUNDS				
$ 193,765	DESIGN $ 27,000 / CONST. $ 116,765	AEC $ --- / GE $ 193,765	COMMIT'S. TO 11-20-60	$ 123,996
			ESTIMATED TOTAL COST	$ 160,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 3-30-59 / CONST. 6-8-60		DESIGN --- / CONST. 5-31-61		DESIGN 4-29-60 / CONST. 2-1-61

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE	3	380
COST PLUS FIXED FEE	6	300
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		400
GE FIELD ENGINEER	.4	14

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	90	90
FF	4	90	90
CPFF	30	69	69
FP	66	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project will increase the contaminated liquid waste handling facility in the 300 Area and involves greater storage capacity and improved load-out accommodations.

The Ray Britton contract is complete except for furnishing some engineering data.

The J. A. Jones Co. work is progressing satisfactorily.

PROJ. NO.	TITLE	FUNDING
CAH-822	Pressurized Gas Cooled Facility	58-e-15

AUTHORIZED FUNDS				
$ 995,000	DESIGN $ 40,000* / CONST. $ 995,000	AEC $ --- / GE $ 995,000	COMMIT'S. TO 11-13-60	$ 897,262
			ESTIMATED TOTAL COST	$ 995,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 8-19-59 / CONST. 10-17-60		DESIGN --- / CONST. 6-30-61		DESIGN 4-29-60 / CONST.

ENGINEER

HLO - DP Schively

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	61	50**
FF			
CPFF			
FP		61	50**

SCOPE, PURPOSE, STATUS & PROGRESS

Revision 3 to the project proposal requesting an increase of a $125,000 in project funds has been submitted to the Commission. Minor Construction has started repairs on packages "A", "B", and "D".

* Does not include design performed by Struthers-Wells.

** This percentage is only for the J. P. Head subcontract work on Phase "C-D".

1251549

SEMI-MONTHLY PROJECT STATUS REPORT H-13

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CGH-834	Modifications & Additions to High Pressure Heat Transfer Apparatus - 189-D Building	0290

AUTHORIZED FUNDS				
$ 700,000	DESIGN $ 66,000 / CONST. $ 634,000	AEC $ --- / GE $ 700,000	COMMIT'S TO 11-13-60	$ 672,234
			ESTIMATED TOTAL COST	$ 700,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 4-20-59 / CONST. 4-22-59		DESIGN --- / CONST. 10-15-60		DESIGN 7-1-60*** / CONST. 3-1-61**

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	0	3150
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	0	600
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	99***
AE			
GE	100	100	99***
CONST.	100	100*	90**
PF			
CPFF	100	100*	90**
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides necessary modifications to existing equipment to simulate more severe in-reactor operating conditions in out-of-reactor facilities for research and development studies. Anticipated shipment of the water storage vessel from Struthers-Wells has slipped again and every effort is being made to expedite vendor to improve progress. Resumption of field activity had been planned for mid-December but this is contingent, to a great extent, upon receipt of this vessel.

* Per current Directive

** Per Project Proposal, Rev. 1, submitted to the Commission for approval

*** Design is essentially complete. The one remaining drawing that was contingent on vendor design information is now nearing completion.

PROJ. NO.	TITLE	FUNDING
CAH-842	Critical Reactivity Measuring Facility	58-3-15

AUTHORIZED FUNDS				
$ 360,000	DESIGN $ 45,000 / CONST. $ 315,000	AEC $ 148,000 / GE $ 212,000	COMMIT'S. TO 11-20-60	$ 84,426 (GE)
			ESTIMATED TOTAL COST	$ 360,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 11-17-59 / CONST. 10-3-60		DESIGN --- / CONST. 4-30-61		DESIGN 11-18-60 / CONST. 4-30-61

ENGINEER

HLO - WS Kelly

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	96
AE			
GE			
CONST.	100	NS	3
PF			
CPFF			
FP	80	NS	3

SCOPE, PURPOSE, STATUS & PROGRESS

Contractor has started excavating for the building foundation.

1261550

SEMI-MONTHLY PROJECT STATUS REPORT H-14

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CGH-857	Physical & Mechanical Properties Testing Cell-327 Building	0290

AUTHORIZED FUNDS				
$ 75,000	DESIGN $ 75,000	AEC $ ---	COMMIT'S. TO 11-20-60	$ 24,317
	CONST. $ ---	GE $ 75,000	ESTIMATED TOTAL COST	$ 500,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 10-29-59		DESIGN ---		DESIGN 1-15-60
	CONST. ---		CONST. ---		CONST. 7-1-63

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER	1	
DESIGN ENGINEERING OPERATION	2	
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	85
HLO	25	25	18
CE&IO	75	75	66
CONST.	100	NS	0
FF			
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 cel in 327 Building. 1) Additional vendor information was requested and obtained on the fatigue testors. Comment drawings have been issued on one of the two machines. 2) Comment drawings have been issued on the impact testor. 3) Design has not been completed on the creep testing machine plugs, electrical resistivity or vacuum annealing furnace. 4) Comment drawings have been issued on the Universal tensile testing machine. The mechanical portion of the work is 80% complete. Most of the design has been commented upon. The electrical portion is ready for comments and the structural design has been started. The American distributor for the German-made dilatometer machine has notified GE that prints are not available as only a prototype unit was shown. This item of equipment may have to be deleted from the project until the production model is available.

PROJ. NO.	TITLE	FUNDING
CGH-858	High Level Utility Cell - 327 Building	0290

AUTHORIZED FUNDS				
$ 70,000	DESIGN $ 70,000	AEC $ ---	COMMIT'S. TO 11-20-60	$ 35,394
	CONST. $ ---	GE $ 70,000	ESTIMATED TOTAL COST	$ 500,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 10-29-59		DESIGN ---		DESIGN 1-15-60
	CONST.		CONST. ---		CONST. 7-1-63

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER	1	
DESIGN ENGINEERING OPERATION	2	
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	84	81
HLO	20	17	14
CE&IO	75	70	65
Vendor	5	0	0
CONST.	100	NS	0
FF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS This project will provide facilities to prepare specimens from irradiated materials for use in determining their physical and mechanical properties and involves the installation of a cell in 327 Building.

A design criteria was sent to AEC for approval.

Design is continuing on equipment and structure. Comments were made and reviewed on the cell cast iron castings. Comment drawings were issued on the flat tensile former. Desig was started on the round tensile former. Several drawings have been checked on the slitter machine. Bids were opened on Nov. 21, 1960, for the decladder machine and th were no responsible answers in the six bidders contacted. Negotiations were entered with Mr. B. A. Pearson of Norfin Inc. on Nov. 28,for this design but were unsuccessful. Negotiations will continue to find a designer for this item.

125151

SEMI-MONTHLY PROJECT STATUS REPORT H-15

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CAH-866	Shielded Analytical Laboratory - 325 Building	60-a-1

AUTHORIZED FUNDS				
$ 60,000	DESIGN $ 60,000	AEC $ 45,000	COMMIT'S. TO 11-20-60	$ 9,660 (GE)
	CONST. $ ---	GE $ 15,000	ESTIMATED TOTAL COST	$ 70,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN: 6-27-60		DESIGN 11-31-60		DESIGN 11-14-60
	CONST. --		CONST.		CONST. 2-1-62

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE	90	100	100
GE	10	100	100
CONST.	100	NS	0
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow greater capacity for analytical work involving todays more highly radioactive solution, and consists of adding a shielded laboratory to the 325 Building.

Design from the A-E was completed on 11-14-60. A project proposal for total project funds is being prepared.

PROJ. NO.	TITLE	FUNDING
CAH-867	Fuel Element Rupture Test Loop	58-e-15

AUTHORIZED FUNDS				
$ 1,500,000	DESIGN $ 130,000	AEC $ 770,000	COMMIT'S. TO 11-20-60	$ 202,797 (GE)
	CONST. $ 1,370,000	GE $ 730,000	ESTIMATED TOTAL COST	$ 1,500,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 8-1-60*		DESIGN ---		DESIGN 2-1-61
	CONST.		CONST. 10-1-61		CONST. 10-1-61

ENGINEER

HLO - PC Walkup

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	78	76
AE	20	31	40
GE	80	88	85
CONST.	100	NS	5**
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

* Scope design was started November 2, 1959, and completed March 15, 1960. Detail design was started August 1, 1960.

** George A. Grant Company portion of construction is approximately 5 per cent complete. No schedules for individual portions of the work has been provided by the Contractor to date.

Orders have been placed for $213,206 worth of equipment; total worth of required equipment is estimated to be $416,000.

1251552

SEMI – MONTHLY PROJECT STATUS REPORT H-16

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CAH-870	Facilities for Recovery of Radioactive Materials-325-A Bldg. 60-a-1	

AUTHORIZED FUNDS $					
	DESIGN $ 46,000	AEC $ 446,000	COMMIT'S. TO 11-20-60	$ 35,193 (GE
	CONST. $ 440,000	GE $ 40,000	ESTIMATED TOTAL COST	$ 486,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 4-18-59		DESIGN 3-1-60		DESIGN 3-1-60
	CONST. 3-22-60		CONST. 6-1-61		CONST. 6-1-61

ENGINEER

FEO - RW Dascenzo ,

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT – ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE	90	100	100
GE	10	100	100
CONST.	100	69	69
FF			
CPFF			
FP	100	66	66

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for recovery of specific radioisotopes from wastes, and involves an addition to 325 Building.

1. Forms, re-steel, pipe sleeves and conduit being placed for last concrete pour on Vaults "B" and "C" and pipe trenches. Pour scheduled on Dec. 2, 1960.

2. Poured concrete for last of pipe trench covers.

3. Poured concrete for work slab below pipe trench liner; installed building separation between pipe trench and building and placed stainless steel pipe trench liner.

4. Poured concrete in remainder of wall block-outs.

5. Shielding installed for base of transfer station and concrete pour made around it.

6. Transfer station moved to site and installation started.

7. Roof decking placed on both roofs and insulation and asphalting of roofs started.

8. Mechanical subcontractor prefabricating and placing water and steam lines, installing pipe sleeves in last wall pour, re-routed eight S/S waste lines along Col. Line 6, installing service piping and supply H & V ducts.

9. Electrical subcontractor running conduit from basement to ground floor elevation, poured curb and installing instrument panel and placing lights on ground floor.

10. Grinding and sacking of vault walls is underway.

SEMI-MONTHLY PROJECT STATUS REPORT

H-17

HANFORD LABORATORIES OPERATION

HW- 67538

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CAH-885	Geological and Hydrological Wells - FY 1960	60-1

AUTHORIZED FUNDS				
$ 69,000	DESIGN $ 1,000 / CONST. $ 68,000	AEC $ 59,000 / GE $ 9,100	COMMIT'S. TO 11-20-60 / ESTIMATED TOTAL COST	$ 9,045 / $ 69,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 2-15-60 / CONST. 6-8-60		DESIGN / CONST. 3-15-61		DESIGN 4-1-60 / CONST. 2-15-60

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE	4	449
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE			
CONST.	100	72	78
PF	15	60	60
CPFF			
FP	85	74	81

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of exploratory type wells used in determining the conditions of water tables within Hanford Works.

Eight of the ten wells on this project have been completed for a total of 4,000 ft. of hole. Contractor is currently 4 per cent ahead of schedule.

PROJ. NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements - 108-F Building	60-h-1

AUTHORIZED FUNDS				
$ 40,000	DESIGN $ 40,000 / CONST. $	AEC $ 30,000 / GE $ 10,000	COMMIT'S. TO 11-20-60 / ESTIMATED TOTAL COST	$ 9,997 (GE) / $ 420,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 8-8-60 / CONST.		DESIGN 2-1-61 / CONST.		DESIGN 3-1-61 / CONST.

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	46	28
AE	83	35	13
GE	17	100	100
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides additional space for biological research supporting services and involves an addition to the 108-F Building.

The Architect-Engineer visited Hanford November 28, 29 and 30, for conference and review of Title I Design comments.

Title II work was held up pending resolution of the funding problem but is now in progress with original completion date unchanged.

A revised project proposal requesting construction funds is being prepared.

SEMI-MONTHLY PROJECT STATUS REPORT H-18

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CAH-896	Stress Rupture Test Facility	60-1

AUTHORIZED FUNDS				
$ 80,000	DESIGN $ 7,500 / CONST. $	AEC $ 69,000 / GE $ 11,000	COMMIT'S. TO 11-20-60	$ 6,763
			ESTIMATED TOTAL COST	$ 80,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN.	7-29-60	DESIGN		DESIGN	12-1-60
CONST.	2-1-60	CONST.	10-15-61	CONST.	10-15-61

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	100	100
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

Detail design will be completed December 2, 1960, as scheduled.

PROJ. NO.	TITLE	FUNDING
CAH-902	Structural Materials Irradiation Test Equipment - ETR	0290

AUTHORIZED FUNDS				
$ 125,000	DESIGN $ 15,000 / CONST. $ 110,000	AEC $ 21,000 / GE $ 104,000	COMMIT'S. TO 11-20-60	$ 9,300
			ESTIMATED TOTAL COST	$ 170,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN.	9-15-60	DESIGN	2-15-61	DESIGN	2-15-61
CONST.		CONST.	10-15-61	CONST.	10-15-61

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	2	30
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	20	20
AE			
GE	100	20	20
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

The project proposal revision has been forwarded to Contract Accounting Operation. Design is continuing, based on the revised scope.

This project provides the installation of equipment at the ETR for which changes in the physical properties of reactor structural materials subjected to in-reactor conditions can be determined.

1251555

SEMI-MONTHLY PROJECT STATUS REPORT

H-19

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CGH-902	Uranium Scrap Burning Facility	61-j

AUTHORIZED FUNDS $	DESIGN $	AEC $	COMMIT'S. TO 11-20-60	$ 0
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 36,000

STARTING DATES	DESIGN. 2*	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN 8*
	CONST. 6*		CONST.		CONST. 38*

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a means of making Uranium scrap material safer for storage and off-plant shipment. It will consist of a burning furnace and structure adjacent to the 306 Building.

This project proposal was submitted to HOO-AEC for authorization on June 16, 1960.

* Weeks after authorization.

PROJ. NO.	TITLE	FUNDING
CGH-907	Strontium-90 Interim Program	Special

AUTHORIZED FUNDS $ 420,000	DESIGN $ 35,000	AEC $	COMMIT'S. TO 11-20-60	$ 175,460
	CONST. $ 385,000	GE $ 420,000	ESTIMATED TOTAL COST	$ 420,000

STARTING DATES	DESIGN. 9-8-60	DIRECT COMPL. DATES	DESIGN.	EST'D. COMPL. DATES	DESIGN 3-1-61
	CONST. 9-8-60		CONST. 3-1-61		CONST. 3-1-61

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	25	1200
PLANT FORCES	2	30
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	78*	80
AE			
GE	100	78*	80
CONST.	100	25*	25
PF	11	25*	20
CPFF	89	23*	25
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

Work is progressing according to schedule.

* Based on schedules submitted to the Commission for approval.

This project will allow the separation of Strontium-90 material from Separations Plant waste streams on an interim basis, and involves the conversion of the Hot Semi-Works Plant for this purpose.

1251556

SEMI-MONTHLY PROJECT STATUS REPORT H-20

HANFORD LABORATORIES OPERATION

HW- 67532

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CGH-914	Rattlesnake Springs Radioecology Facility	61-j

AUTHORIZED FUNDS $	DESIGN $ 1*	AEC $	COMMIT'S-TO $
	CONST. $ 2*	GE $	ESTIMATED TOTAL COST $ 72,000

STARTING DATES	DESIGN.	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN
	CONST.		CONST.		CONST.

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU/
DESIGN			
AE			
GE			
CONST.			
PP			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow performance of radioecological studies under local environmental conditions. It consists of constructing field facilities for this purpose.

Project proposal submitted to HOO-AEC on September 19, 1960.

* Months after authorization.

PROJ. NO.	TITLE	FUNDING Funds
CGH-916	Fuels Recycle Pilot Plant	Available to Comm

AUTHORIZED FUNDS $ None	DESIGN $	AEC $	COMMIT'S. TO $
	CONST. $	GE $	ESTIMATED TOTAL COST $ 5,000,000

STARTING DATES	DESIGN.	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN 1-1-62
	CONST.		CONST.		CONST. 2-1-63

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	NS	0
AE			
GE			
CONST.			
PP			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

A preliminary project proposal was written and sent to AEC early in November, requesting $50,000 to perform scoping design for this project.

SEMI-MONTHLY PROJECT STATUS REPORT H-21

HANFORD LABORATORIES OPERATION

HW- 67532 H

DATE November 30, 1960

PROJ. NO.	TITLE	FUNDING
CAH-917	Field Service Center - Atmospheric Physics	61-j

AUTHORIZED FUNDS $	DESIGN $	AEC $	COMMIT'S. TO $
	CONST. $	GE $	ESTIMATED TOTAL COST $ 125,000

STARTING DATES	DESIGN. 1*	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN 4*
	CONST. 5*		CONST.		CONST. 9*

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

Project Proposal has been submitted to the Commission and is on the agenda for the Review Board Meeting of December 1, 1960.

* Months after authorization.

PROJ. NO.	TITLE	FUNDING

AUTHORIZED FUNDS $	DESIGN $	AEC $	COMMIT'S. TO $
	CONST. $	GE $	ESTIMATED TOTAL COST $

STARTING DATES	DESIGN.	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN
	CONST.		CONST.		CONST.

ENGINEER

MANPOWER	AVERAGE	ACCUM.MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

1251558

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of November 30, 1960, the staff of the Hanford Laboratories totalled 1379 employees, including 656 exempt and 723 weekly salaried. Of the total 562 possess technical degrees, including 335 B.S., 123 M.S., and 104 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for November was 1.56 as compared with 1.80 for the preceding month. There were no disabling injuries or serious accidents during the month. There were 4 security violations bringing the total for the year to date to 31, as compared with 42 for the corresponding period last year.

PROFESSIONAL PLACEMENT

During November there was one visit by a Ph.D. candidate seeking employment and an HLO offer was accepted by an experienced Ph.D. physicist. Two offers were rejected during November, including an HLO offer to an experienced Ph.D. chemist and a CPD offer to an inexperienced Ph.D. chemical engineer. Current open offers include an FPD offer to an inexperienced Ph.D. physicist and two IPD offers to inexperienced chemical engineers.

During November thirteen HAPO scientists and engineers participated in Company Ph.D. recruiting, and seven BS/MS recruiters visited twenty schools.

Two Technical Graduates were added to the rolls and five accepted permanent assignments during the month. At month's end there were 67 Technical Graduates on the roll including six members of the Engineering and Science Program

EMPLOYMENT

There were 14 requisitions received during the month, 14 vacancies were filled, 1 was cancelled, and 20 remain to be filled.

COMMUNICATIONS

A story on Hanford research requested by the Spokesman-Review for their annual progress edition was edited and released.

The Washington State Department of Commerce and Industrial Development has requested several minutes of film on HLO activities to be included in a new motion picture aimed at bringing new industry to the state.

COMMUNICATIONS (Cont'd.)

Assistance was provided for the publicity of the PRTR criticality. A TV news film prepared by Relations with HLO assistance was shown on the Cascade Network.

Three luncheons were held by the Manager, Hanford Laboratories for employees in November.

TRAINING

Seminars in BOCE, Creative Approach and Understanding People continued with a total enrollment of 40 Laboratories employees. A proposed Columbia Basin College "Engineering Aid" night class curriculum was reviewed by selected Laboratories managers and comments forwarded to Relations Operation, Education and Training.

Acting Manager
Professional Placement
and Relations Practices

RS Himmelright:lmh

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1960 to Date

	Visits to Richland				Offers			
	Cases Considered	Invited	Visited	To Visit	Extended	Accepted	Open	On the Roll
PhD	189	52	7	11	9	1	3	-
Exp. BS/MS	149	27	14	3	15	7	4	6
Prog. BS/MS	--	-	-	-	16	2	14	2

B. Technical Recruiting Activity - HLO - September 1, 1960 to Date

	Visits to Richland				Offers			
	Cases Considered	Invited	Visited	To Visit	Extended	Accepted	Open	On the Roll
PhD	189	52	7	11	4	1	-	-
Exp. BS/MS		16	10	3	2	-	-	-

In addition to the above activity, 3 exempt employees have transferred into HLO from other HAPO departments and 6 technical graduates have accepted Off-Program placement in HLO to date.

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Oct.	Nov.
Requisitions		
At end of month	21	20
Cancelled	2	1
Received	20	14
Filled	16	14

Nonexempt Transfer Request	Oct.	Nov.
Transfers		
Active cases at end of mo.	78	80
Cancelled	3	0
New	2	2
Effected	2	0

C - Technical Graduate Program
Month ending November 30, 1960

Number Personnel on assignment	67
(HAPO Tech Grad Program 61	
(Western District E.P. 6	
Distribution of Assignments by Departments	
IPD	29
HLO	17
FPD	8
CPD	6
CE&UO	5
C&AO	2
Distribution of Assignments by Function	
R&D or Engineering	44
Other	23

FINANCIAL OPERATION MONTHLY REPORT
NOVEMBER 1960

Personnel

An employee was transferred from Laboratory Auxiliaries to work in Property Accounting.

Activities

GENERAL ACCOUNTING

The level of travel in Hanford Laboratories was lower than in the previous month following an established seasonal trend. It is expected to be higher than normal in December due partially to the ANS meeting in San Francisco.

Accruals for equipment received not billed and equipment shipped by the vendor prior to December 1, 1960, with F.O.B. terms vendor's plant were made at the request of Contract Accounting. Accrual by Program is shown below:

02 Program	$ 51 363
03 Program	-
04 Program	64 313
05 Program	190
06 Program	915
	$116 781

Total equipment expenditures including the above accrual are compared to our current allocation as follows:

(Amounts in Thousands)

Program	Allocation	Expenditures	Percent Expended
02	$1 877	$411	22%
03	25	4	16%
04	708	274	39%
05	43	11	26%
06	100	19	19%
Total	$2 753	$719	26%

Reconciliation by C&AO of the physical inventory of the Hot Semi-Works facility and the inventory of movable cataloged equipment in custody of Radiation Protection continues. C&AO advises reconciliation will be completed in December.

Preparations were completed for the physical inventory of movable cataloged equipment in the custody of Physics and Instrument Research and Development Operation to begin on December 12, 1960. The actual count is scheduled to be completed by January 2, 1960.

The Mid-Year Budget Review covering HLO Inventories was submitted to Contract Accounting. Total HLO inventories balance for June 30, 1961 was reduced by $51,000 from that previously reported.

Fourty-one items valued at $13,753 were received at the Laboratory Equipment Pool during the month of November. Twenty-four items were loaned or permanently placed in lieu of placement of requisitions valued at $7,912. One item valued at $1,464 was withdrawn by custodian. There are currently 593 items valued at $234,843 located in the equipment pool. It is interesting to note that since June 30, 1960, equipment valued at $25,820 has been withdrawn in lieu of the placement of requisitions. Our operating cost for this same period was $4,693 indicating a net saving of $21,127. At this rate, net savings to HLO will exceed the original building investment by the end of this fiscal year.

The following Reactor and Other Special Materials were on hand at the Laboratory Pool at month end.

Beryllium	$ 33
Palladium	1 571
Platinum	15 980
Silver	84
Gold	2 961
Zirconium	71 334
	$91 963

In order that unitizations performed by Hanford Laboratories Operation, where HLO has retained project management and accounting, may progress smoothly without duplication of effort the function of project unitization was transferred to Property Accounting in November. In addition during November responsibility for coordinating and control of office furniture and equipment for HLO previously provided by Laboratory Auxiliaries was transferred to Property Accounting. To perform these new assignments and to relieve an increased work load in Property Accounting which has steadily and consistently increased during the last several years, one additional person was added to the staff. As a result all Property Accounting personnel were reassigned to new duties and new job descriptions were prepared and submitted to Relations Practices for review and classification.

A report of results of the annual witnessed physical inventory of reactor and other special materials was issued by Contract Accounting Operation. Conditions reported by Contract Accounting were in general, much improved over those reported at the time of the 1959 physical inventory. It was reported again this year that many holders have material in their custody where no immediate future use is anticipated. This material should be in the custody of the HLO Central Control Custodian and reissued as the need arises. To correct this, we will intensify our efforts to transfer this material to the Laboratory Equipment Pool.

COST ACCOUNTING

The FY 1961 Mid-Year Budget Review was completed and required data were transmitted to Contract Accounting within the established due dates.

As a result of the Mid-Year Review, additional 02 Program Research and Development funds in the amount of $64,000 were allocated to Hanford Laboratories by the General Manager - HAPO. Other highlights of the Mid-Year Review include (1) an additional allocation of $100,000 in Reactor Program funds from IPD for river

radioisotope work, (2) a decrease of $30,000 in IPD-sponsored Metallurgy work, (3) a net increase of $35,000 in CPD-sponsored 02 Program Research and Development and (4) a $25,000 increase in CPD-sponsored process technology. The preceding fund changes and other miscellaneous adjustments will be reflected on November reports. Those portions of the Mid-Year Review requiring approval of the AEC will not be reflected on November reports, but will be factored into the HLO Control Budget as they are approved.

Two special requests were received by Hanford Laboratories during the month:

(1) Provide engineering services at Dugway Proving Ground for the Defense Systems Department, General Electric Company. Estimated billing price - $500.

(2) Provide four pieces of zircaloy tubing under the sheath tube exchange program to Savannah River Plant, E.I. DuPont DeNemours and Company. Estimated billing price - $500.

Three program codes were established during the month as follows:

Code	Title	Remarks
.30	Reactor Studies - Supercritical	New research and development programs sponsored by Division of Reactor Development.
.31	Aluminum Corrosion and Alloy Development	
.13	Protective Coating Testing Methods	New program sponsored by Division of Production.

Organization code 7621 - Hot Semi-Works has been established to accumulate salaries, materials and services associated with the Strontium-90 Purification activities at the Hot Semi-Works facility.

Progress toward the conversion of the HLO cost accounting system to electronic data processing was further accomplished during November with the utilization of individual Time Distribution Reports and the conversion of the manual work request system to the EDP work order system.

Concurrent with the transfer of 100-F area landlord reponsibilities on November 1, 1960, from Laboratory Auxiliaries to Biology, applicable FY 1961 budget and costs-to-date were segregated. Separate reporting is planned for the future.

Action as indicated occurred on the following projects during the month.

New Funds Authorized HLO

CAH-896	Stress-Rupture Test Facility	$3 500

Physical Completion Notices Issued

CAH-848	Geological and Hydrological Wells, FY 1959
*CAH-864	Shielded Animal Monitoring Station, 100-F

*AEC Services only.

Construction Completion and Cost Closing Statements Issued

CGH-790 High Level Radioactive Material Receiving and Storage Addition, 327 Building

CAH-848 Geological and Hydrological Wells, FY 1959.

Financial restrictions were placed on miscellaneous Capital Work Orders under $20,000 in Hanford Laboratories due to a limitation of authorized funds for FY 1961. Several jobs have been cancelled and several more are being held up pending a review of HAPO requirements.

Payroll Statistics

Number of HLO Employees	Total	Exempt	Non-Exempt
Changes During Month			
Number on Payroll at Beginning of Month	1 382	663	719
Additions and Transfers In	17	3	14
Removals and Transfers Out	(19)	(10)	(9)
Employees on Payroll at End of Month	1 380	656	724

Overtime Payments During Month	November	October
Exempt	$13 409	$ 9 212
Nonexempt	28 691	19 108
Total	$42 100	$28 320

Gross Payroll Paid During Month		
Exempt	$ 578 513	$579 695
Nonexempt	462 982	360 597
Total	$1 041 495	$940 292

Participation in Employee Benefit Plans at Month End	November		October	
	Number	Percent	Number	Percent
Pension Plan	1 216	99.3	1 217	99.4
Insurance Plan				
Personal Coverage	1 372	99.7	1 372	99.8
Dependent Coverage	980		985	
U. S. Savings				
Stock Bonus Plan	75	37.7	75	36.9
Saving Plan	88	6.4	90	6.5
Saving and Security Plan	1 155	85.4	1 051	85.2
Accident Insurance	797	57.9	797	57.8

Insurance Claims	November Number	November Amount	October Number	October Amount
Employee Benefits				
Life Insurance	-0-	$ -0-	-0-	$ -0-
Weekly Sickness and Accident	15	547	10	730
Comprehensive Medical	34	1 819	55	2 456
Dependent Benefits				
Comprehensive Medical	69	7 322	84	8 139
Total	118	$9 687	113	$11 325

Good Neighbor Fund	November	October
Number Participating	942	941
Percent Participating	68.3	68.1

W. Sale
December 15, 1960

INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

INVENTOR	TITLE OF INVENTION OR DISCOVERY
J. J. Hauth	Fabrication of Ceramic Fuel Elements by Ultrasonic and Low Frequency Vibratory Compaction
J. J. Hauth	Mixed Pellet Powder, High Density Ceramic Fuel Elements
W. E. Baily and J. B. Burnham, Jr.	Fabrication of Ceramic and Cermet Solid Solution Fuel Elements by Hot Swaging
E. G. Peterson	Proton Recoil Neutron Spectrometer
J. M. Skarpelos	Fixation of Radioactive Residues - Use of an Activated Carbon Pretreatment to Remove Organic Impurities and Enhance Cesium Removal from Radioactive Wastes by Natural and Synthetic Zeolites

W. Sole
for Hay Parker

[redacted]

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