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# HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

NOVEMBER, 1962

DECEMBER 14, 1962

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HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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Series A

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MONTHLY ACTIVITIES REPORT  
NOVEMBER, 1962

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Compiled by  
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TABLE I - HANFORD LABORATORY PERSONNEL REPORT

DATE: November 30, 1954

	At Beginning of Month		At Close of Month		Total
	Exempt	Salaried	Exempt	Salaried	
Chemical R & D	131	136	132	135	267
Reactor & Fuels R & D	177	164	179	166	345
Physics & Instrument R & D	92	61	92	62	154
Biology	40	59	41	59	100
Applied Mathematics	18	4	18	4	22
Radiation Protection	41	92	42	92	134
Finance & Administration	122	110	123	111	234
Programming	15	3	13	3	16
General	3	4	3	4	7
Test Reactor & Auxiliaries	<u>58</u>	<u>300</u>	<u>57</u>	<u>299</u>	<u>356</u>
Total	697	933	700	935	1,635

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BUDGETS AND COSTS

November operating costs totaled \$2,330,000, an increase of \$37,000 from the previous month; fiscal year-to-date costs are \$11,417,000 or 38% of the \$30,008,000 control budget. The control budget was increased \$824,000 to reflect the revised research and development authorizations contained in the recent HOO-AEC Financial Plan #2. Included therein were three new programs authorized for the first time in the following amounts:

04 Program	EBWR Program	\$400 000
05 Program	Plutonium Physical Metallurgy Research	80 000
08 Program	Fission Products Production Study	100 000

Hanford Laboratories' research and development costs for November, compared with last month and the control budget are shown below:

(Dollars in thousands)	COST				
	<u>Current Month</u>	<u>Previous Month</u>	<u>FY To Date</u>	<u>Budget</u>	<u>% Spent</u>
HL Programs					
02 Program	\$ 84	\$ 70	\$ 368	\$ 1 069	34
03 Program	9	16	35	175	20
04 Program	944	1 019	4 872	12 170	40
05 Program	101	87	467	1 375	34
06 Program	288	244	1 275	3 154	40
08 Program	1	-	1	100	1
	<u>\$1 427</u>	<u>\$1 436</u>	<u>\$7 018</u>	<u>\$18 043</u>	<u>39</u>
FPD Sponsored	109	104	492	1 370	36
IPD Sponsored	105	93	484	1 325	37
CPD Sponsored	<u>118</u>	<u>100</u>	<u>635</u>	<u>1 369</u>	<u>46</u>
Total	\$1 759	\$1 733	\$8 629	\$22 107	39%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

Examination of five NPR inner fuel tubes after irradiation to 3000 Mwd/ton revealed that warp was small, the Be-Zr brazed closure was sound, and hydrogen pickup by the cladding during irradiation was nil or negligible.

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An experimental dual-enriched single-tube N-Reactor fuel element failed during its fifth cycle of operation in the ETR M3 Loop. The failure resulted from a high radial flux gradient in the test facility and was unrelated to the dual enrichment design feature under test.

Inner fuel tube supports for the N-fuel were successfully fabricated by a hot forming process that requires less ductility of the Zircaloy-2 strip than was required by previous methods.

Continued burnout monitoring of production reactor graphite has shown that burnout is largely a surface phenomenon, and hence, extrapolation from in-reactor samples to stack graphite requires interpretation.

A heat pulse transit time (flash) method has been used to determine the thermal conductivity of irradiated TSX graphite. The method requires only small samples and is fast and simple to apply. Results agree well with typical conventional measurements.

The contractions in annealing AGOT-LS graphite irradiated under compression were found to be similar to those of uncompressed samples.

Graphite prepared by impregnation with furfuryl alcohol was found to contract more upon irradiation at 500 to 700 C than untreated graphite.

Eccentric placement of an NPR inner fuel component (as might occur with the supports flattened or sheared off) caused a 40 to 50% decrease in burnout heat flux at mass velocities of  $1-4 \times 10^6$  lb/hr/ft<sup>2</sup>. At mass velocities less than  $1 \times 10^6$  lb/hr/ft<sup>2</sup>, the eccentric placement apparently increased the burnout heat flux.

A visual and photographic study was continued to determine the amount of boiling present in the existing production reactors when fuel element supports collapse and allow the fuel to approach the wall of the process tubes.

Investigations of various interchannel water mixers for present production reactors showed reductions in cross-section coolant temperature variations of 50 to 70%. However, total pressure drops across the charge in  $6.5$  to  $13$  psi.

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Comparisons between boiling burnout conditions of a 6.3-foot-long electrically heated model of a 19-rod fuel bundle and a 19 1/2-inch-long section of similar geometry indicated no length effect on boiling burnout.

Aluminum alloys exposed to neutral, deionized water in KE corroded at slightly higher rates than control samples in process water. The red-orange colors of films on the coupons in the deionized water were quite different from those of the controls, which were typically a dull rusty color.

A series of in-reactor experiments has been completed to determine corrosion rates of aluminum alloys in process water containing 1.0 and 1.8 ppm dichromate. Although no effect of dichromate concentration was found, the data indicate, unexpectedly, that X-8001 alloy may give a two- to threefold lower corrosion rate than 1100 alloy under the same water conditions. Confirmation is required.

Corrosion rates of A212 carbon steel, AISI 304 stainless steel, and Zircaloy-2 in 300 C deionized water with pH adjusted to 10.0 with ammonium hydroxide were comparable to corrosion rates obtained using LiOH for pH control (tests conducted in the TF-1 out-of-reactor loop).

A PRTR Zircaloy-2-clad  $\text{UO}_2$  fuel element with supplemental feet (they had been added to provide additional support contact area between the fuel element and pressure tube) showed fretting corrosion marks less than 1-mil deep, compared to wire wrap fretting corrosion marks 3 to 4 mils deep in the same tube. The fuel element had been subjected to an impressed 80 cps external vibration for 2 weeks in flowing water at PRTR primary system conditions.

Measurements of residual plutonium on surfaces of PRTR components following decontamination indicate that less than 1% of the plutonium from the  $\text{MgO-PuO}_2$  rupture remains on the primary system surfaces.

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Eight PRTR Zircaloy-2 pressure tubes were visually inspected; inside diameters and gas gaps were measured. Nothing unusual was observed. One tube had contained an MgO-PuO<sub>2</sub> fuel element which ruptured during the month of August. By removal of their tube and destructive examination in the vicinity of the rupture, it was confirmed that the ruptured fuel had not contacted the tube wall.

Neutron exposure to  $2 \times 10^{17}$  nvt did not affect the strength and ductility of the cold-worked section of a Zircaloy-2 pressure tube removed from the PRTR and burst tested at 570 F.

Four PRTR elements were fabricated to complete a total of 16 needed for the next reactor operating period. Aluminum-plutonium alloy (HX Pu<sup>240</sup>) fuel elements needed for PCTR physics experiments were completed and delivered.

The second series (GEH-21-41) of four specimens containing UO<sub>2</sub>-0.154 mole % PuO<sub>2</sub> and UO<sub>2</sub> (1.00 mole % U<sup>235</sup>) was successfully irradiated for 5 minutes at a power of 20 kw/ft in the Hydraulic Rabbit Facility (VH-4) of the MTR.

Failure of two one-foot-long sections of cold-swaged, PRTR UO<sub>2</sub> fuel rods occurred at 7820 and 7880 psi during burst tests at 550 F. The burst pressure was more than twice the maximum internal pressure that will be present in PRTR fuel rods after 10,000 Mwd/ton<sub>U</sub> exposure.

A 66 vol% UO<sub>2</sub>-tungsten cermet capsule was fabricated by Dynapak compaction and irradiated without incident for 1 hour at a calculated surface temperature of 2300 C.

In a meeting with ANL personnel, criteria were adopted for the design and fabrication of plutonium fuel elements for use in the EBWR demonstration experiment.

A short irradiation of uranium monosulphide was completed successfully in the ETR.

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High quality replicas of irradiated fuel rod cross sections were made in the Radiometallurgy Laboratory using a silicone rubber. These replicas are inexpensive, satisfactory for optical microscopy, and easily stored for future reference.

A new "laminated neutron spectrum" core design was conceived and investigated as a means of providing an economical way to overcome the large positive coolant void effect (+18%  $\Delta k/k$ ) found for the Fast Super-critical Pressure Power Reactor core. Initial calculations show that a zero void effect can be achieved with this design.

Over 1000 specimens of Zircaloy-2 and AISI 304, 347, 410, and AM-350 stainless steels and other structural alloys have been irradiated in the HLO G-7 hot-water facility in ETR during the last 14 months. This facility, the only known in-reactor loop devoted exclusively to the irradiation of structural materials, has operated satisfactorily at design temperature for 95% of the reactor operating time.

Postirradiation tests on Zircaloy-2 specimens indicate that this material does not become notch sensitive after an irradiation of  $5 \times 10^{19}$  nvt.

Measurements of the effects of neutron irradiation on the creep properties of Zircaloy-2 have been completed for 30,000 psi and a range of temperatures and tests at a stress of 20,000 psi have been started.

TD Nickel, a new dispersion hardened nickel alloy developed by duPont, is being evaluated for high-temperature gas atmosphere applications. The finely dispersed thoria particles appear to markedly improve resistance to softening in the temperature range of 1100 to 2000 F.

Further confirmation of the pronounced effect of neutron dosage rate on the corrosion of Zircaloy-2 was obtained.

Basic studies continued on the effects of neutron irradiation and carbon impurity level on defect structures in single crystal molybdenum

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and their effects on mechanical properties and deformation mechanisms of this material were also studied.

Primary melting of thorium-2.5 wt% Orallo-1 wt% zirconium fuel material has been completed preparatory to coextrusion with Zircaloy-2 cladding and irradiation testing.

## 2. Physics and Instruments

In the program for loading the EBWR with a plutonium-fueled core, the dimensions of the Zircaloy tubing have been fixed and that material can now be ordered. An upper limit of 3 wt% of  $\text{PuO}_2$  in the mixed oxide fuel has also been set. These results were obtained in concurrence with staff members of Argonne National Laboratory. Physics analyses are continuing for final design of the experiment.

In the instrument field, the second generation monitor for gamma emitters in liquid effluent was accurately calibrated and installed at the PRTR for use in the containment trip circuit. The minimum detectable amount of  $\text{Cs}^{137}$  was determined to be  $10^{-5}$   $\mu\text{c/ml}$ .

In computer code development for PRP, work continued on the Monte Carlo portion of the RBU code and various cross-section subroutines used in conjunction with HFN, GAM-1, TEMPEST, and CALX codes. The GROUSS code, which computes group self-shielding factors used in resonance escape calculations, is being developed and checked against experimental data and the P-3 and  $S_n$  transport theory codes.

A widely used theoretical description of the energy exchange between neutrons and light water (Nelkin's scattering kernel) has been found to be in disagreement with experimental data from Hanford and Chalk River experiments. Although some reduction in the discrepancies is achieved by modifying the basic constants of the model as indicated by experiment, the discrepancies remain large. Water's resonance structure is being studied with the hope of obtaining a model that will more closely agree with experiment.

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In reactor studies, the comparison of uranium and plutonium fuels for compact space power reactors is being extended to a unit cooled with Li<sup>7</sup>. Additional analyses of the Phoenix-fueled Zr-H<sub>2</sub>O compact reactors yielded further evidence of the flat reactivity response over a wide range of fuel loading mentioned in last month's report. These calculations were for a Pu composition of 90% Pu<sup>239</sup> and 10% Pu<sup>240</sup>.

A milestone was passed at the Critical Mass Laboratory with completion of the program of studies on the first vessel (a 14-inch-diameter sphere). Final measurements were designed to explore the effects of reflection from nearby objects—not in actual contact with the vessel—by studying the effect of a 4-inch air gap between the vessel and a surrounding thick spherical concrete shell. To attain criticality, 40% more plutonium was required with the gap as compared with the situation when the concrete was in contact with the vessel.

Experiments began in the Critical Mass Laboratory with an 11-1/2-inch-diameter sphere. These tests will allow measurements on higher plutonium concentrations with good reflection.

A special liquid conductivity monitor was developed to determine the presence of plutonium-bearing solutions in certain 234-5 Building locations.

In the production reactor program, a series of buckling measurements has been completed in an exponential pile mockup of the overbored C pile. These measurements will help determine the change in buckling caused by water flooding of the pile graphite. Interpretation of the data is in progress.

Instrumentation activities included: design of an instrument to measure the ID of K process channels, preparation of functional specifications for a fission counter preamplifier for NPR, completion of further instrument system designs for the PRTR fuel test loop, analysis of the NPR flow monitor system, start of a 4-node simulation study of the N reactor, and a simulation study of the NPR pressurizer-injection system.

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Tape punch systems were developed for the automatic logging of fuel dimension data in the N fuel plant and the KE underwater measurement facility.

In computer code development to accommodate features requested by IPD, additional changes have been made to the kinetics code TRIP.

Hydride concentrations in Zircaloy-2 have been nondestructively detected with an eddy current method. Instruments are being developed for further evaluation of the method and for comparison with other detection schemes under study. The development of multiparameter eddy current testing equipment was also in progress.

Tentative recommended practices for the ultrasonic testing of Zircaloy fuel sheath tubing have been prepared in rough draft form on the basis of results to date from the AEC/AECL Nondestructive Testing program. Further work is continuing on the experimental and theoretical bases for selection of these test parameters.

First analysis of the diffusion data obtained at Vandenberg Air Force Base was completed, adding considerably to our understanding of dispersion processes in the marine layer along the rugged California Coast. Except for the summer "ducting" phenomena and enhanced dilution resulting from increased surface roughness, results were generally consistent with those obtained at Cape Canaveral.

Good progress was made on the development and assembly of the new portable mast instrument system for meteorology studies.

The shadow shield counter was taken to Seattle to perform some experiments in cooperation with Swedish Hospital at their Northwest Research Institute. Two of the experiments, measurement of the effect of an artificial kidney on the body burden of potassium and localization of an  $I^{131}$  tagged compound in tumors, were done for the Swedish staff. Two experiments of interest to us were started to calibrate our counter for potassium and  $Zn^{65}$ .

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During the course of this work our shadow shield counter was made capable of differential scanning.

In the instrument field, one prototype miniature gamma-sensitive signalling dose meter was provided to Radiation Protection for evaluation testing. Another was modified for experiments on neutron sensing.

Nondestructive testing technical services included: completion of work on PRTR process tubes, eddy current testing of NPR instrument tubing, emergency testing of a downcomer expansion joint at 105-KW, continuation of tests on a DR cross header, provision of a test to sort mixed lots of NPR stainless steel and Inconel tube fittings, and development of two tests to aid the N fuel extrusion process.

In the basic data field, measurements of total neutron cross sections in the energy range of 3 to 15 Mev have been continued. Data were obtained on ten more elements: carbon, sulfur, chlorine, titanium, chromium, nickel, zinc, cadmium, arsenic, and iodine. No measurements at all had previously been reported for arsenic and iodine from 3 to 14 Mev. This brings the total number of elements measured on this program to 33.

### 3. Chemistry

The fuel elements in the aluminum reactor tube that uses deionized cooling water were discharged and new elements were reloaded. Evaluation of radioisotope concentration changes indicates that both the tube and fuel element surfaces must be inhibited for radioisotope reduction methods to be effective.

Excellent quality water was produced by the Water Treatment Pilot Plant with an alum concentration of 7 ppm (vice 18 ppm normal) and a floc zeta potential near zero. The  $As^{76}$  concentration was twofold below the control, but the  $P^{32}$  concentration was not significantly different.

Analyses of reactor coolant gas drier condensate indicate  $H^3$  to be a major contributor to the beta activity and  $C^{14}$  to be minor. Based on

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these analyses and operating conditions, the maximum output of  $C^{14}$  was 2 curies per month at a K Reactor and 0.2 curie per month at a D Reactor.

A more reliable and reproducible means for ion exchange resin pumping in semicontinuous contactors than that currently used in the Purex and Redox plants was demonstrated. Large (3/4 to 1 inch) ball check valves operating submerged in a resin bed were combined with a reciprocating bellows to operate as a solids pump.

A solvent extraction process was evolved for the simultaneous recovery of fission product cesium, strontium, and rare earths from acidic Purex waste. The solvent is a mixture of BAMBP (a phenol), di-2-ethylhexylphosphoric acid (D2EHPA), and Soltrol diluent. The key to the process is a synergistic effect of D2EHPA on BAMBP. If preliminary results are corroborated, the process would markedly simplify fission product recovery processing in B Plant.

Scouting experiments demonstrated that feed solutions suitable for D2EHPA-Soltrol extraction of strontium and rare earths can be prepared from acidic Redox waste.

Laboratory column experiments demonstrated room temperature loadings of strontium on Linde 4A zeolite (30-35 mesh) to 2.4 meq of strontium per gram of zeolite.

The  $Pm^{146}/Pm^{147}$  isotopic ratio in an exhaustively purified sample of promethium recovered from Purex waste sludge was determined,  $3.05 \times 10^{-7}$  0.75 Mev gammas and  $2.46 \times 10^{-7}$  0.45 Mev gammas per  $Pm^{147}$  beta. A 250 thermal watt promethium heat source would require 1/2 inch of lead to shield to a level of 200 mr/hr at 1 foot, compared with 4-1/2 inches of lead for a similar  $Sr^{90}$  source.

Relatively large quantities of tartrate, hydroxyacetate, citrate, and EDTA are employed as complexing agents for iron and fission products in the strontium recovery program and routed ultimately to waste storage tanks.



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Hot cell experiments over a 2-month period indicate that the complexed neutralized waste will decrease from pH 10.5 to about 7.5-8 minimum as a result of radiolysis of these organic materials.

Another successful full-level pot calcination run was made in the A-Cell pilot-scale calcination equipment, bringing the total number of full-level runs to four. A special objective of the run was to determine the effect of alkaline earth addition on the decomposition of sulfate and volatilization of ruthenium. Sulfate decomposition was suppressed, but ruthenium evolution was unaffected.

Initial tests of the Cold Semi-Works radiant-heat spray calciner (18-inch-diameter, 10-foot-long) were completed with encouraging results. The off-gas cyclone was very effective and a sodium decontamination factor of 10,000 was obtained from feed to condensate.

A newly developed British large area alpha spectrometer meets the criteria for accurate analyses of ashed tissue samples in connection with uranium ore inhalation studies. Work is in progress to construct one of these instruments.

A  $\text{PuO}_2\text{-UO}_2$  electrolytic co-deposition from a  $\text{KCl-LiCl}$  melt at 550 C was achieved by electrolyzing in the presence of an  $\text{O}_2\text{-Cl}_2$  sparge. No separate  $\text{PuO}_2$  phase was detected, and X-ray diffraction studies indicate at least 70% of the  $\text{PuO}_2$  is a solid solution with  $\text{UO}_2$ .

#### 4. Biology

Exploratory tests of the toxicity of reactor decontaminants show that SULFAM-3 is intolerable to fish at 200 ppm, but not at 100 ppm. In raw river water, however, the fish are able to tolerate 200 ppm, apparently because of the greater buffering capacity of river water.

The final aerial survey of chinook salmon spawning in the Columbia River between Richland and Priest Rapids indicated the second highest

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number of nests recorded since spawning census was begun in 1947. (The increase may be the result of the partial barrier to upstream migration created by the Priest Rapids Dam.)

Evidence in support of the ion pair hypothesis was obtained by testing the effect of changing the concentration of Zn-Cd—one member of the pair. Transfer of these ions through Visking casings and intestinal sacs taken from rats were markedly different.

An "Erythropoiesis Stimulating Factor" was detected in a pig which had been fed  $625 \mu\text{c Sr}^{90}$ /day. This is the first time that this factor has been demonstrated in a large experimental animal. Previous demonstration of this factor had been obtained in a small animal that was receiving essentially whole-body radiation as compared to the bone marrow being selectively radiated.

Iodine-131 in the thyroids of calves born to cows being fed radioiodine was one-third to two-thirds of that in the dams. (These values are considerably less than that described by other workers.)

The gastrointestinal absorption of  $\text{Np}^{237}$  was measured as a function of valence states. Valence (VI) was the highest and valence (IV), the lowest. Different valences caused a four- to fivefold change in the absorption coefficient.

A 2-year-old female miniature swine that had received  $1.3 \mu\text{c of Pu}^{239}$ /kg body weight at 1 year of age showed severe skeletal lesions, including multiple fractures, disorganization of trabecular bone, sclerotic areas, and areas of bone dissolution. These lesions are more severe than any others noted to date on miniature swine containing body burdens of other bone-seeking radionuclides.

Seventy days after depositing  $100 \mu\text{c to } 2 \text{ mc Ce}^{144}\text{O}_2$  by inhalation, leukopenia developed and K concentration of the blood serum dropped. Other constituents and characteristics of the blood remained normal but for an increase in arterial blood  $\text{CO}_2$ .

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Alligators are surprisingly resistant to X-radiation. No deaths were caused by 1500 to 9000 r 3 weeks after exposure. Only leukopenia is apparent.

Mice were protected from the effects of X-radiation by being injected with rat bone marrow cells. The mice, after 10 weeks, registered both antihost and antigraft hemagglutinins.

##### 5. Programming

A tabular summary of isotope value (preliminary results) in spent fuel is presented in the body of the report. These studies indicate, for example, that Pu<sup>242</sup> may have a value of about \$50 per gram as source material for Cm<sup>244</sup>. Consideration of the market for radioactive heat sources may drastically affect fuel cycle economics.

The photoexcitation method for separating mercury isotopes has not been exploited because of limited interest in the isotopes. A literature search and study of published data has been started to explore the feasibility of using photoexcitation for separating hydrogen isotopes. Extensive data on irradiation of hydrogen isotopes exist, but separation of irradiation-activated isotopes does not appear to have been attempted.

#### TECHNICAL AND OTHER SERVICES

There were no new plutonium deposition cases confirmed by bioassay analyses during the month. The total number of plutonium deposition cases that have occurred at Hanford is 310, of which 226 are currently employed.

A CPD process operator received a plutonium-contaminated injury at the 234-5 Building while machining a plutonium metal casting. Examination of the injury with the wound counter showed approximately  $5 \times 10^{-2}$   $\mu\text{c}$  of plutonium. Excision of tissue by the industrial physician reduced the plutonium contamination at the wound site to about  $4 \times 10^{-3}$   $\mu\text{c}$  (approximately 10% of the MPBB for bone). In prior years, the same employee had received

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two other plutonium-contaminated injuries to his hands, both requiring medical excision of tissue. The medical action was successful in removing the contamination from an injury that occurred in 1961, but in June 1960, about  $9 \times 10^{-3}$   $\mu\text{c}$  plutonium (approximately 20% of the MPBB for bone) remained at the wound site after the excision. Because of the location of the injury on the knuckle of the index finger, no further excision was made. DTPA was administered and evaluation of bioassay analyses indicated internal deposition of < 10%. Subsequent examinations of the injury with the wound counter, including examination of the area at the time of the most recent injury, have shown no measurable decrease in the amount of plutonium at the wound site.

Concentrations of fallout materials in the air of the Pacific Northwest increased this month. Weekly average values for periods ending 11/2, 11/9, 11/16, and 11/23 were 5, 11, 8, and 8  $\mu\mu\text{c}$  gross beta per  $\text{m}^3$  of air, respectively. As a result of the increased fallout, average concentrations of  $\text{I}^{131}$  in milk exceeded 100  $\mu\mu\text{c}$ /liter for three of the farms and for the two composite samples collected. The highest concentration in a milk sample was 550  $\mu\mu\text{c}$ /liter; it was obtained from a farm at Ringold on November 27.

One fuel element from each incoming ingot of enriched uranium is currently measured for reactivity. An acceptance plan was formulated which permits measuring groups of fuel elements as a composite sample, thus reducing the amount of measuring required while at the same time giving assurance that no ingot having an unusual amount of enrichment will be accepted.

An analysis of recent warp data from 140 NPR fuel extrusions, presumably coextruded under similar process conditions, showed the presence of strong cycles and trends in the data. Further detailed analysis is being made to aid in determining the reason for this behavior and the feasibility of setting up statistical controls.

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As a result of an evaluation of the existing method of setting limits for standard samples in the CPD analytical laboratories, a change in procedure was recommended and adopted that makes the control program more responsive to current laboratory precisions and accuracies.

A rough draft report is being prepared in connection with assessing risks associated with the shipment of radioactive materials by rail. The report, which contains many tables summarizing various types of data, will be of great use in finding the risks involved in a given situation.

Preparations were made for, and presentations were made at, seven staff meetings in connection with reporting the results of the 1962 HAPO Attitude Survey to Management.

The analysis was completed of data from an experiment to estimate the organic zero shift of the gamma absorptiometer to be used for analyzing feed stream concentrations in future pulse column experiments.

Analytical studies continued on the problem of determining the propagation phenomena of disturbances in elastic media. An EDPM program is nearing completion which will compute the pertinent parameters which characterize the various modes of behavior of large slabs of homogeneous materials.

The analysis of mass spectrometer data on three gas standards was completed. The total variation in data was resolved into between-run components on a within week basis, individual peak components, and experimental error. The results of the analysis will provide an estimate of the precision of a quantitative analysis of a gas sample based on the comparison with a known standard previously analyzed on the same instrument.

#### SUPPORTING FUNCTIONS

The PRTR remained down throughout the month. Efforts concentrated on inspection and restoration of the primary system following system decontamination. All spiral wound gaskets were replaced and other

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mechanical joints and valve packings were inspected on a sampling basis to assure against the presence of caustic. At restoration completion, the system was hydrostatically tested at 2060 psi.

Fuel element decontamination was completed and PRTR charging was underway at month end. All fuel elements were inspected for mechanical integrity before charging. One  $\text{UO}_2$  element was inspected in the fuel element examination facility. (This marked the initial operation of the facility with an irradiated element.) Overall, the fuel elements were found to be in satisfactory condition with the exception of a few pins which connect the fuel elements to their hangers. Some bending of pins was noted as well as loss of pin-retaining clips. All such fuel elements were either repaired before charging or were set aside for future repair and charging.

The PRTR's original primary system  $\text{D}_2\text{O}$ , which had a purity of ~94%, was replaced with 99.9%  $\text{D}_2\text{O}$ . Final purity after draining of demineralized  $\text{H}_2\text{O}$  was 99.7%. Total  $\text{D}_2\text{O}$  loss for the month was 552 pounds and helium losses were 57,500 scf. The primary system ion exchanger was replaced.

Several tests were conducted on the PRTR's light water injection system while  $\text{H}_2\text{O}$  was in the primary system. Adjustments were made to the diesel well pump, piping systems, and valve controls. Procedures were altered, as necessary, to assure adequate performance of the light water injection system.

The reactor charge included 27  $\text{UO}_2$ - $\text{PuO}_2$  fuel elements.

Considerable improvement was gained in operability of PRTR shim rods by replacing two units and making in-place repairs.

Status of shim rods (11-1-62):

- 6 units completely operable (both A&B rods)
- 5 units with "A" rod only, operable
- 1 unit with "B" rod only, operable
- 6 units completely inoperable

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Status after repair efforts (11-27-62):

- 12 units completely operable (both A&B rods)
- 3 units with "A" rod only, operable
- 2 units with "B" rod only, operable
- 1 unit completely inoperable

A total of nine units were repositioned in the reactor to provide the maximum effectiveness.

A re-examination of the formulation used to generate the PRTR Xenon Tables uncovered an error in the method used to derive the flux level from the tube power; and a re-evaluation of the xenon calculation was made. A comparison of the results from the existing xenon tables and from the revised calculation is made in Table I.

TABLE I

<u>Element</u>	<u>Power, Kw</u>	<u>Calculation</u>	<u>Equilibrium Poisoning, Xe (+ Rh)</u>	<u>Potential Poisoning, iodine</u>
UO <sub>2</sub>	880	Old	26.534 mk	113.560 mk
		New	24.602 mk	224.500 mk

The equilibrium poisoning listed as new includes both xenon and rhodium, the rhodium contributing 2.5% of the total. The very large increase in the potential poisoning due to iodine indicates that the peak poisoning of the transient following a scram from equilibrium will be almost a factor of two larger than had been estimated previously. Efforts were initiated to attempt comparison of the new calculation with the experimental results of Power Test 16.

Examination of autoradiographs, obtained from rods of typical mixed-oxide fuel elements, indicated plutonium agglomeration. An evaluation of the severity of heat output from these localized spots was started.

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The cell of the Plutonium Recycle Critical Facility was pressurized for the first time since completion of the architectural contract. After fixing numerous leaks, the leak rate was  $\sim 2000 \text{ ft}^3/\text{day}$  at a cell pressure of  $\sim 1$  psig. The first two drums of  $\text{D}_2\text{O}$  were added to the moderator system. System heel measurements and tank recalibrations were in progress at month end. The ion exchanger was deuterized and placed in service.

Work was completed on the PRCF safety rod housings to permit repair work without cell cover block removal.

Month end design test status for the Fuel Element Rupture Test Facility was as follows: electrical and instruments, complete; mechanical design testing, 25 % complete. During mechanical testing, pressure control valve RL-3 was accidentally closed during repair of its controller. The subsequent pressure increase (to about 2400 psig) caused a vent connection on the return pipe to the annex to fail. The pipe was replaced with heavier schedule pipe and additional investigation led to replacement of two other sections of piping. Investigation also detected a faulty valve; the valve was corrected.

At the end of this reporting period, the Gas Cooled Loop was 93% complete. The replacement heater installation for the Loop was completed during November except for electrical connections. All new Hastelloy X weld X-rays were acceptable and the heater and new piping were successfully subjected to a 550 psig pneumatic test.

Preliminary tests (in air) of the new Bristol-Siddeley polytetrafluoroethylene journal bearings for the Gas Cooled Loop were successful and in-loop tests were initiated.

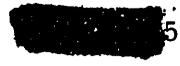
Technical Shops' total productive time for the period was 21,412 hours. This includes 16,831 hours performed in the Shops, 3963 hours assigned to Minor Construction, 500 hours assigned to off-site vendors, and 118 hours to other project shops. Total shop backlog is 19,483 hours, of which 70% is

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required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 6.0% (1133.3) of the total available hours.

Total productive time for Laboratory Maintenance realized was 15,300 of a possible 16,700 hours theoretically available. Of the total productive time realized 91% was expended for HLO components with the remaining 9% directed toward providing service for other HAPO organizations. Overtime worked during the month was 2.4% of total available hours.

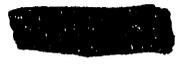
A revised Financial Plan was received from HOO-AEC which reflected increases in program funds as follows:

<u>Program</u>	<u>R &amp; D</u>	<u>Equipment</u>
04	\$642 000	\$213 000
05	82 000	5 000
08	100 000	--
Total	\$824 000	\$218 000

Two Ph.D. applicants visited HAPO for employment interviews. In the advanced degree program, one offer was extended; two acceptances and one rejection were received. Three offers are currently open.

Twenty-two program offers and two direct placement offers were extended. Offers rejected: one program and one direct placement. Current open offers: 26 program and three direct placement.

Three Technical Graduates were placed on permanent assignment. One new member was added to the roll. Current program members total 58.



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The Laboratory Storage Pool responsibilities have been expanded to provide all HAPO with instruments that are usable. This action is expected to expedite research programs by having additional usable instruments available and saving equipment funds.



Manager, Hanford Laboratories

HM Parker:JEB:dph

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATIONTECHNICAL ACTIVITIESA. FISSIONABLE MATERIALS - O2 PROGRAM1. Metallic Fuel Development

Fuel Irradiations. Warp data have been obtained on five N-inner fuel tubes (NIE's) irradiated to 3000 MWD/T. Residual single throw warp on the 24-inch long elements was small and varied from 0.005 to 0.012 inch. Additional metallographic examination of the Be-Zr brazed closures of these elements revealed no indications of poor closure performance. Post-irradiation hydrogen analysis of two cladding samples from one 3000 MWD/T exposure NIE averaged 25 ppm hydrogen; thus, the hydrogen content of the cladding remained essentially unchanged from the pre-irradiation value.

Automatic punch tape readout was installed on the K-East basin fuel element shape measuring equipment, and two N-outer fuel tubes recently discharged from KER Loop 4 after 1500 MWD/T exposure were measured. A comparison of the measurement chart records obtained before and after irradiation shows that irradiation produced only small shape changes in the fuel tubes and that the basin equipment faithfully records shape anomalies corresponding with those observed on the fuel before irradiation. Computer analysis of the measurement data will be initiated as soon as the computer program is modified to accept the tape output from the post-irradiation measurement equipment.

An experimental dual-enriched single-tube N-Reactor element failed during its fifth cycle of reactor operation in the ETR-M3 loop. The failure resulted from a cladding hot spot which developed in an area where warp of the element had restricted coolant flow. Warping of this test element had been observed in previous irradiation cycles as a result of the flux gradient which exists across the test facility. At the time of failure the reactor was operating at full power, but the loop was not yet at the desired 260 C operating temperature. The element had received a maximum exposure of about 900 MWD/T.

A second dual-enriched single tube element was charged into the M-3 test loop. It is operating at a peak power of 160 kw/ft.

Cold-water irradiations of three 18-inch long, fluted N-inner fuel tubes in KE Reactor was initiated. After these tubes have reached

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an exposure of 2000 MWD/T or more, they will be transferred to the ETR for high temperature irradiation. The swelling and irradiation behavior of these elements will be compared with that of a similar element now being irradiated in high temperature water in the ETR P-7 loop.

Hot-Headed Closure Studies. Attempts to utilize a series of multiple projection welds to produce a continuous weld in the regions between the end cap and the fuel element cladding have not been entirely successful. While continuous welds without voids have been made in small areas, it has not been possible to produce these results over the entire Zircaloy-to-Zircaloy faying surfaces.

In an attempt to combine projection welding and diffusion bonding in the Zircaloy-to-Zircaloy region, joints were made using 6-ring projection type caps. The recesses or depressions between the projections were plated with copper. Cross sections of two of these samples which had six projections showed complete bonding across the end cap. This bonding consisted of a combination of projection welds and diffusion bonds in the Zircaloy-to-Zircaloy regions and the Zircaloy-to-uranium regions. The small annular areas which had been void areas previously were now filled with a copper-Zircaloy alloy.

Currently, effort is being applied to 4-ring projection caps using the same techniques. The 4-ring projection type cap is simpler in design and should provide more uniform Cu-Zr bond areas.

Copper plating between the projections on hot-headed closures aids solid state diffusion for Zircaloy-to-Zircaloy and Zircaloy-to-uranium. Electroplating copper to the cap was not satisfactory due to variation in plating thickness adjacent to the masked off projections. Evaporative plating is desirable because a dense high integrity layer is readily formed. Evaporative plating equipment is not available at this time; therefore, displacement plating is being used. Displacement plated surfaces are uniform; however, they are porous and difficult to reproduce. Techniques are being developed to establish proper cap preparation, plating rates and short time storage methods prior to usage.

Self-Brazed Closures. Another group of five test elements (10 closures) was prepared for examination and testing of closure quality. Ultrasonic tests indicated sound bonds in all closures at the U/Zircaloy interface but gave indications of poor bonding at the cap/wall interfaces. Two of these apparently defective specimens were metallographically examined at progressively increasing depths below the cap face. No unbonded regions, voids, discontinuities, cracked

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bonds nor any defects were disclosed. Thus, it appears that the procedure for ultrasonic testing the U/Zircaloy bonds is not applicable for testing the cap-sidewall bonds. A possible reason is the fact that the crystal of the ultrasonic transducer spans the entire brazed annulus and covers the angular faces of the cap skirts, which may result in ultrasonic reflections similar to those excited by bond defects. Equipment is being constructed to concentrate the ultrasonic beam on the annular braze layer, thus avoiding any effect from the skirt angles.

A self-brazed closure specimen having the earlier V-type cap was machined on the end face until uranium was encountered in the annulus braze. The defected specimen was autoclaved and the hydrogen evolution rate monitored. After five hours at 300 C, 2000 psig, there was a sharp increase in evolution rate, indicating that rapid uranium corrosion was beginning. The autoclave was immediately shut down and the specimen removed and examined. A blister about 5/8-inch in diameter had formed in the sidewall beside and below the cap; the can wall was distorted and torn. However, the cap remained firmly in place and there was no evidence of undercutting in the bond layers. This behavior speaks well for the braze material and the integrity of the bonds formed.

N-Reactor Fuel Support Development. In the laboratory program to fabricate a demonstration quantity of N-inner supports, the equipment for forming the supports from sheet has been built and the procedure for making supports has been established. The procedure involves the following steps:

1. Slitting sheet at 200 C to form 1/4-inch strip.
2. Cutting and crowning blanks from the strip.
3. Hot forming supports.
4. Hot sizing by compression of support.
5. Trimming, dimpling, and final sizing.

Most of the plastic deformation which occurs during forming and initial sizing is accomplished at elevated temperature with the support heated momentarily by resistance heating. Temperatures of 600 C and greater may be employed with no significant surface oxidation or observable effect on the microstructure. The hot forming procedure allows for the production of supports from sheet stock having marginal bend ductility at room temperature.

The Zircaloy-2 sheet stock which is to be used for the initial production of a trial lot of N-inner supports is being fabricated in the laboratory by two procedures. In one procedure, sheet is rolled from

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extrusions in the form of bar or tubing and in the other procedure the sheet is fabricated from two-inch plate which is purchased off-site. Sufficient sheet for the production of about 5000 supports has been rolled from extruded tubing. However, flat extruded sheet bar is considered to be a better starting material for quantity production, and preparations are being made for producing  $4\frac{1}{2}$ -inch x 1 inch extrusions for this purpose. Approximately 100 pounds of two-inch plate formed by beta-forging and beta-rolling, obtained for use in this program, is of questionable quality because of possible phase segregation. Studies are being made to determine if suitable sheet can be rolled from this plate.

Hot rolled Zircaloy-2 rod,  $\frac{5}{8}$ -inch diameter, was hot swaged at 600 C to  $\frac{1}{4}$ -inch diameter. The  $\frac{1}{4}$ -inch rod was then cold swaged to  $\frac{9}{64}$ -inch diameter with immediate 600 C anneals. The resulting wire was then cold rolled to 0.035-inch x  $\frac{1}{4}$ -inch strip. The resulting strip was formable but showed a wide range of behavior when subjected to bend tests. Strip made from the same starting  $\frac{5}{8}$ -inch rod by a straight rolling procedure was unacceptable.

Fluted Single-Tube Fuel Element. Test elements embodying the fluted single-tube design concept for N-Reactor fuel are being fabricated for irradiation in the M-3 pressurized water loop in the ETR. The end closures on these elements employ a tapered fit between the Zircaloy-2 cap and uranium. The closure, coupled with the fluted geometry, presented problems in fit-up and brazing. However, the requirements for brazing were established, and the end caps on three elements were successfully brazed in place.

Fuel Element Straightening. Design of a hot warp measuring and straightening device for use in studying warp mechanisms is approximately 85 percent complete. The device will employ resistance heating for the fuel element. Resistance heating removes the problems associated with furnace heating and permits refinement of measuring techniques.

Cladding Deformation Studies. Fabrication of components for a second irradiation test of 125 fuel rods with non-uniform cladding thickness has continued. The filling of thirty-seven sample capsules with NaK has been completed and the capsules helium leak checked and x-rayed for NaK level. Four of the capsules were rejected because of errors in loading the proper amount of NaK. Welding spacer tubes to each of the capsules will complete these assemblies. The problem of sealing stainless steel thermocouples into the Zircaloy-2 capsules was solved, and five thermocouple capsules have been successfully assembled. Two of these capsules have been filled with NaK, helium leak checked, and x-rayed.

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Analysis of Fuel Element End Caps. The discontinuity between the fuel material and end cap material is a potential area for stress induced fuel element failure. One possible means of relieving some of the thermal expansion incompatibility is to shape the end cap. A method of analysis has been proposed, the equations programmed, and a sample calculation is being run to check out the method of analysis. Parametric studies of various shapes are planned.

Drawing Lubricant Studies. The asphalt base drawing lubricant developed by Metal Fabrication Development has been applied to the cold drawing of pure nickel, high nickel ferrous alloys and X-280 Hastelloy. In each case,  $\frac{1}{2}$ -inch diameter rods were cold drawn to  $\frac{1}{8}$ -inch diameter. The lubricant again performed successfully, producing material of high quality. The surface finish produced, while smooth, had a matte appearance. A mirror finish can be developed by removing the asphalt lubricant prior to final drawing and using a Hangsterfer's drawing oil. The latter lubricant provides inferior protection for the major reductions employed but does permit a burnishing action of the die on the wire for a single draw which can only occur when the lubricating film is extremely thin.

N-Reactor Process Tube Scratch Study. Recent full-length process tube charging tests have shown that some scratching of the autoclaved Zircaloy-2 N-Reactor process tubes will occur. A laboratory program has been initiated to study the cumulative effect of this damage as fuel supports repeatedly pass over scratched areas. The equipment for running these tests has been installed. With this equipment, fuel element supports are repeatedly pulled along an 8-foot section of process tube in such a manner that each support will travel approximately 60 feet along the same scratched area (eight passes per support). Appraisal of the process tube damage after 2000 support-passes should provide a reasonable approximation of the maximum damage which might be expected in the lifetime of an N-Reactor process tube.

## 2. Corrosion and Water Quality Studies

Erosion-Corrosion of Aluminum Alloys. Two aluminum alloys containing 10 percent Si, one percent Ni, and one containing 12 percent Si, one percent Ni, 0.8 percent Mg were compared to alloy X-8001 during corrosion tests in 300 Area tap water at 102 C and 76 ft/sec flow velocity. The amount of corrosion was nearly the same for each sample after 24 hours.

Another set of samples was prefilmed by autoclaving at 300 C in deionized water for five days. Each sample was then exposed to the

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high velocity test for 24 and 72 hours. Corrosion was negligible on prefilmed samples exposed for 24 hours. After 72 hours, break-through of the autoclaved film was observed on all samples except those containing 12 percent silicon. The reverse side of one such sample was then exposed for seven days with results nearly the same as those for 72-hour exposures on the other samples. The alloy containing 12 percent silicon, one percent nickel, and 0.8 percent magnesium formed a more erosion-corrosion-resistant autoclave film than the other alloys tested.

Behavior of Li-Al Alloy in 300 C pH 10 Water. In the low flow pH 10 water at 300 C, aluminum - 3.5 percent Li alloy failed catastrophically and was completely oxidized during a 24-hour exposure. Penetrations on 1245 and X-8001 alloy coupons in the same test were 1.6 and 0.8 mils, respectively.

Effect of Low Dichromate in pH 6.6 Process Water. Initial results from in-reactor testing at 100 C show that corrosion of X-8001 aluminum alloy and carbon steel are essentially the same in pH 6.6 water with 1.0 ppm dichromate as in pH 6.6 water with 1.8 ppm dichromate. However, 1100 aluminum alloy showed more corrosion in the water with 1.0 ppm dichromate than in the water with 1.8 ppm dichromate. These results indicate that corrosion of the fuel cladding (X-8001 aluminum) and effluent piping (carbon steel) would not be significantly affected by reducing dichromate concentration from 1.8 down to 1.0, but that corrosion of process tubes (1100 aluminum) might be slightly greater in the low-dichromate water.

Rates of uniform corrosion measured in this testing showed different behavior for the different aluminum alloys after three months of exposure in the test. Samples of X-8001 aluminum show an equilibrium corrosion rate of 0.3 mils/month in both types of water. Samples of 1100 aluminum, on the other hand, showed unexpectedly different equilibrium rates. In water with 1.8 ppm dichromate, the measured corrosion rate for 1100 aluminum was 0.5 mils/month, and was 0.75 mils/month in water with 1.0 ppm dichromate.

Low equilibrium corrosion rates were measured for two experimental aluminum alloys included in these tests. Both 288W and Alcoa 199116 aluminum alloys corroded at equilibrium rates of less than 0.25 mils/month in both the low-dichromate and high-dichromate waters. Initial penetration of both these alloys was 1.4 mils during the first month in both types of water.

Corrosion of Aluminum in Neutral Deionized Water. Relatively high corrosion was measured for aluminum samples exposed to neutral

deionized water at 97 C in the aluminum tube in facility SP-7. A total penetration ranging from 3.2 to 3.8 mils in 2½ months was measured for samples of aluminum alloys X-8001, 1100, 6061, X-8003, 288 W, and "KYZ". Comparable penetrations for most of these same alloys in treated natural water range from 0.5 to 2.5 mils.

Film colors on K4N test elements and coupon samples were noteworthy. Most K4N elements were covered with a very black film, as compared to the reddish-brown film common to elements exposed in process water. Some of the K4N elements from the deionized water exposure exhibited a mottled color pattern of distinct red and black. All of the spacer pieces and the coupon samples were covered with a loose red-orange film. Shiny metallic surfaces appeared underneath, but subsequent cleaning showed that considerable oxide was present on the samples.

Nucleate Boiling on Zircaloy Samples. The nucleate boiling test in TF-3 was terminated during the month and the Zr-2 clad heater rod was removed for inspection. Operating conditions during the test were maintained at 628 F and 2000 psia using lithiated water adjusted to a pH of 10.0. The initial temperature of the etched Zr-2 surface was 635 F at the operating heat flux of 280,000 Btu/hr-ft<sup>2</sup> and the  $\Delta T$  across the water film and cladding was 8 F.

Examination of the heater showed moderate crud deposition in the region of heat transfer; however, flow effects had kept one side of the heater fairly free of film. The cladding thermocouple was located on the film-free side of the heater and, consequently, the  $\Delta T$  observed was probably not the maximum obtained. A 304 S/S band had been used to fasten the cladding thermocouple and surface thermocouple to the heater and to provide a crevice for corrosion studies. When this band was removed, an area of extensive corrosion (5-10 mils deep) was observed on the Zr-2. A white deposit was present which was identified as ZrO<sub>2</sub>. A black deposit was also present, but identification has not as yet been made. The 304 S/S band also showed several mils penetration. No LiOH was found as such; however, a pH test of the corroded area showed it to be quite caustic. Thorough metallurgical examination is being made on the heater in this region as well as areas where normal corrosion was found.

Ex-Reactor Corrosion Rates in Water at pH 10 (NH<sub>4</sub>OH). A test to determine the corrosion rates of A212 carbon steel, 304 stainless steel, and Zr-2 in 300 C deionized water with pH adjusted to 10.0 with ammonium hydroxide has been completed in TF-1. The initial penetrations were 0.055 mil and 0.01 mil for the carbon steel and stainless steel, respectively. The uniform rates for both alloys

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were 0.06 mil/year. Localized corrosion did not occur. These rates are comparable to rates obtained using LiOH for pH control. The corrosion rate of the Zr-2 was less than 0.02 mil/year.

Samples of A212 carbon steel which had been previously exposed to six cyclic decontaminations (one week exposures to 300 C, pH 10 water followed by a two-step decontamination consisting of alkaline-permanganate followed by Wyandotte-5061) were tested for 2000 hours in 300 C, pH 10 (NH<sub>4</sub>OH) water to determine if the corrosion rate would return to a normal carbon steel rate typical of water exposure or if the rate would continue at an accelerated amount due to the decontaminations. The results indicate that the corrosion rates return to their normal predecontamination values.

Reactor Decontamination After Rupture. Laboratory evaluations are progressing with several solutions for uranium dissolution. Two of the solutions are capable of oxidizing a large quantity of uranium, upwards of 50 grams/liter, but form a precipitate of uranyl acetate and uranyl oxalate. The uranyl acetate precipitates only upon cooling, however. The uranyl oxalate is soluble under alkaline conditions.

Presently the temperatures have been specified as 80 C for the use of the oxalic-peroxide-peracetic and the oxalic-peroxide-gluconic solutions. This temperature can be lowered to 40 C to facilitate handling and to decrease the corrosion of metals such as brass alloys. Further determinations are under way, and analytical procedures for analysis of the remaining peroxide and oxalate ion are being devised.

Instrumentation in NPR. The Hays dissolved oxygen analyzer was installed in an IPD test loop in 189-D Building to provide information for the operators on the coolant oxygen concentration and to obtain information on the analyzer operating characteristics in solutions containing both oxygen and hydrazine. This information is needed since analyzers of this type are scheduled for use in the NPR secondary coolant system which will be operating under these conditions. The results obtained demonstrate that the analyzer can be operated successfully in this application; however, calibration of the analyzer is affected by the presence of the hydrazine. Quantitative measurement of this effect has not been accomplished to date.

The analyzer will be removed from this facility in the near future and will be used to evaluate the hydrazine interference reaction under laboratory conditions.

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KER-1 Startup. The KER-1 Loop is scheduled to start up again during the first part of January. The first series of tests will be designed to evaluate use of  $\text{NH}_4\text{OH}$  to regulate pH in NPR. After the initial magnetite film is formed, the loop will be cleaned and ammonia will be used to regulate pH. Thermocouple slugs will be used to determine rate of crud build-up on the fuel elements.

Different designs are being considered for the thermocouple slugs. In one design, a PuAl alloy will be encased in a stainless steel sleeve and clad in Zircaloy. It may also be desirable to include heat-generating elements other than fuel elements to obtain additional information, especially about the effects of flux fields on film deposition.

### 3. Gas Atmosphere Studies

Graphite Burnout Monitoring. Burnout-monitoring samples in channel 3478 at D-Reactor from July 10, 1962 to October 22, 1962, were measured. Results were indicative of high upstream oxidation rates. A graph of the rate vs distance from the front face of the graphite stack showed a sharp peak of about 45%/KOD at 80 inches and a lower peak of about 4%/KOD at 168 inches. The high peak is attributed to oxygen, the low peak to water or carbon dioxide. From early August to the time of discharge there were 12 shutdowns, thereby increasing the probability of operation at oxygen concentrations above the normal limit of 0.02 percent. Also, during part of this period, the reactor was operated in a "wet" condition.

Rates were measured for monitors from channel 3066 at KE-Reactor. The period covered was from September 27 to October 31, 1962. The burnout rate profile showed a very sharp peak of approximately 33%/KOD at 80 inches. In the region from 130 to 300 inches the burnout rates were below 2%/KOD.

Early in July carbon dioxide in the gas atmosphere at KW-Reactor was replaced by nitrogen. At this same time new graphite monitors were placed in channel 1880. Half the monitors were exposed directly to the reactor gas, whereas the other half were shielded by a 3/8-inch wall of graphite. On October 13, 1962, they were discharged and measured. Results from the unshielded monitors showed a peak of about 11%/KOD at 80 inches, and a second peak of 2 to 4%/KOD at 160 inches. The high peak was due to reaction with oxygen, whereas the peak nearer the center line was most probably due to water vapor. However, the possibility cannot be dismissed that carbon dioxide, at least in part, was the oxidant.

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A profile of the shielded monitors showed a flattened curve, gradually rising to 0.6%/KOD at 180 inches. This observation confirms once again that the burnout by oxygen as measured by the monitors occurs predominantly on the surface. Measurements over the past year show burnout rates of the shielded monitors about one order of magnitude lower than the unshielded ones. However, in the case of reaction of graphite with carbon dioxide (carbon dioxide and water), the rates from the two types of monitors are closer together. In order to increase unshielded monitoring in the upstream region, the use of shielded monitors will be confined to around the center line.

In the September 1962 Monthly Report, it was stated that F-Reactor operates wetter than B-Reactor but has a lower burnout rate. It was therefore suggested that the burnout peak located at 140 inches in B-Reactor was probably not due to oxidation by water. However, data show that less water has actually been collected from F-Reactor than from B-Reactor during the past two to three years. If this is used as a measure of water concentration in the gas phase, the water-graphite reaction cannot be excluded at this time as a cause of the burnout in B-Reactor.

#### 4. Process Tube Development

Properties of Irradiated Zr Tubing. Three additional specimens from the KER-3 process tube have been transferred to Radiometallurgy and positively identified. One specimen is from the reactor shielding area. The other two compare in total exposure to the moderate and high exposure samples described in the preliminary report on evaluation of KER-3 (HW-75052). Specimens are in preparation for burst testing at 550 F and for tensile testing over a range of temperatures to 650 F.

Tensile Testing of Zr Tubing. A new test specimen design has been proposed and tentatively accepted for tensile test specimens cut from tubing. This design relates all dimensions of the specimen to the wall thickness of the tubing. In this manner the ratios of gage length, width, and thickness are standardized for all types of tubing. This is expected to provide a more valid comparison of test results, particularly as related to elongation.

Stress Rupture of Reactor Pressure Tubes. An extensometer is under development to measure circumferential strain of tube specimens in elevated temperature stress-rupture tests. It provides for remote read-out without test shutdown. The extensometer incorporates a wrap around chain connected to a pressure sensitive transducer.

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Testing of two extensometers of this type began in October 1962. After 34 days, one extensometer failed due to a short in the transducer. The other extensometer, attached to a different tube test with a faster rate of creep, has now operated for 27 days at 575 F. In the first 14 days of this test the transducer indicated 0.0142 inch of creep deformation. A mechanical device indicated 0.0145 inch of deformation. The last 13 days have shown a 0.005 inch difference between the two methods of measuring. This is believed to be caused by misadjustment of the extensometer after shutdown and startup of the test. The extensometer has been re-adjusted, and further testing is in progress.

5. Thermal Hydraulic Studies

NPR Boiling Burnout Studies. Thirteen additional boiling burnout conditions were determined using a horizontal 32-inch long electrically heated test section simulating the inner flow annulus of the NPR fuel element. The inner tube was placed eccentrically within the outer tube so that the minimum dimension produced would be comparable to that occurring in an actual fuel element if the inner fuel tube supports sheared off leaving the weld tabs intact (0.050 inch). Boiling burnout heat fluxes were determined for mass velocities ranging from  $0.4 \times 10^6$  to  $4 \times 10^6$  lb/hr/ft<sup>2</sup> at a pressure of 1515 psia. The location of the burnout was found in these experiments to be equally distributed between the inner and outer tubes and generally occurred within two inches of the downstream end of the heated length. Comparisons of the present data to earlier data obtained with a concentric test section of similar geometry demonstrated that the eccentric placement of the inner tube of this fuel geometry toward the bottom of the outer tube will cause a decrease in the burnout heat flux of about 40 to 50 percent in the range of mass velocities between  $1 \times 10^6$  lb/hr/ft<sup>2</sup>. At lower mass velocities, the eccentric placement was observed to increase the burnout heat flux somewhat rather than to decrease it. The eccentric placement of the inner tube toward the bottom of the outer tube possibly offset the effects of stratification usually present at these low flow rates by providing a larger flow passage at the top of the annulus and thus resulted in the increase of the burnout heat flux over the concentric case.

Visual Studies of the Effects of Fuel Supports on Boiling. Laboratory experiments were continued in the visual and photographic study of boiling heat transfer anomalies caused by the presence of various devices employed to center the fuel elements in the process tubes of the Hanford production reactors. The test section consisted of a 24-inch long, 1.304-inch OD electrically heated tube placed with 75%

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eccentricity\* within a 1.504 ID glass tube. Two different types of centering devices were tested. The first type was the conventional BDF reactor rail type bumpers ground down from the normal 0.040-inch height to 0.024 inch. The second type was an elliptical shaped bumper, 1 inch long, 0.2 inch wide and 0.024 inch high. These will be referred to as type 1 and type 2, respectively.

The experiments were run with coolant flow rates of 32.4 gpm and 18.6 gpm which corresponded to reactor central zone and fringe zone flows, respectively. The heat generation in the test section was increased in steps and visual examination and high speed photographs were made of the observable boiling characteristics of each type of fuel support. The results of this series of experiments are summarized in the following table.

Run No.	Conditions	Heat Flux B/hr/ft <sup>2</sup>	Comments
46	Central Zone Flow Rate 75% eccentricity	0.2 x 10 <sup>6</sup>	Localized surface boiling starting at downstream end of heated section.
		0.33 x 10 <sup>6</sup>	Stream of bubbles issuing from type 1 supports 5-3/4" and 14-3/4" from downstream end. No boiling at any type 2 supports.
		0.357 x 10 <sup>6</sup>	Stream of bubbles issuing from type 2 support 18-5/8" from downstream end. Other boiling behavior unchanged.
		0.408 x 10 <sup>6</sup>	Stream of bubbles started to emerge from type 2 supports 9-5/8" from downstream end and at the downstream end. Vigorous boiling under type 1 support 5-3/4" from downstream end.
		0.433 x 10 <sup>6</sup>	Violent boiling under type 1 support 5-3/4" from downstream end. High noise level due to collapse of vapor voids.

\*Percent eccentricity is defined as the percentage of the nominal annulus thickness that the central heated tube is displaced from the normal central position.

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These data supported earlier conclusions that the use of the elliptical shaped supporting devices result in less vapor generation than the BDF rail type supports.

The supports were removed from the heated length and the rod was installed in the glass tube with 100% eccentricity. With the heated rod in this position, the cross-section geometry approximated that which would be encountered in a reactor if the fuel element supports were missing. Visual and photographic examinations of the boiling phenomenon were made with the flow rate equal to that of a central zone BDF process tube. At a heat flux of  $0.03 \times 10^6$  B/hr/ft<sup>2</sup>, a large "dry" area appeared on the line of contact between the heated test section and the glass tube. As the heat flux was increased, the dry area was seen to increase somewhat. At a heat flux of  $0.246 \times 10^6$  B/hr/ft<sup>2</sup>, the test section was destroyed by overheating.

Effectiveness of Process Tube Flow Mixers. Experiments were conducted to determine the effectiveness of various types of water mixers for use in the present Hanford reactors and to determine the effects of these mixers on fuel column pressure drop and on the ratio of the annulus flow to that of the central hole. The function of these mixers is to minimize the radial temperature discrepancies in the reactor coolant channels resulting from an unbalance in the coolant flow areas and the heat transfer areas and to minimize circumferential temperature discrepancies resulting from eccentric fuel placement in the process tube. By equalizing the coolant temperatures across the coolant passage cross-section, fuel cladding and process tube corrosion can be alleviated.

The experimental results demonstrated that a two-inch long water mixer can reduce cross-section coolant temperature discrepancies by 50 to 70 percent. A special experimental spiral vane mixer showed a slightly greater mixing effectiveness than the mixer which is presently in-reactor. The use of one mixer in a process channel will, however, increase the total pressure drop across the fuel charge from 6.5 to 13 psi at typical reactor flow rates. Both the presently used-type of flow mixer and the special spiral type caused an increase of about 5 percent in the annulus-to-hole flow ratio.

Heat Transfer Equipment. A special preheater was installed in the 189-D Heat Transfer Laboratory to supply high quality steam-water mixtures to the inlet of test sections in the high pressure heat transfer apparatus. This preheater was designed to deliver 1200 Kw of heat when connected to the motor generators and is capable of operation at pressures up to 2000 psig. This equipment will allow

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examination of heat transfer processes for reactor fuel elements at conditions not previously possible in the laboratory.

B. WEAPONS - O3 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 - 04 PROGRAM****1. Plutonium Recycle Program  
Fuels Development**

PRTR Fuel Fabrication. Three, swage compacted, 19-rod clusters and four, vibratory compacted clusters were assembled for charging in the PRTR. Fabrication of more PRTR fuel elements was started with the objective of maintaining a work-in-process inventory in approximate relation to the anticipated fuel requirements of the PRTR.

PRTR Fuel Element Decontamination. The PRTR fuel element decontamination facility was found capable of a decontamination factor of two when trace quantities of contaminant are present on fuel element surfaces. A 19-rod cluster PRTR fuel element was purposely contaminated by pumping a slurry consisting of approximately two grams of MgO-0.21 w/o UO<sub>2</sub> in 40 gallons of water past the element for two hours. A total of 18 micrograms of UO<sub>2</sub> was deposited on the fuel element surfaces (including end fittings, wire wrap spacers, etc.). Approximately 50 percent of the UO<sub>2</sub> was removed by normal processing in the decontamination facility.

Irradiation of UO<sub>2</sub>-PuO<sub>2</sub> Mixtures. A capsule (GEH-14-85) which originally contained UO<sub>2</sub>-2.57 m/o PuO<sub>2</sub> was successfully irradiated to a burnup of 1.16 a/o, as determined by mass spectrometric analyses of the fuel. During irradiation, the fuel released 30% of the krypton and 31% of the xenon formed.

Ceramographic examination of a capsule (GEH-14-86) which initially contained UO<sub>2</sub>-4.13 m/o PuO<sub>2</sub> revealed a central region of equiaxed grains surrounded by a region of columnar grains. An autoradiograph of the transverse cross section showed a marked depletion of fission products in the central region. During its last cycle of irradiation, this capsule was inadvertently subjected to a neutron flux about twice that which it experienced during previous irradiation cycles.

The scheduled 15-minute irradiation of a capsule (GEH-21-15) containing UO<sub>2</sub> (1.00 m/o U-235) plus 0.154 m/o PuO<sub>2</sub> was successfully completed in the MTR Hydraulic Rabbit Facility. This capsule, the third in a series, operated with a heat generation rate of 20 kw per foot. The fourth capsule (GEH-21-16) in the series will be irradiated for 60 minutes with a similar heat rating.

Irradiation of ZrO<sub>2</sub>-PuO<sub>2</sub> Capsules. Microstructural features different than those normally observed in irradiated ceramic fuels were found during ceramographic examination of four capsules containing ZrO<sub>2</sub>-10.4 w/o PuO<sub>2</sub> (solid-solution sintered pellets). Five

distinct microstructural zones were observed. The second zone from the cladding was unique in that it appeared white. The width of this band increased with increasing exposure and/or temperature. The innermost (or, in some cases, the next to innermost) zone was essentially free of voids and had no apparent grain structure.

These Zircaloy-clad capsules were irradiated to exposures of from  $0.5 \times 10^{20}$  to  $1.0 \times 10^{20}$  fissions/cc and operated with calculated center temperatures of 1650 and 2760 C.

Examination of the MgO-PuO<sub>2</sub> PRTR Element. Radiometallurgical examination of the MgO-PuO<sub>2</sub> element which ruptured in the PRTR is continuing. Corrosion and hydriding of the Zircaloy cladding, similar to that seen in the rupture area, occurred in regions of the fuel rod away from the rupture zone. Examination of one of the fuel core regions which had a high concentration of PuO<sub>2</sub> revealed that localized temperatures were sufficiently high to cause columnar grain growth and central void formation.

"Phoenix Fuel" Experiment. Investigation of the effect of burnup on the reactivity of high exposure plutonium is continuing. The Al-Pu capsule which initially contained 6.25 percent Pu-240 in Pu is being irradiated for its seventh and last cycle. The sample containing 16.33% Pu-240 in Pu completed six cycles of irradiation, and dynamic reactivity measurements are being made. A capsule containing 27.17% Pu-240 in Pu was irradiated for seven cycles and is now cooling prior to making reactivity measurements.

Burst Tests of Cold Swaged PRTR Fuel Rods. Pressures of 7820 and 7880 psi were required to burst two, one-foot long sections of cold swaged PRTR fuel rod at 550 C. These pressures are considerably greater than the maximum internal pressure of fission gas (approximately 2500 psi) calculated for a PRTR fuel rod irradiated to 10,000 MWD/T.

These tests, which simulated PRTR fuel element cladding temperatures, showed that the limiting stress conditions that might be caused by internal gas pressure or waterlogging can be calculated more closely from the tensile strength than from the yield strength.

There was no evidence that failure was induced by roughening of the internal cladding surface during swaging. Heat affected zones adjacent to the welds bulged before ductile failure.

Leak Tests on Autoclaved, Swaged UO<sub>2</sub> Fuel Rods. Recent studies at GE-AP&D have suggested that defects may appear in swaged UO<sub>2</sub> fuel rods during autoclaving. Because swaged fuel rods are not normally leak tested at Hanford after autoclaving, 57 such rods were subjected to an extensive series of post-autoclave leak tests. No defects were detected in any of the rods.

Remote Fabrication for Recycled Fuel. The remote fabrication pit has been converted into a dual purpose facility. One-half was enclosed in a steel shell in which two remotely controlled manipulators are to be installed. This enclosure has been connected to the building exhaust system so all UO<sub>2</sub> fabrication work will be isolated by a negative air differential. The other half of the area can still be used for non-radioactive compaction studies.

A fuel element support and positioning mechanism for the remote fabrication cell was assembled. This device will hold and align, in a vertical position, the two sizes of tubing of the eight-foot long nested tubular fuel element as closure welds are made. This is the last piece of equipment required to make experimental welds on a remotely fabricated fuel element.

High Energy Impaction of Plutonium-Bearing Fuels. The model 1200 Dynapak has been installed in the 308 Building where it will be used to process plutonium-bearing materials. A secondary containment type of hood is planned to expedite experimental use of the machine.

Fuel for Interchange Between Fast and Thermal Reactors. A dummy Fermi blanket fuel element assembly and detailed drawings of this fuel element were received from AP&D. The drawings will be used to complete the design of a fuel element which will operate in both the Fermi and Plutonium Recycle Test Reactor. The dummy assembly will be modified and used as a flow test model of the proposed interchangeable element.

EBWR Plutonium Fuel Loading. A meeting was held at Argonne National Laboratory to resolve basic criteria for the EBWR plutonium fuel loading. A decision was reached to use a 6x6 geometry of fuel rods per fuel assembly with a 6x6 array of fuel assemblies in the central core region. A total of 42 assemblies will be fabricated by vibrational compaction for the first loading. These will be Zircaloy-clad, 48 inches long, and contain depleted uranium with 2 - 3% plutonium enrichment (8% Pu-240).

Corrosion and Water Quality Studies

Fretting Corrosion of Zircaloy-2. A PRTR Zr-2 clad 19-rod UO<sub>2</sub> fuel element with clip-on wear pads to provide additional support contact area between the fuel element and process tube was tested for two weeks in flowing water at PRTR primary system conditions in an ex-reactor loop. External vibration (80 cps) was imposed to increase the severity of service conditions and thereby permit an accelerated determination of the effects of the increased support area on fretting corrosion. After one week exposure the oxide was found to be partially fretted off the supports on one side of the fuel element, but corresponding pits in the Zr-2 process tube were less than one mil deep. Fortunately, a splendid control specimen was present; on the side of the element opposite to the support fretting (180° away) one of the rod wire wraps was found to have been in contact with the process tube, and here fretting corrosion had penetrated the process tube to a depth of 3-4 mils and had removed up to 50% of the wire diameter at one location. No fretting was found between the wire wrap and the fuel element cladding. Examination at the end of the second week of exposure showed no additional fretting on the wire wrap and some color change but no measurable wear at wear pad-process tube contact areas.

Decontamination of PRTR. The results of the PRTR decontamination operation are being evaluated. No excessive corrosion of any part of the reactor has been noted except for some snap rings on the nozzle cap spiders which were identified as carbon steel rather than 400 series stainless, and consequently suffered considerable corrosion. The uniform corrosion rates of stainless steel, Zircaloy, and Stellite were very low; carbon steel coupons corroded about 5 mils during the decontamination. The activities at practically all points were satisfactorily low. The metal surfaces were bright and shiny. From measurements of residual plutonium on PRTR surfaces, it is estimated that over 99% of the plutonium was removed.

Corrosion damage and retention of chemical decontaminants in the spiral stainless steel-asbestos process tube gaskets were of particular interest. Examination showed that corrosion or leaching of the asbestos fibers was slight.

The amount of residual decontaminant present in the gaskets was approximated by leaching one-half of a disassembled gasket in 50 ml of boiling deionized water, filtering and analyzing the filtrate for sodium. Excluding blanks, 21 gaskets were examined

and found to contain between 0.3 and 2.0 mg of sodium ions per gasket. Blank corrections were very small. The only known access to sodium ions was from the chemical decontaminants. The several gaskets that were tested all showed a basic reaction to pH paper. All the stainless steel-asbestos gaskets have been replaced.

Aluminum Corrosion in PRTR. A 6061-T6 aluminum alloy tubing which carried a moderate flow of high purity deuterium oxide to a shim well of the calandria failed. Metallurgical examination of the failed one-fourth inch OD tubing revealed an intergranular corrosion which penetrated the tube from the exterior. Several other spots of mild intergranular attack were observed close to the break. The exterior of this tubing near the point of failure is exposed to stagnant D<sub>2</sub>O which may be contaminated with small amounts of dissolved gases such as helium, nitrogen oxides, hydrogen and oxygen. It was also saturated with steel corrosion products. The point of failure was close to a 300 series stainless steel sleeve to which it was galvanically coupled. During at least part of its operating life it was exposed to a helium atmosphere with minor contaminants. Service history indicates a maximum temperature of about 70 C.

Quantitative Oxide Removal From Ferrous and Nickel Base Alloys.

Corrosion samples exposed to high temperature water and superheated steam environments are difficult to evaluate because oxide losses during testing invalidate weight gain measurements. To determine the actual corrosion, the oxide must be quantitatively removed to allow an accurate weight loss measurement of the base metal. Oxide films formed during exposure to water or steam up to temperatures of 400 C are readily removed. Removal of oxides formed during exposure to 550 C steam has been much less successful.

A stripping procedure originated by Haynes Stellite Company appears to be very promising. The specimen is made the cathode of an electrolytic cell in which the electrolyte is molten (1050 F) 60 w/o sodium hydroxide, 40 w/o sodium carbonate. Nickel base alloys (Inconel "X", Hastelloy "N", and PDRL-102) were completely cleaned in less than five minutes using a current density of approximately 75 amps/dm<sup>2</sup>. Samples of Fe, Cr, Al alloys were also tested and completely cleaned in 30 seconds or less at a current density of 14 amps/dm<sup>2</sup>.

### Reactor Components Development

Second Generation Mechanical Shim Rod for PRTR. Detailed design, fabrication and procurement of components for the second generation rod were resumed. Efforts to procure the desired type limit switches have been unsuccessful thus far.

EDEL-I Renovation. The leak problem associated with the deionized water piping system has been solved by using approximately three wraps of teflon tape on the stainless steel threaded pipe rather than a single wrap previously used. About 90% of the leaking joints have been repaired. Modifications to the pressure piping will be resumed when rework of the deionized water piping is finished. The 12 gph injection pump and its concrete pad have been removed in preparation for the installation of the new Milton Roy injection pump.

Considerable effort was expended during the month in reviewing and filing loop fabrication and procurement records as part of the Code review of EDO piping systems.

Fretting Corrosion Investigation. Difficulty has been experienced in procuring satisfactory vibration pickups and vibration analyzing instrumentation within allowable funds. Bids received thus far have either been for unsatisfactory equipment or for equipment which exceeds the need. An attempt will be made to negotiate a contract with the low bidder for equipment which meets specifications.

Pressure Tube Inlet Gas Seals. The final report (HW-75425) covering the testing work on improved inlet gas seals was completed.

PRTR Gas Loop Components. Fabrication of the test section nozzle caps was completed. Seal drawings are currently being "as built".

Pressure Tube Monitoring. Eight PRTR Zircaloy-2 pressure tubes, including the tube in which the MgO-PuO<sub>2</sub> fuel element ruptured, were visually inspected and inside diameters and gas gaps were measured. Three fretting/wear corrosion marks less than one mil deep caused by fuel rod wire wraps were found in the general vicinity of the rupture. No discoloration, staining or marking of the tube wall was noted in the vicinity of the rupture; however, the tube was removed to determine if any hydriding of the tube was caused by the rupture. New shallow fretting/wear corrosion marks (less than one mil deep) were found at contact points with the end brackets of four tubes. There was no increase in inside tube diameters indicating no measurable creep, and no gas gaps less than 110 mils were found in any of the tubes.

Base measurements of inside diameters and gas gaps for future comparisons were also made on three tubes, one replacing the one in which the fuel element ruptured and two others which had nozzle bolting flanges replaced.

Pressure Tube Monitoring Equipment. The protective sheath tube on the M-2 borescope presently used for visual inspection of the PRTR pressure tubes has been rebuilt. Incorporated into the design are a sturdier light mount, a new dial gage arrangement for measuring depths of fretting corrosion and mechanical damage marks, provisions for drying the tubes, and easier maintenance. Check-out tests have begun on the new design features.

Testing has begun on the Mark III monitoring equipment which combines visual and instrument inspection functions in a single probe. Tests on the ID measuring gage showed that tube diameters can be reproducibly measured to  $\pm 1/2$  mil. To provide adequate water tightness and easier maintenance, a new gas gap gage body has been fabricated. Tests of the new gas gap gage showed that gas gap measurements are reproducible to  $\pm 5$  mils. To avoid overheating of the borescope lense and provide a suitable mounting base for the fretting corrosion measuring gage, a new light mount has been fabricated and is now ready for testing.

A radiation resistant television camera vidicon tube was successfully subjected to  $10^9$  Roentgen of gamma irradiation with no degradation of the television picture obtained. This is the first vidicon tube known to have received this amount of radiation with no effect on picture quality. The tube is being returned to the manufacturer for further electronic evaluation.

#### Hazards Analysis

Convection Cooling. Fuel element cooling following a total electric power failure has been re-examined in light of recent primary system pressure drop measurements. Calculations indicate that adequate fuel element cooling can be maintained following loss of electric power as follows:

1. Primary coolant pump flywheel run down provides forced circulation of the coolant for 2 to 4 minutes.
2. Liquid thermal convection circulation starts.
3. In the event of vapor blockage or an insufficient flow rate of coolant by thermal convection circulation, boiling

starts in the pressure tubes. The onset of boiling results in the expulsion of 80-100 cu ft of primary coolant from the system through the safety relief valves. The loss of primary coolant and contraction in cooling to ambient temperatures lowers the liquid level in the pressure tubes to a point  $1\frac{1}{2}$  to 2 feet above the top of the fuel elements.

4. Boiling circulation with condensation in the steam generator continues to cool the fuel elements.
5. The primary coolant system is depressurized by cool-down and an adequate inventory of water can be maintained in the primary coolant system by continued condensation in the steam generator or injecting well water from the diesel driven well pump as needed.

To insure that the fuel elements are covered with coolant at all times, a reactor core liquid level indicating instrument is required.

Plutonium Recycle Critical Facility. Since it is planned at the conclusion of the PRCF startup tests to conduct a series of tests using light water moderation, safeguards studies of these tests have been started. The mathematical model for a plutonium-aluminum core with light water has been formulated for the analog study of reactor transients.

All of the process specifications needed for PRCF startup tests have been issued for acceptance and approval. Eight of the 19 specifications have been approved.

## 2. Plutonium Ceramic Fuel Research

ThO<sub>2</sub>-PuO<sub>2</sub> Sintered Compacts. The sintered density of ThO<sub>2</sub>-PuO<sub>2</sub> mixtures increases linearly with increasing PuO<sub>2</sub> content between 2 w/o PuO<sub>2</sub> and 15 w/o PuO<sub>2</sub> (the range of compositions investigated to date).

PuO<sub>2</sub>-Carbon Reactions. Four samples of varying carbon to PuO<sub>2</sub> content were prepared by mixing the two materials in the powder form and then pressing into pellets. The PuO<sub>2</sub> was the product of plutonium oxalate which had been calcined at 950 C; the carbon was spectrographic grade graphite. Each sample contained 5 grams of PuO<sub>2</sub> and was mixed with carbon as indicated below.

<u>Sample</u>	<u>Grams Carbon</u>	<u>Desired Product</u>
1	0.0975	PuO <sub>1.56</sub>
2	0.0842	PuO <sub>1.62</sub>
3	0.0665	PuO <sub>1.70</sub>
4	0.0620	PuO <sub>1.72</sub>

After firing at about 1400 C for six hours in a helium atmosphere, the samples were analyzed for carbon content. In each case it was found that the reaction had only reached between 40 and 45% completion.

PuO<sub>2</sub>-MgO Phase Studies. Investigation of the solid phase relationships in the PuO<sub>2</sub>-MgO was started. The PuO<sub>2</sub> was obtained by 500 C calcination of plutonium oxalate. Seventeen different compositions between the limits of the pure components were blended, pressed into pellets, and sintered in helium at 1600 C for 20 hours. No significant correlation was found between the pellet green densities, averaging 57% of theoretical and the sintered densities, averaging 94% of theoretical. It was also observed that sinterability was independent of composition.

Sintered pellets were crushed in an atmosphere of nitrogen and the -325 mesh fraction was used for x-ray diffraction analyses. Preliminary results showed neither solid solubility between the two phases nor compound formation in the region between PuO<sub>2</sub> and PuO<sub>2</sub>-60 m/o MgO. There is, however, evidence of reduction of the PuO<sub>2</sub>. In the PuO<sub>2</sub>-rich region, alpha Pu<sub>2</sub>O<sub>3</sub> was detected in addition to the two major constituents, PuO<sub>2</sub> and MgO.

### 3. Ceramic (Uranium) Fuel Research

High Temperature Stoichiometry of UO<sub>2</sub>. The existence of a stable UO<sub>2-x</sub> phase at high temperature is one possible explanation for the appearance of metallic uranium inclusions often found dispersed in UO<sub>2</sub> cooled from near the melting point. Uranium dioxide heated to 3100 C in closed tungsten vessels, then quenched, was examined to determine if evidence of the UO<sub>2-x</sub> phase could be obtained. The heating cycle involved four minute holds at temperatures of 1300, 1500, 2000, 2500, 2600, 2700, 2800, 2900, 3000, and 3100 C followed by cooling to room temperature in less than one minute.

The starting material was single phase UO<sub>2.00</sub> single crystals with a lattice parameter of 5.4690 ± 0.0005 Å. After heating, the UO<sub>2</sub> was still single phase and no change in lattice parameter occurred. A probable explanation for this negative result is that uranium inclusions only form when a sink for oxygen is present.

No detectable reaction between the tungsten containers and the  $UO_2$  occurred.

Hardness of  $UO_2$  Single Crystals. The micro-indentation hardness of single crystal was determined as a function of crystal direction. The measurements were made at various orientations of a Knoop indenter on a crystal surface. Knoop hardness of a (100) plane of  $UO_2$  indicated four maxima per  $360^\circ$  rotation. The average variation in hardness between the maxima and minima was about 7.5% (at 100-gram load). The presence of four maxima is consistent with the crystallographic symmetry of the (100) plane.

Basic Materials for Research. Single crystal  $UO_2$  spheres are being prepared for Euratom use in fundamental studies. The Hahn-Meitner Institute has requested 50 specimens having a diameter from 1 to 5 mm. The Commissariat a l'Energie Atomique (CEA) requires 56  $UO_2$  crystals for fission product diffusion studies over a wide range to temperature. Euratom has also requested a 20-40 pound supply of high energy impact formed  $UO_2$  for fabrication tests and fission gas diffusion measurements. Such measurements will provide the U.S. with urgently needed information.

Ten one-gram spheres of  $UO_2$  single crystals were prepared for the NBS to use in studies of noble gas solubility and diffusion in  $UO_2$ .

Fabrication of Cermets. A high rate densification technique for fabricating cermet specimens, which was reported previously, was used to prepare enriched  $UO_2$ -tungsten samples for irradiation testing. The technique was evaluated for use with other materials by fabricating cermets containing 65 v/o  $UO_2$  in molybdenum, stainless steel, and nickel-chromium alloy. Densities of 97.6, 97.9 and 95.8% of theoretical, respectively, were obtained.

Irradiation of Cermets. A 66 v/o  $UO_2$ -tungsten cermet capsule was irradiated for one hour at Hanford under conditions chosen to give a surface temperature of 2300 C. It was verified that a temperature greater than 2100 C was achieved by comparing the microstructure of the irradiated sample with microstructures of other samples heated out-of-reactor. During irradiation the tungsten matrix (continuous phase) sintered to form a high integrity barrier to gross relocation of  $UO_2$  and fission products. Uranium dioxide sublimed from a thin surface layer of the cermet and deposited on the inner surface of the tungsten cladding. No evidence of reaction between the  $UO_2$  and the tungsten matrix or cladding was observed.

A second cermet capsule was successfully irradiated in the MTR "rabbit" facility. The tungsten clad fuel was contained in an evacuated test assembly designed to give a fuel surface temperature of 2400 C.

The cermet for both of these test capsules was 96% theoretical density and was fabricated by high energy impaction. The fuel pins were 0.195-inch OD x 3-inch long and clad in 0.250-inch OD x 0.025-inch wall tungsten.

Electron Microscopy of Cermets. A high energy impacted, non-sintered 66 v/o W-UO<sub>2</sub> cermet has been examined during heating by reflection electron microscopy. Above 800 C, UO<sub>2</sub> surfaces exhibited random topographical changes including crystallite growth, roughening, and changes in color (determined by optical means). No structural difference was immediately apparent between particles which turned golden and those which remained black. However, the tungsten remained unchanged up to 920 C, the maximum temperature studied, suggesting that unidentified impurities (nitrogen?) within the UO<sub>2</sub> may be responsible for the reaction.

Improvements in Radiometallurgy Examination Techniques. Two examination techniques recently instituted by Radiometallurgy Operation have resulted in increased quantity and quality of information from examinations:

1. An autoradiographic technique (originally developed at GE-APED) which utilizes a beta sensitive emulsion on a glass plate provides autoradiographs with extremely fine resolution. These autoradiographs are particularly valuable for fission fragment and plutonium relocation studies.
2. High quality replicas of entire fuel rod cross sections were made using silicone rubber. These replicas are satisfactory for high magnification optical microscopy and allow photographic work to be done out-of-cell, thereby greatly reducing the costs of producing photo-mosaics. The replicas can be stored easily and indefinitely for future detailed examination.

Electron Microscopy of Irradiated Fuel. Investigation of new methods of replication applicable to large (approximately 0.5-inch diameter) irradiated surfaces has continued. Room-temperature-curing silicone rubber is suitable for light-microscopy replicas (below about 1000X magnification), but the fine specimen detail necessary for electron microscopy does not reproduce well by this method.

Replicas suitable for electron microscopy were obtained from polystyrene, dissolved initially in ethylene dichloride. However, it is difficult to strip this material intact from large areas, particularly under conditions encountered in remote handling of irradiated specimens. Alternative methods of applying polystyrene are being investigated.

Uranium Monosulfide. The first of two capsules containing uranium monosulfide was irradiated for 20 minutes in a rabbit facility. Uranium monosulfide has been shown to have good high temperature stability by studies at ANL. However, no previous irradiation experiments were completed on this material. The sample of US which was irradiated was obtained for a cooperative experiment with ANL. A second US capsule was readied for irradiation in the ETR.

UO<sub>2</sub>-ThO<sub>2</sub> Phase Equilibrium. Solubility relationships in the UO<sub>2</sub>-ThO<sub>2</sub> system are being investigated by thermal analysis, metallography, and x-ray diffraction techniques. The room temperature lattice parameter as a function of ThO<sub>2</sub> content was measured for 12 different compositions between 2 w/o and 95 w/o ThO<sub>2</sub>. A plot of the lattice parameter against composition gave a nearly straight line that is slightly concave downward. However, a possible discontinuity occurred at 4 w/o ThO<sub>2</sub>. If real, this may indicate the presence of an anomalous phase boundary at this composition. Previous work indicated a minimum in the liquidus at an approximate composition of 3 w/o ThO<sub>2</sub>. Additional analyses are in progress.

#### 4. Basic Swelling Studies

Irradiation Program. Uranium specimens in a general swelling capsule (No. 16) are being irradiated at a constant temperature of 525 C when the reactor is up and 380 C when the reactor is down. Three additional capsules are complete (Nos. 17, 18 and 19) and are ready for charging. The irradiation temperatures for the specimens in these capsules will be 525 C, 625 C, and 625 C, respectively, regardless of reactor operating conditions. Two capsules (Nos. 10 and 15) containing uranium specimens that had reached their goal exposure at a constant irradiation temperature of 575 C are still being held in the reactor discharge basin for additional radioactive decay before shipment to Radiometallurgy. Assembly of a new capsule (No. 20) has begun. Two previously irradiated capsules (Nos. 13 and 14) have been disassembled and post-irradiation examination of the specimens is beginning.

The recently purchased analog to Digital Readout Translator (Data Logger) for the uranium swelling program has arrived on site and is being tested in the laboratory before shipment to the reactor for installation. The thermocouple extension wire, power connections and cable for the capsule heaters, temperature controllers and auxiliary equipment are being installed at the reactor as part of the monitoring and control system to be used with the data logger.

The 25 one-eighth-inch diameter heaters that were recently ordered from Continental Sensing Company have been received and are being installed in capsules. Three heaters from this vendor have been successfully placed in capsules and the capsules bench tested. The heaters performed as designed. In-reactor operating experience will be gained shortly.

Post-Irradiation Examination. Metallography by optical and electron microscopy has been completed on specimens from capsule 11, which had been irradiated at 425 C to a burnup of 0.16 a/o. The specimens consisted of two types: (1) fine equiaxed grains obtained during high alpha extrusion of the stock uranium, and (2) same as (1) with the exception of a final beta heat treatment after machining. The "low" temperature of irradiation coupled with cycling from 425 C to ambient has resulted in gross dimensional instability of both types of specimens. Specimens were extremely difficult to remove from their holders. The major difference between the two types, however, is that the fine grained specimens show far less internal tearing and external irregularities than is the case for the large grained specimen. Density values obtained by immersion methods are suspect in view of the extreme porosity of the specimens. Likewise, metallography is suspect in view of possible retention of NaK and subsequent reaction products which may form within the porous specimen during processing. A retained "second phase" constituent present only on specimens which are in the as-polished state is ejected or decomposed during ion bombardment etching. Etched specimens, therefore, show only cavities. X-ray diffraction will be used to study the as-polished specimens and analyze the extraneous constituent which comprises ~ 10% of the specimen volume.

Microscopic examination of all samples showed a highly worked microstructure and the presence of many large tears dispersed throughout the sample. In many instances, the walls of the tears resemble surfaces which are typical of brittle fracture. The tears are randomly oriented and are not related to any crystallographic features of the sample. The tears are unquestionably due to microstresses. This observation bears out original concepts which were

advanced to include dimensional instability and its consequences in considering in-reactor pseudo-swelling. Gas pores which are present can be differentiated from the tears by their size and shape. These pores are spherical and approximately  $0.1\mu$  in diameter. The number of pores and their range of sizes are extremely small. Microcracks which are bounded by small pores were also occasionally observed. Interpretation of the electron and optical micrographs is far from complete.

Capsules 13 and 14, which were irradiated in a tandem arrangement at respective control temperatures of 575 and 625 C to 0.27 a/o B.U., were opened in Radiometallurgy. Each capsule contained three tubular specimens (split longitudinally): two were as-extruded and the third was beta-treated prior to irradiation. The samples in capsule 13 completed this irradiation with no temperature excursions although there was one power outage that occurred while the reactor was down that caused the temperature to drop to ambient for about one-half day. This is believed to have an insignificant influence on the results. One temperature excursion occurred on capsule 14 that allowed the specimens to be heated into the beta range for about 30 seconds. Two power outages also occurred (both with the reactor up) which permitted the specimen temperatures to drop to about 450 C in both instances. It was possible to remove one specimen in capsule 13 (575 C) and two specimens in capsule 14 (625 C) from their holders, but the rest of the samples are stuck and cannot be removed without severe damage. All of the samples have suffered macro damage but the samples irradiated at 575 C were appreciably worse than were the samples irradiated at 625 C. Very faint striations in the extrusion direction can be seen in the 625 C as-extruded specimen and a very slight amount of warpage has occurred. The other as-extruded specimen in capsule 14 which operated at an estimated 600 C showed pronounced striations in the extrusion direction and rather severe warpage. The beta-treated sample (large grained) which operated at about 600 C showed severe surface roughening and general warpage. The as-extruded samples from capsule 13 exhibited severe striations in the extrusion direction and the beta-treated sample showed very severe surface roughening.

The observations made on the specimens from capsules 13 and 14 corroborate observations recently made on other similar samples irradiated in other capsules. There is little doubt but that "growth" effects are still present up to 600 C. Furthermore, large grained material behaves worse than does fine grained (as-extruded) material. Detailed metallographic examination of these specimens will be conducted and density measurements will be made.

## 5. Irradiation Damage to Reactor Metals

Alloy Selection. Evaluation of several nickel base alloys has continued during the past month. Oxidation tests on Rene 41 and Allegheny Alloy R-235 have been completed. These alloys were tested in CO<sub>2</sub> environments for 300 hours with specimen temperatures at 1800 F. Both alloys followed a parabolic oxidation rate with Rene 41 exhibiting a somewhat slower oxidation rate. Specimens of Inconel 625, Inconel 718, and Hastelloy N alloys are being prepared for similar tests.

TD nickel (nickel dispersion hardened with 2% thoria) is being evaluated for high temperature gas atmosphere applications. Time-temperature softening curves for the metal have been determined on samples work hardened by an 80% reduction in area by warm rolling. For annealing temperatures between 1100 and 2000 F and times up to 60 hours, the thoria dispersion limits softening from 99 R<sub>p</sub> to no less than 90 R<sub>p</sub>. In marked contrast, work hardened nickel, given similar annealing treatments, will soften from 99 R<sub>p</sub> to around 50 R<sub>p</sub>. It is this metallurgical stability of the thoria dispersion which enables TD nickel to retain useful mechanical properties at temperatures around 2000 F.

Tensile test specimens of Hastelloy N, Haynes R-41 and Haynes R-235 have been machined and heat treated. The Hastelloy N alloy was heated to a temperature of 2165 F for 20 minutes and air cooled. The R-41 alloy was given a solution treatment at 2150 F for two hours, air cooled and aged for four hours at 1650 F, followed by air cooling. The R-235 was heated to 2200 F for 15 minutes, water quenched and reheated to a temperature of 2050 F and air cooled. These specimens will be irradiated in the ETR G-7 hot water loop facility at a temperature of 280 C. Tensile specimens of Hastelloy N, R-41 and R-235 will be irradiated in a gaseous environment typical of the graphite channels of a Hanford reactor. Graphite boats are presently being fabricated to hold these specimens. During the same irradiation, Charpy V-notch impact specimens of Hastelloy X-280 and 406 ferral aluminum alloy will be irradiated. The Charpy V-notch specimens are now being fabricated. Two thermocouples will be placed in the graphite boats and attached to specimens to monitor the specimen temperature.

Hanford Laboratories is to be responsible for the procurement, storage, and disbursement of structural materials to be used in the Irradiation Effects on Reactor Structural Materials Program where use of a material is by more than one site. As previously reported, specifications for most materials have been written.

Orders for A302B, A212B, Inconel X-750, and Inconel 600 have been placed with delivery expected about January 15, 1963. In addition, a heat of Hastelloy X-280 now located at HAPO was selected and orders to fabricate this alloy into useable plate have been placed with Haynes Stellite Steel Company.

In-Reactor Measurement of Mechanical Properties. Another creep capsule was charged in the reactor this month to continue the study of the effects of neutron irradiation on the creep properties of Zircaloy-2. This capsule contains a 20 percent cold worked specimen. The scheduled test conditions are: stress 20,000 psi; temperature, 310 C. This test is the first of a series to determine the stress dependency of creep during irradiation. The same test temperatures, namely 250, 310 and 350 C, will be utilized for the 20,000 psi series as were used on the completed series at 30,000 psi. The load will be placed on the specimen to begin the creep test after the calibrational procedures are completed on the capsule and the reactor reaches stable operation.

A series of three more activation energy measurements were completed this month during the reactor outage. Previously, an activation energy value for the creep of Zircaloy-2 during a reactor outage was measured to be 55,800 cal/mole. The same specimen during irradiation exhibited a value of 85,000 cal/mole. The three measurements obtained during this outage were: 55,800, 57,500 and 60,000 cal/mole. These values are in excellent agreement with the ex-reactor activation energy which is about 58,500 cal/mole. All the measurements are based upon the temperature increment method, utilizing the temperature changes between 350 and 370 C. These activation energy differences between reactor on, to reactor off conditions lend support to a proposed theory for radiation effects on creep. The differences are caused by rapid annealing of radiation induced defects after the neutron irradiation is discontinued at 350 C. This effect has the same cause as increased creep rates when the neutron irradiation is discontinued.

Negotiations are now in progress for the procurement of additional creep capsules. The specifications call for ten capsules identical to those now being used in the program and parts for an additional ten capsules that can be tailored to particular environmental tests. The assembled capsules can be operated between temperature limits of 200 and 700 C, with stresses between 0 and 80,000 psi and strain recorded for one-half inch of elongation. The unassembled capsules can be altered to extend the above limits as a particular test or environmental condition may dictate.

Pre-post-irradiation Measurements. During the month, 53 irradiated and 82 control, unirradiated specimens were tested. The irradiated specimens included plain and notched tensile specimens of Zircaloy-2 exposed both to hot water (230 C) in the ETR, G-7 facility and to ambient water (~ 50 C) in an adjacent position. The control specimens consisted of both stainless steel and Zircaloy-2, most of which were exposed to hot water in the out-of-reactor loop.

Hardness and weight-gain measurements were made on both irradiated and unirradiated bend-test specimens. The weight-gain data fell on extrapolated trend curves established by previous data, and reflect a 10- to 13-fold increase in the extent of corrosion over specimens given comparable exposures in the out-of-reactor loop.

A study to determine the effect of irradiation on the formation of ferrite (or martensite) in unstable austenite and on embrittlement was initiated. These investigations are being conducted on AISI 304, 347, and AM-350 stainless steels. It is generally agreed that embrittlement takes place near 975 C in the higher chromium ferritic stainless steels; however, there is disagreement concerning the lower limits of the chromium content at which this phenomenon will occur. There is also disagreement upon the effect of nickel additions to the alloys. If the addition of nickel merely tends to slow the reaction, the influence of a neutron flux may be to promote diffusion and override the rate control of the nickel addition. Furthermore, if unstable austenite partially reverts to ferrite under the influence of either cold work or neutron flux (or both), localized regions high in chromium content will result. These regions may then serve as sites for sigma-phase nucleation. Annealing studies of the above stainless steels containing various levels of cold work were initiated. In addition to mechanical properties tests and metallographic investigations, the percent of ferrite in the alloys is being determined by both magnetic permeability and saturation inductance measurements.

Current investigations of nickel-base and other high temperature resistant alloys require facilities for conducting tensile tests at temperatures to 1000 C. Toward this end, a radiant-energy furnace for attachment to existing Instron tensile apparatus is being developed. The unique feature of this furnace is a parabolic reflector which uniformly distributes energy from a single lamp bank (7200 watts) over the specimen gage section. This reflector, which swings free upon opening the furnace, leaves the specimen unencumbered for remote insertion and replacement. A standard vacuum system provides a protective environment during the test.

Information concerning the notch strength of Zircaloy-2 has been gathered to determine if neutron irradiation causes the material to become notch sensitive. For the conditions investigated, the notch strength has been found to be a linear, increasing function of the yield strength. The corresponding notch strengths for three yield strengths (varied by cold work in the as-prepared condition) are as follows:

Yield Strength	70*	80	90
	<u>As-Prepared</u>		
Transverse Notch Strength	159.0	189.0	200.0**
Longitudinal Notch Strength	168.8	185.0	200.0
	<u>Hot Water(540 F) Exposure Out-of-Reactor</u>		
Transverse Notch Strength	108.0	118.0	127.0**
	<u>Hot Water(540 F) Exposure In-Reactor (<math>\sim 5 \times 10^{19}</math> nvt)</u>		
Transverse Notch Strength	103.0	111.2	119.7
Longitudinal Notch Strength	102.2	111.5	121.0

\* All strengths -  $\times 10^{-3}$  psi

\*\*Extrapolated

The notch strength has been drastically reduced by hot water exposure out-of-reactor. Similar in-reactor exposure to hot water combined with a neutron exposure of about  $5 \times 10^{19}$  nvt has resulted in only a small additional loss in notch strength. Also, in the as-prepared condition directionality has a prominent effect on notch strength at low yield strength, but practically no effect at higher yield strength. Directionality effects are generally absent for all yield strengths in the irradiated condition. These data reveal that serious misinterpretations can result from analogies between irradiation and cold work effects on the notch strength of Zircaloy-2. Whereas cold work increases notch strength, neutron irradiation reduces notch strength. The observation of an increase in notch strength with yield strength and a notch-strength to yield-strength ratio greater than one after  $5 \times 10^{19}$  nvt exposure indicates that notch sensitivity has not yet occurred.

Environmental Effects on Structural Materials. In- and ex-reactor corrosion and chemical effects studies were continued during the

month. Since July, six out-of-reactor cycles simulating the G-7 loop operation for ETR cycles 43 through 48 have been concluded in the Chemical Metallurgy high temperature test loop.

Zircaloy-2 corrosion test coupons analyzed to date show no significant correspondence between corrosion weight gain and extent of cold work, but the extent of corrosion (average corrosion rate) in-reactor exceeds that found out-of-reactor by a factor of at least ten for the exposure conditions studied. This observation of enhanced Zr-2 corrosion rates upon exposure to fast ( $> 1$  Mev) neutron fluxes on the order of  $10^{13}$  nv is in general agreement with information reported by other investigators.

Hydrogen analyses for samples irradiated at ETR show hydrogen gains averaging 15 to 20% of the theoretical corrosion hydrogen, comparable to fraction pickup observed ex-reactor. The very limited in-reactor hydrogen pickup data also indicate a tendency toward reduced pickup for samples with 10% cold work. Only minor and inconsistent differences in hydrogen pickup were noted among other degrees of cold work.

In recent months duPont has developed a nickel alloy hardened by a dispersion of sub-micron size particles of thoria (2 v/o  $\text{ThO}_2$ ) which is reported to maintain excellent stress-to-rupture and ultimate tensile strength properties at temperatures above 2000 F. Although inferior to many of the nickel-base super-alloys in oxidation resistance, duPont's preliminary data indicate that the 2 v/o  $\text{ThO}_2$  alloy has oxidation resistance superior to pure nickel at 2000 F in air. A preliminary analysis of the alloy's reliability in oxidizing atmospheres, and oxidation mechanisms is under way. High purity research-grade oxygen (Matheson Company, Newark, California) at 25 mm Hg pressure has been used in all experiments. Specimens of the alloy for oxidation were in the form of coupons  $\frac{1}{2}$ -inch by 2 inches by 0.030 inch, which were annealed in vacuo at 1020 C and bright-etched prior to testing.

Weight-gain versus time plots from a continuously recording Ainsworth semi-micro balance show the expected relation between temperature and oxidation rate at 1000, 950, and 900 C. However, the oxidation rates at 850 and 800 C are anomalous. Initial weight gains at these temperatures are higher than weight gains at corresponding times for a temperature of 900 C.

Recent investigations by Gulbransen and Andrews (Westinghouse Research Labs) on oxidation of pure nickel show higher weight gains for temperatures and times corresponding to those of the

present investigation. However, higher pressures of oxygen were used, and valid comparisons are difficult to make at this time.

Analysis of the data obtained thus far indicates that at higher temperatures, parabolic kinetics are observed, while at lower temperatures a transition to more complex kinetics takes place. A logarithmic rate law has been found to apply in certain cases. The temperature anomalies observed in the current experiments are as yet unexplained.

Irradiation Damage to Inconel. As reported previously, the Inconel tube from the DR-1 gas loop separated circumferentially as it was being pulled from the reactor. The section of the tube that contains the broken end was borescoped and photographed. Close inspection of the tube near the broken end revealed several small transverse cracks on both the inner and outer surfaces. These cracks were located in one small area. The remainder of the tube near the break showed no visible defects. Visual inspection of the fracture surface revealed the following:

1. There appears to be a small shear lip on both the inner and outer surface over about one-fourth of the circumference. This is probably where the final break occurred.
2. There are several dark areas in the fracture surface. These areas extend up to one-half of the wall thickness.
3. About three-fourths of the fracture surface appears brittle, with some areas having a granular appearance.

Further metallography will be done on transverse and longitudinal samples from the broken area.

Damage Mechanisms. The objective of this program is to establish the nature of the interaction between defects present prior to irradiation and those produced during irradiation with emphasis on the role played by interstitial impurities. The investigation is presently concerned with high purity iron and its low carbon and nitrogen alloys.

Installation of the heat exchanger using demineralized water for the internal cooling circuit of the Thermonic induction generator brought this equipment to operational status. Assembly of a zone refining fixture, transmission line, and associated accessories is proceeding satisfactorily.

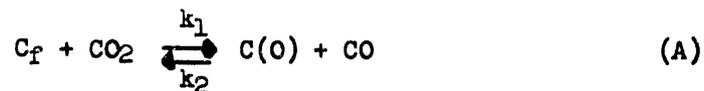
Evaluation of fabrication techniques for high purity iron have shown that swaging with a lubricant does not introduce the spiral flow of metal produced by swaging without a lubricant. Cold drawing has proved to be unsatisfactory because of the low tensile strength of high purity iron. Reductions in area from 50 to 75% have reduced the grain size but do not produce a uniform grain size. Recrystallization appears to be complete after a two-hour anneal in vacuum at 650 C.

## 6. Gas-Graphite Studies

Graphite Oxidation Studies. Studies of the initial phases of oxidation of TSX graphite by carbon dioxide at 875 C are continuing. Two general consistencies are apparent: (1) the oxidation rate of samples with no pretreatment decreases with time over the range 0.5 to 1% oxidation; (2) the oxidation rate of samples that have been pretreated by outgassing in a vacuum at 875 C for 15 hours or more increases with time over the same range of oxidation.

At least part of the cause of (1) appears to be the oxidation of machining dust, which, because of the high surface area is more reactive than the solid body.

The accepted mechanism of graphite oxidation by carbon dioxide is:



where  $C_f$  represents the active sites and  $C(O)$ , chemisorbed oxygen.

A possible mechanism for (2) consistent with the above equations is that the outgassing removes adsorbed gases on the active sites which then build up again with little change in weight when oxidation of the sample is begun. As these oxidation sites become occupied, the rate of carbon weight loss increases by the reaction (B). Other workers have found that below 625 C (B) does not occur and it is observed that the rate of CO production from (A) decreases with time consistent with an approach to equilibrium.

Radiation-Induced Graphite - Water Vapor Reaction. Measurements of the rate of reaction of CSF graphite with helium containing small

partial pressures of water vapor in the Co-60 gamma facility have continued. Sample temperatures ranged from 600 to 700 C, and the helium flow rate was about 0.5 CFH. The dose rate was approximately  $3.2 \times 10^6$  roentgens/hr. As before, oxidation rates were compared at each temperature to those obtained with dried helium to determine the effect of residual oxygen. The oxidation rates for the samples in dried and undried helium (125-150 ppm H<sub>2</sub>O) were about  $5 \times 10^{-6}$  hr<sup>-1</sup>; for all practical purposes, essentially zero. (At this rate a 7.5-gram sample would lose only about 0.1 mg in 250 hrs.) In subsequent experiments, a distilled water bubbler, held at 0 C, was used to add water to the helium. If the helium was saturated, the water concentration was about 6000 ppm. The oxidation rates at 600 and 700 C, respectively, were  $1.88 \times 10^{-6}$  and  $3.42 \times 10^{-6}$  hr<sup>-1</sup>. Comparison of these rates to rates extrapolated from measurements made at dose rates of  $8.3 \times 10^5$  roentgens/hr in helium containing 430 ppm, shows the extrapolated values to be about 40% higher than the measured values. This difference may be due to one or more of the following factors: (1) difference in graphite samples, (2) non-linear dependence on dose rate, and (3) a slight dependence on water concentration (zero order dependence was assumed in the extrapolation). The activation energy obtained from the most recent rate measurements was 10.1 kcal/mole in good agreement with the value 9.4 kcal/mole obtained previously with CSF graphite at the lower water-vapor concentration and dose rate.

Thermal Conductivity of Irradiated Graphite. The thermal diffusivity of irradiated NPR (TSX) graphite has been measured from 25 to 600 C by a newly developed flash method which is believed to be highly applicable to irradiated graphite since it requires only small samples, is simple and fast. The samples were irradiated at approximately 650 C to an exposure of 5000 MWD/AT in K-Reactor. The thermal conductivity calculated from the thermal diffusivity data was 0.1 cal/cm-sec-C parallel to the extrusion direction and 0.08 cal/cm-sec-C in the transverse direction, in good agreement with typical conventional measurements. The thermal conductivity remained almost unchanged from 25 to 600 C. The samples were recharged for additional exposure.

Irradiation of Graphite Under Stress. Transverse samples of AGOT-LS graphite, which had been irradiated to  $1.52 \times 10^{21}$  nvt ( $E > 0.18$  Mev) at approximately 625 C in the 150 psi compression test boat, P-5, were annealed in successive steps with temperatures increasing to 1900 C. Contraction occurred in each step, occurring mostly between 1000 and 1500 C. There was only a small difference between the contraction (caused by annealing) of the samples that had been

irradiated under stress and the contraction in the samples that were irradiated without stress.

The contraction during annealing is probably due to annealing of the  $c$  spacing, which increased during irradiation. It was previously noted that there was no significant difference between the  $c$  spacing changes of stressed and unstressed samples during irradiation (cf HW-74153A, p. 41). However, since the difference in physical length change of the stressed and unstressed samples is only about 10% of the measured  $c$  spacing changes during irradiation, a difference in  $c$  spacing due to irradiation may exist which is masked by the uncertainty of the measurements.

The 150-psi compression boats P-6 to P-10 have been discharged, measured, and are being returned to the reactor for a fourth irradiation. Additional contraction has taken place and the stressed samples continued to contract slightly more than the unstressed samples during the third irradiation.

A boat, T-1, containing samples of NC-8 graphite under a constant tensile stress of about 100 psi has been charged in 2C hot test hole at KW-Reactor. These samples will be discharged and examined early next month.

#### 7. Graphite Radiation Damage Studies

Electron Microscopy of Irradiated Graphite. Replication of samples irradiated in capsule GEH-13-8 in the ETR is in progress. Prior to irradiation replicas were obtained from indexed areas for a comparison of pre- and post-irradiation replicas of the same structural features. Preliminary estimates indicate that the samples were irradiated at 600 to 700 C to an exposure of  $1.1 \times 10^{21}$  nvt,  $E > 0.18$  Mev. Replicas from the pre-selected area on a sample of CSF graphite reveal the development or enlargement of microcracks during irradiation. Two distinct types are found. The first occurs along grooves developed by cathodic vacuum etching prior to irradiation. They are parallel to the  $a$  direction and apparently represent enlargement in the  $c$  direction of a microcrack system. This microcrack system probably developed as a result of anisotropic contraction while cooling after graphitization. These cracks have opened enough to permit thin sheets of the Formvar replica to penetrate to depths up to  $1 \mu$ . In most cases the replicating material that penetrated cracks was too thin to be self-supporting. Crack width is about 0.1 to 0.2  $\mu$ .

Another type of void developed along the intercept of chevron-like crack systems. Narrow fingers of replica material 0.1 to 0.2  $\mu$  wide penetrated these openings to depths up to 2  $\mu$ . Further study of this and other samples included in the irradiation is required to establish the extent of microcrack development. Microcracks may be the result of radiation-induced contraction; however, stresses at the surface of the sample could be sufficiently atypical to preclude the assumption that microcracks develop throughout the structure.

Effect of Impregnation on High Temperature Contraction. The second irradiation has been completed on the series of samples which are intended to determine the effect of impregnation with furfuryl alcohol on high temperature radiation-induced contraction. The samples were irradiated in capsules each containing four specimens: (1) unimpregnated; (2) impregnated and baked to 900 C; (3) impregnated and graphitized at 2650 C; and (4) impregnated and graphitized at 2900 C. Irradiation temperatures are estimated in the range 500 to 700 C. Since each capsule was subjected to different neutron and gamma flux, comparisons strictly are valid only among samples in a single capsule. The results continue to show that the impregnation is detrimental to the dimensional stability of both TSX and HLM-85 under high temperature irradiation. In all cases the total contraction of the samples which were impregnated is larger than the contraction displayed by the unimpregnated material.

#### 8. Aluminum Corrosion and Alloy Development

Behavior of Plated Aluminum Alloys in Water at High Temperatures. Corrosion tests were run in 300 C, low flow (2 gp hr), pH 10, water in which unclad X-8001, 1245 and electroless nickel plated X-8001 specimens were exposed, and in 300 and 330 C, high flow (25 fps), pH 6.6 and pH 10 water were both plated and unplated X-8001 and 1245 alloys were tested.

Nickel-plated X-8001 alloy coupons were exposed to 300 C, pH 10 water for 30 days at two oxygen levels (4 and  $<$  0.1 ppm). Two nickel-plated coupons were placed in each autoclave; in each case, one of the coupons had intentional defects, exposing the aluminum substrate to the pH 10 environment. On coupons with and without defects the attack was more pronounced in the high oxygen system. For coupons having exposed aluminum, weight losses were 108.5 and 7.0 mg, respectively, at high and low oxygen levels. The observation, while admittedly isolated, indicates that oxygen may contribute to the attack on aluminum in pH 10 water. Several failures in the

nickel film occurred on the coupon without initial defects in the high oxygen system; no discernible failures were observed on the corresponding coupon in the low oxygen system.

In 300 C, pH 6.6 water, 3-4 ppm O<sub>2</sub>, at high flow rates (25 fps) no accelerated attack occurred on nickel-plated X-8001 and 1245 aluminum, with or without plating defects.

In a 53-hour exposure at 300 C, pH 10 and 25 fps flow rates, a slightly accelerated attack occurred on both alloys with defected plates exposed, but with no evidence of catastrophic failure.

In the high flow system at 330 C and pH 6.6, five out of seven nickel-plated 1245 alloy coupons in the test failed catastrophically during a 10-day exposure. None of the coupons which failed had intentional defects. Failure apparently was initiated at pin-point flaws in the cladding. The two 1245 alloy coupons which did not fail had been heat treated at 400 C prior to the test to create a nickel-aluminum diffusion layer. Even though cracks appeared in the nickel film penetrating to the aluminum substrate, no massive failure was initiated on the heat treated specimens during exposures up to 80 days. No accelerated attack occurred on clad X-8001 coupons in the same test.

#### 9. Metallic Fuel Element Development

Metallic Thorium Fuel Element Fabrication. Primary melting of 1 w/o Zr - 2.5 w/o or alloy-thorium fuel material is completed. Seven 3.7-inch diameter ingots have been melted and are currently being prepared for final melting. Two final 5-3/4-inch diameter by 180-pound ingots will be made. The electrodes for these heats are being fabricated by threading the primary ingots and nipling them together end to end.

Chemical cleaning of thorium in preparation for end closure brazing is not satisfactory. Visible oxidation occurs in less than 15 seconds, which does not permit sufficient time for handling and pumping down in the braze chamber.

Cleaning will be performed by cathodic etching in an inert atmosphere within the braze chamber. The end of the fuel will first be cathodically etched in a partial argon atmosphere, braze metal and cap positioned by manipulators, and then brazed by normal induction heating.

10. USAEC-AECL Cooperative Program on Development of Heavy Water Moderated Power Reactors

Thermal Hydraulic Studies. Analysis of the data gathered earlier on an electrically heated 19-rod fuel bundle model to demonstrate the steam generation characteristics of the fuel configuration was continued. The test section was constructed of 19 Inconel rods, each 0.587 inch OD and 6.3 feet long, spaced 0.050 inch apart. Spacing of the rods was maintained by means of 0.050-inch wire wraps on 12 of the 19 rods. The bundle was instrumented with thermocouples in 14 of the rods and in 10 of the flow channels. The pressure tube was 3.25-inch OD and was placed in a horizontal position.

Thirty-five experimental runs were made in order to investigate (1) isothermal characteristics, (2) pressure drop-flow characteristics during boiling, (3) coolant mixing behavior, and (4) boiling burnout heat fluxes at various flow rates and coolant enthalpies. All runs were made at a pressure of 1200 psig.

The data gathered in the phase of this investigation covering the boiling burnout behavior of the model 19-rod cluster fuel assembly were completed and the results are summarized in the following table.

Boiling burnout occurred, generally, on one or more of the inner rods. However, at mass velocities of  $0.5 \times 10^6$  and  $1 \times 10^6$  lb/hr/ft<sup>2</sup>, the burnout occurred on the uppermost rods in the outer circle of 12. This was probably due to the additional influence of flow stratification on the effective coolant quality at the top of the bundle during these low flow tests.

Portions of the results reported above were compared to data obtained earlier on a test section of identical cross section geometry but only  $19\frac{1}{2}$  inches long. Where valid comparisons of the data could be made, substantial agreement was observed between the boiling burnout behavior of the  $19\frac{1}{2}$ -inch test section and that of the 6.3-foot long test section. This indicates that there is no length effect on boiling burnout in the 19-rod cluster configurations in the range of lengths considered.

<u>Flow Rate</u> lb/hr/ft <sup>2</sup>	<u>Outlet Enthalpy</u> Btu/lb	<u>Outlet Quality</u> % by weight	<u>Burnout Heat Flux</u> B/hr/ft <sup>2</sup>
1.28 x 10 <sup>6</sup>	701	20.9	0.294 x 10 <sup>6</sup>
1.06	698	20.5	0.294
0.82	716	23.3	0.295
1.32	659	14.0	0.389
1.65	654	13.2	0.389
2.35 x 10 <sup>6</sup>	649	12.4	0.390 x 10 <sup>6</sup>
1.35	612	6.2	0.493
1.83	587	2.2	0.493
1.80	637	10.4	0.492
2.53	622	7.8	0.492
1.02 x 10 <sup>6</sup>	637	10.4	0.463 x 10 <sup>6</sup>
1.01	746	28.3	0.284
1.01	703	21.2	0.356
1.01	666	15.1	0.424
0.51	711	22.6	0.242
0.51 x 10 <sup>6</sup>	792	35.8	0.174 x 10 <sup>6</sup>
0.50	757	30.1	0.209
0.50	674	16.5	0.276
3.03	632	9.6	0.477
1.99	662	14.4	0.328
2.02	642	11.2	0.462

Dome Seal Type Nozzle Closures. Fabrication of the dome seal test assembly is estimated at 20% complete. The type 403 stainless steel for the nozzle assembly has been received and fabrication of the nozzle is under way. A test stand to support the nozzle-seal assembly is also being fabricated. Required fittings to connect the nozzle into EDEL-II test facilities are on order and a flow schematic of the required EDEL-II test cell modifications has been made.

Calculations of the stress at five selected points in the cross section of the test dome have been made. Analysis of these data is continuing. Initial indications are, however, that the maximum stress occurs on a circle half-way between the dome center and the dome edge.

## 11. Advanced Reactor Concept Studies

Fast Supercritical Pressure Power Reactor. Alternate core designs for the FSPFR are being studied to reduce the large positive coolant void coefficient and still allow the desired power output and density together with an acceptable neutron economy.

A new "laminated neutron spectrum" core design was conceived during the month and was investigated. This design concept is a fast core divided into several sections which are separated by a moderating material and possibly fertile material layers. This reduces interaction between the several fast neutron regions and enables them to retain leakage properties which counteract the effect of coolant voiding.

Coolant loss in this core causes the fast neutron leakage to the moderating region to increase. Neutrons are slowed down in the moderating region and returned to the fast cores degraded in energy. The lower energy neutrons are less important in the fast core since the capture to fission ratio is higher and resonance absorptions are higher for the lower energy neutrons. The net result is that the coolant voiding effect is reduced.

Original calculations done with the HFN code in 16 energy groups showed that this phenomenon exists if the sizes of the bare fast regions were limited in size. The 16-group set has a poor lower neutron energy structure so calculations using 18 energy groups were performed to verify the results and increase the accuracy. Eighteen-group calculations show that for one region, bare cylindrical cores, a negative void coefficient occurs for radii between 0 and 39 cm. For radii larger than 39 cm, a positive void coefficient exists.

Calculations have also been done for various fast region radii and moderator thickness (water moderator was used in these calculations).

<u>Cases A</u>			
( $r_1$ - 30 cm, 35% PuO <sub>2</sub> , $r_3 = r_2 + 20$ cm)			
<u>Water Thickness</u>	<u>k<sub>eff</sub> Base</u>	<u>k<sub>eff</sub> Void</u>	<u>k Base to Void</u>
2 cm	1.144	1.162	+ 0.018
5 cm	1.197	1.223	+ 0.026
7 cm	1.175	1.193	+ 0.018
10 cm	1.106	1.119	+ 0.013

<u>Cases B</u>			
( $r_1$ - 25 cm, 35% PuO <sub>2</sub> , $r_3 = r_2 + 20$ cm)			
5 cm	1.155	1.168	+ 0.013
10 cm	1.051	1.058	+ 0.007

When vertical leakage and streaming are considered, all of these results will probably have a negative or very small positive void coefficient. These results should be reduced even more when a thin layer of depleted uranium is placed at the boundaries of the moderating region. The U-238 will absorb the slower neutrons leaving the moderating region.

Preliminary calculations have also been carried out utilizing beryllium as the moderator. However, beryllium exhibits a greater reflection of high energy neutrons, making it less effective in reducing the positive coolant void effect. Other hydrogen containing materials, such as Zr(H)<sub>x</sub>, appear feasible, however. Physical properties of Zr(H)<sub>x</sub> are being studied for possible use in the FSPFR.

The effect on coolant density of varying the pressure drop through the core was determined in an effort to reduce the hydrogen content of the core. By raising the pressure drop to twice the value for the SPPR core, the hydrogen density was reduced by 13.5% in a typical case. Nine core sizes and configurations were investigated for later evaluation of their effect on the void problem.

A very preliminary calculation on the requirements for a gas cooling system for the outer fuel element can was carried out. For the same heat load as the SPPR moderator, a helium cooling system with  $6 \times 10^4$  lb/hr at 600-1000 psi and temperatures over 800 F would be required. The estimates of heat loss from the fuel are being revised to suit possible FSPFR design parameters. The input is being readied for the computer code FUGUE (devised

by Atomic International) to re-evaluate heat loss for practical gas temperatures and for various insulation thicknesses in the fuel elements.

Fuel Re-use. The draft of a formal report on fuel re-use was completed and forwarded for approval. A dummy radial blanket fuel assembly for the Enrico Fermi fast breeder reactor was received from Atomic Power Development Associated, together with a set of drawings. These will be used in fuel design studies for possible fuel re-use experiments in the PRTR and Fermi Reactor.

Use of Plutonium in Space and Rocket Reactors. Limited studies of the effects of substituting plutonium for uranium fuel in compact reactors for space applications are being performed jointly with Applied Physics Operation. The preliminary estimates of weight savings reported last month were revised slightly. Two fast reactor systems were investigated: (1) the GE-NMPO 220 Mw(t) hydrogen-cooled rocket propulsion reactor, and (2) the ORNL 300 Kwe boiling-potassium cooled space power unit. In both cases, the direct substitution of plutonium may permit substantial size and weight reductions in the reactor and shield. Percentage weight reductions were 28% for the NMPO reactor and 17% for the ORNL reactor. In calculating weight changes, only the reactor core, reflector, and a minimal "shadow" shield were assumed to be affected. It was also assumed that the plutonium fuel could be directly substituted for uranium; no estimate was made of the effects of possible differences in temperature limitations or materials compatibility characteristics. For the rocket engine, minimum reactor size was estimated to be limited by heat transfer considerations to 20% larger than that calculated by nuclear considerations. Shielding requirements for the ORNL reactor were estimated since these were not stated in the reactor description. Results are summarized below.

Weight Comparison Study for Pu-239 vs U-235 in Space Reactors  
(GE-NMPO Rocket Engine (220 Mw(t), UO<sub>2</sub>-W cermet fuel, H<sub>2</sub> cooling)

<u>Component</u>	<u>UO<sub>2</sub>-W Fuel</u> <u>wt., lb</u>	<u>PuO<sub>2</sub>-W Fuel</u> <u>wt., lb</u>	<u>Wt. Saved</u> <u>lb</u>	<u>% Wt.</u> <u>Saved</u>
Core	980	525	455	46
Reflector	615	420	195	32
Shield	2080*	1710	370	18
Total	3675	2655	1020	38

\*GE-NMPO shield weight designation for 1-hr powered flight in manned vehicle. No details of shielding construction or of supplemental shielding (if any) given.

(ORNL Space Power Unit (300 Kwe, UO<sub>2</sub> fuel, boiling K cooling))

<u>Component</u>	<u>UO<sub>2</sub>-W Fuel wt., lb</u>	<u>PuO<sub>2</sub>-W Fuel wt., lb</u>	<u>Wt. Saved lb</u>	<u>% Wt. Saved</u>
Core	125	65	60	48
Reflector	645	495	160	25
Shield	3930**	3340	590	15
Total	4700	3890	810	17

\*\*HLO estimates of "shadow" shield requirements to give dosage rates of 10<sup>3</sup> r/hr gamma and 10<sup>3</sup> rem/hr neutrons at outer surface of shield (unmanned vehicle).

Plutonium-Fueled Spacecraft Reactor. Conceptual design work on the 5 Mwe PFSR has been completed to the point where an informal document is being prepared describing work done on this concept. Design studies indicate a reactor weight of 9300 lb (including shield) for the PFSR, and a total powerplant weight of 51,000 lb, or 10.2 lb/Kwe. Major problem areas which would require considerable research and development programs are envisioned in the fields of reactor control, high temperature materials and heat transfer.

#### D. RADIATION EFFECTS ON METALS - O5 PROGRAM

Capsules 18S, 18R, and 18T which had been irradiated to  $\sim 10^{18}$  nvt (fast) were opened with a remotized milling machine and all specimen and flux monitor wires were removed. A similar series of capsules -- 19S, 19R and 19T -- were discharged after an exposure of  $\sim 10^{19}$  nvt (fast). These capsules were decontaminated, lightly etched, and then monitored for radioactivity. Since the radiation level was quite high, it was decided to store the capsules and remove their contents later. A similar series of capsules -- 20S, 20R, and 20T -- also containing single crystal tensile, x-ray, and length change specimens as well as a variety of polycrystalline specimens, are currently under irradiation to a goal exposure of  $10^{20}$  nvt (fast). Capsules containing polycrystalline microhardness, tensile, and stored energy specimens which had received an exposure of  $\sim 10^{19}$  nvt (fast) were opened for removal of specimens. Similar capsules are under irradiation to a goal exposure of  $10^{20}$  nvt (fast).

Eight single crystal molybdenum samples irradiated to  $10^{18}$  nvt (fast) were tested in tension. The stress-strain curves were essentially unchanged by irradiation for the low carbon specimens. The medium and high carbon samples showed a pronounced yield point, decreased ductility, and decreased strength. After deformation in tension all irradiated crystals showed prominent, well defined slip traces which extended into their

shanks. Only one slip system appeared to be active. This is in contrast with the results observed for unirradiated crystals in which slip traces were not discernible and in which slip systems were not well defined. X-ray examination of the deformed samples is incomplete, but it appears that a  $\sqrt{112}$  plane is the slip plane. No evidence of twinning has been observed.

Lattice parameters of the irradiated single crystal specimens are being measured with a modified diffractometer. Four peaks, the  $d_1$  and  $d_2$  of the (660) and (550) reflections, are to be measured on each side of the 180 degree  $2\theta$  position. It is anticipated that precision better than one part in  $10^5$  will be attained. These measurements will be compared with the dimensional changes observed from length measurements. As indicated in the previous monthly report, defects in molybdenum foils containing carbon as an intentional impurity form during irradiation to  $\sim 10^{19}$  nvt (fast). The number of black spots and loops in 20 individual  $1 \mu^2$  areas on each of two micrographs were counted in the as-irradiated and in the 575 C annealed state. Since the thickness of thinned foils for these two states can differ by at least a factor of two, a comparison of number of defects present per unit volume of the foil can be in error by at least a factor of two. However, the ratio of black spots to loops is independent of foil thickness and is a much better index of changes in defect population associated with the annealing treatment. The respective ratio of spot defects to loops is listed in order of decreasing specimen purity for (1) Johnson Matthey, (2) 10-30 ppm C, (3) 100-200 ppm C, and (4) 400-500 ppm C specimens: as irradiated states, 40, 20, 9, and 10; annealed states, 56, 3, 2.3, and 2.4. In order to further explore recovery of these foils, specimens have been annealed at 750 C for two hours. As soon as x-ray broadening and lattice parameter measurements are completed, they will be prepared for electron microscopy.

Preparation of cold worked polycrystalline wires and rods of molybdenum for electrical resistivity and stored energy release experiments has been unsuccessful to date. Specimens have cracked. The reduction and annealing schedules previously used will therefore be altered by increasing the number of intermediate anneals and perhaps increasing the annealing temperature.

Very little success has been achieved by Linfield Research personnel in obtaining a field ion microscopic image of carbon doped molybdenum. The images have in general been very diffuse. Wire specimens of pure molybdenum, purified by zone melting techniques are being made into emitters to establish a "normal" pattern for molybdenum. If no success is achieved, tungsten emitters will be made, irradiated, and re-examined.

Apparatus is currently being installed to measure changes in length of irradiated single and polycrystalline specimens. A punch and die fixture for producing electron microscope tensile specimens has been fabricated. It will be used to stamp out specimens from foil stock representing several levels of carbon as impurity. If thinning and subsequent deformation studies in the electron microscope prove successful, specimens will be prepared for irradiation to  $10^{18}$ ,  $10^{19}$ , and  $10^{20}$  nvt (fast). An electrolytic jet milling device for thinning foils is under construction. With this apparatus the specimen oscillates back and forth and the jet of electrolyte which strikes the specimen moves simultaneously up and down. Consideration is also being given to the design of an electrolytic saw for obtaining wafers parallel to a given crystallographic plane in single crystal rod specimens.

A molybdenum polycrystalline specimen which had been annealed at 1050 C for 16 hours and then irradiated at  $\sim 50$  C to  $10^{18}$  nvt (fast) has received successive isochronal anneals in steps of 25 C up to a temperature of 825 C. Microhardness values were taken after each anneal as a convenient index of temperature dependent recovery stages in the irradiated specimen. Anneals at still higher temperatures followed by microhardness measurements are proceeding.

#### E. CUSTOMER WORK

##### 1. Radiometallurgy Laboratory

Examinations. Sections of the outer and inner tubes from the 105-DR gas loop were received and examined using the borescope. Possible crazing and a circumferential crack on the inner surface of the outer tube near the failure was observed (RM C-105). Four irradiated production elements from a tube containing a rupture were received and examined. Indications of a general removal of cladding by corrosion were noted; however, no localized corrosion attack was observed. The cladding thickness remaining on cross-sections from elements #3 and #6 was estimated at approximately 20-25 mils (RM C-406). Examination of a ruptured production element from 2583D showed the rupture was caused by penetration of the internal cladding by "groove corrosion" (RM C-408). Tensile tests were completed on the first group of aluminum process tubes. The broken samples were transferred for chemical analysis and all data were transmitted to the customer (RM-457).

Project CGH-857 (Physical and Mechanical Properties Testing Cell)

CRL Extended Reach Model 8 Manipulators. Two of the four manipulators were delivered to the Radiometallurgy Laboratory for preliminary checkout operations.

Impact Tester. Installation of this equipment was completed and preliminary operational tests proved satisfactory.

Rotating Beam Fatigue Tester. Fabrication of remotization components was initiated. Completion is scheduled for 12/15/62.

Remote Plate Fatigue Tester. Specimens were fabricated and utilized in the functional testing of the equipment at the vendor's plant. Functional tests proved satisfactory and equipment is scheduled for delivery about 11/30/62.

General. Installation of the sample storage holder was completed. Installation of the hydraulic system continued and the functional checkout of the hydraulic lift system (with equipment installed) is scheduled for completion by 12/1/62. Preliminary checkout of the Instron machine track and positioning mechanism was completed and cell installation was initiated. Installation of all glass viewing plugs and windows in the cell was completed.

Project CGH-858 (High Level Utility Cell)

Remaining operations on irradiated materials were initiated following the release of this cell to the Physical and Mechanical Properties Testing Group.

Alpha-Beta-Gamma Personnel Monitors

One of the personnel monitors was returned to HAPO for circuitry modifications which are required before the vendor can complete calibration of the instruments. The unit will then be returned to the vendor with instructions so other instruments can be modified accordingly.

Pulse Annealing Furnace and Micro Sampling Equipment

The equipment is ready for installation in "D" Cell which has been decontaminated and is being re-assembled after modification.

Instron Tensile Grips

Checkout of the grips for remote operation was completed and operational tensile testing was initiated.

Tensile Scribing Device

Checkout of this equipment was completed. Minor modifications are required to increase range of gage length and thickness of specimens to be scribed.

Zircaloy Tube Marking Device

Preparation of this equipment for cell installation was completed.

2. Metallography Laboratories

Two "H" reactor rear face Van Stone flanges from tubes 3156H and 4173H were examined to characterize the mode of failure by which the flanges broke off from the above tubes. The "orange peel" structure on the exterior surface of the flange and the grain distortion and necking of the material, 6061 aluminum, at the fracture were indicative of a tensile failure. It is not clear in what manner these failures occurred, however.

The design of a virtually all-metal cathodic vacuum etching system is complete. This new apparatus will be fabricated to enclose the glass etching chamber and high frequency generator within a shielding enclosure. The enclosure was designed to control stray broadcast of the RF signal. Design consideration was given to: full eight-hour operating periods, minimum maintenance, experimental flexibility, rapid etching, conservation of krypton gas, and safety of the operator. A feature of the cathode design is a well that permits installation of a dial thermometer which will indicate specimen etching temperature.

3. N-Reactor Charging Machine

Modifications. Modification of the lower portion of each vertical lift jack transmission was completed. During this modification, the male ring portion of the ball nut flexible socket was found to be broken on the two rearmost jack assemblies. Apparent cause of failure was misalignment of the ball screw caused by the end thrust stabilizer rods pulling the rear truck frame out of position. A re-designed rod anchor is being considered to remedy the problem.

Testing. Reports on Design Test No. 8, Idler Roller System, and Design Test No. 19, Filtered Water System, have been issued. Rough drafts of reports on Design Test No. 10, Drive Roller System, and Design Test No. 7, Plug Conveyor Functional Test, have been completed.

Motion pictures of the cross travel drive and vertical lift drive were obtained in an effort to determine acceleration and deceleration forces in the charging machine. Analysis of these pictures is continuing.

A new design test, Design Test 22, is being circulated for comment. Purpose of the test is primarily to test the ability of the present charging system to deliver fuel elements into the reactor pressure tubes with serviceable fuel supports. Primary efforts will be directed at investigating the effects of magazine-to-nozzle and nozzle-to-pressure tube transitions, fuel column action, pressure tube bowing, and increases in fuel-tube friction as a result of tube-support scratching and galling. Incidental but important information may be gained on the possible effect of repeated charging of fuel elements under near prototypical conditions on pressure tube service life. Additional minor material needed to perform the test has been ordered to accelerate performance of the test.

#### 4. Special Plutonium Fabrications

##### Fission Product Transient Samples for Phillips Petroleum Company.

Twenty-four fission product transient samples containing U-235-Al alloy cores were completed and shipped to Phillips Petroleum Company. These Al-2 w/o silicon clad tubular elements were fabricated by hot coextrusion at a 10 to 1 reduction in area over a floating mandrel. Work on the final phase of the fabrication, the U-233-Al alloys, is continuing. Extrusion of the calibration standards has been completed.

##### High Exposure Plutonium-Aluminum Fuel for Physics Instrument Research.

Two hundred and thirty eight special fuel elements for the PCTR were completed and delivered. Approximately 50% of the cores for the PRCF loading were extruded. Fifty cans were fabricated by Technical Shops, and delivery of 50 completed elements is expected in December.

Fabrication of Fuel for the C-1 Loop. Extrusion development work indicated that a larger diameter billet was required to obtain the desired wall thickness in the finished element. Fourteen larger billets were cast of Al-8 w/o Pu-2 w/o Ni alloy for cladding by coextrusion. Three cans were machined of X-8001 aluminum for cladding.

A corrosion test in 350 C water for 24 hours indicated no intergranular attack of the extruded Al-8 w/o Pu-2 w/o Ni alloy.

Low Exposure PuO<sub>2</sub>-UO<sub>2</sub> Fuel for Physics Instrument Research. Dry pressing techniques were developed to prepare 16,000 pellets for the PCTR. The pellets are to be made from depleted UO<sub>2</sub> with 0.90 w/o PuO<sub>2</sub>

enrichment. The green density of the compacts was varied from 5.7 to 6.1 g/cc, controllable to 0.1 g/cc using the automatic pelletizing press. However, the sintered densities varied between 86 and 90% of those usually obtained for ceramic grade, normal UO<sub>2</sub>.

The poor sintering characteristics of the depleted UO<sub>2</sub> result from its smaller surface area as compared to ceramic grade, normal UO<sub>2</sub> (2 m<sup>2</sup>/gm instead of 3 m<sup>2</sup>/gm). It will be attempted to obtain greater densities with depleted UO<sub>2</sub> by preparing pellets with a higher green density, 6.6 to 7.2 g/cc, using a binder.

F. NUCLEAR SAFETY STUDIES

1. Nuclear Health and Safety Manual

A draft of the HAPO manual, Nuclear Health and Safety, has been distributed to the departments for comment. This manual presents in summary form, with references, all of the known HAPO contractual obligations in the area of nuclear health and safety.

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

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FISSIONABLE MATERIALS - O2 PROGRAM

REACTOR

Optimization of Retubed Lattices

Vertical traverses in the "C"-Pile mockup with wet CVIN (overbore) fuel have been completed. They were measured for zero, one, and six rods without water flooding and for zero and six rods with simulated flooding produced by polyethylene strips between the graphite bars.

Angular Distributions of Thermal Neutrons

The angular sensitivity curve has been calculated for the detectors used in the angular distribution measurement of thermal neutrons at the surface of a cadmium rod. The detectors were dysprosium foils at the bottom of cylindrical holes in the cadmium bar. If the hole depth is  $d$ , the radius is  $R$ , and the angle  $\theta$  is measured from the axis of the hole, then the angular sensitivity (fraction of neutrons at the top of the hole traveling in direction  $\theta$  which reach the bottom of the hole per unit of angle  $\theta$ ) is proportional to

$$2R^2 \cos^{-1} \left( \frac{d \tan \theta}{2R} \right) - \frac{d}{2} \tan \theta \sqrt{4R^2 - d^2 \tan^2 \theta}.$$

This function is almost linear with  $\theta$ . For  $R = 0.063$  inch and  $d = 0.148$  inch, the sensitivity goes to zero at  $\theta > 23^\circ$  and  $\bar{\theta}$ , the average value of  $\theta$  (or the "probable error" in the direction of the detected neutrons), is  $5.9^\circ$ . The quantity  $\bar{\theta}$  corresponds to the "half-width at half-maximum" for a Gaussian distribution.

An article describing the angular distribution experiment has been started.

A multigroup calculation of the space-energy-angle distribution of neutrons has been done for the PCTR with a copper bar in the center. This study will indicate appropriate locations for angular distribution measurements with detectors of different energy response (Dy, Lu, Cu, etc.). The early runs have given a spectrum which is too hard. The trouble

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appears to be in the transfer cross sections for the thermal groups.

Computational Programming Services

The optional non-standard equation ( $\phi$ ) incorporated in TRIP late last month has produced satisfactory results. Since the projected addition of two equations coupled to the  $\phi$  equation will require extensive recompilation, the version of the program immediately preceding the inclusion of the  $\phi$  equation was frozen as TRIPOO4, in order to remain compatible with documentation. TRIPOO5 is not yet ready for debug.

COMPTAPE, the program to prepare a composite Lilley tape, and LILLEY, the subroutine which positions the CLT, have been checked out with test programs. None of the codes which will use the CLT have been modified to do so as yet.

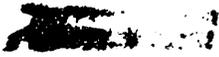
A rush request was made for results from PRØBC in a form incompatible with program output. PRØBC was revised to punch card output, and a new program written to prepare the required report, complete with HW number, page numbers, and table headings. The request was received Friday morning and duplimats were delivered the following Wednesday morning.

Instrumentation

General requirements were established and the basic design was completed for a bore-gage instrument to be used at K-reactors to measure internal diameters of process tubes and graphite channels. A single differential transformer will be the sensor and the results will be chart recorded.

A functional specification was prepared regarding the proposed fission counter preamplifiers for use at NFR and experiments were conducted on a bench-model solid state preamplifier of the type to be supplied by GE-APED. The fission counter prints were thoroughly reviewed and experiments were started to confirm the predicted optimal filling gas pressure to be used in the counters.

General design work continued on the instrumentation for the NFR Experimental Fuel Rupture Testing Loop at FRTR. The complete multichannel analyzer system specifications were completed and submitted. The general system will include the basic analyzer, paper tape perforator, tape reader, typewriter, oscilloscope, and high voltage supply. Continued good progress was made on the general mechanical portions and detector mountings for the installation.



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### Systems Studies

A four-node simulation of the NPR was tested on the EASE analog computer. The purpose of the simulation is to provide a simplified model of the reactor which can be coupled with simulated portions of the primary and secondary loops to facilitate engineering or supervisory studies and operator training. The simulation operates over a ten-decade range and allows for indication of relative rod position in each of the four zones. Some difficulty was experienced with the period readout signal, thus indicating a need for an alternate method. Subcritical operation was also demonstrated.

The Bailey control system ordered by NPR Project Section arrived during the month. To make the system easier to operate for laboratory tests and operator training, the equipment which is normally mounted on control consoles is being mounted on a panel which can be attached to the equipment rack holding the rest of the system.

The NPR pressurizer-injection system must operate in a stable and continuous manner during all reactor transients. The pressurizer vessel with its heaters and sprays, injection and spill valves, pressure injection pumps and all associated control loops is to be studied by means of an analog simulation. Simulation effort is now in progress.

Assistance was provided NPR Project Section in evaluating the Flow Monitor circuit design. This work included an analysis of the operation of the complete system.

A method has been devised for solving non-linear optimization problems, such as xenon poisoning in a reactor. The theory is straightforward, but the application will require the use of a computer because of the number of equations involved.

### SEPARATIONS

#### Experiments with Plutonium Solutions

The series of criticality experiments which were begun in the facility with the 14-inch diameter sphere were completed on November 14, 1962.

During the month the experiments were devoted to a study of the effects of concrete reflectors on criticality of the vessel, and the effect of an air gap between these reflectors and the core. Plutonium concentrations were in the range of  $\sim 47$  to  $118$  g Pu/g with the nitric acid molarity maintained at about 2.

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Criticality data were obtained with the critical assembly vessel in the following states of neutron reflection:

- a) 10-inch hemispherical concrete shell (one-half reflected).
- b) Six-inch spherical concrete shell separated from the core by a four-inch air gap.
- c) Six-inch hemispherical concrete shell separated from the core by a four-inch air gap (one-half reflected).

The critical concentration of plutonium in the full sphere was determined for each of the above conditions of neutron reflection. The data for the effect of the air gap will be of use in evaluating the nuclear safety of in-plant equipment proximate to reflectors.

The results of the current experiments are summarized in Table I. The critical concentrations of plutonium in the full sphere, evaluated from these data, utilizing some previous results, are given in Table II.

TABLE II  
CRITICAL CONCENTRATION OF Pu IN 14-INCH SPHERE

(Measured Sphere Volume 23.22 Liters)

<u>Reflector Condition</u>	<u>Pu Conc. (g/l)</u>	<u>Acid Molarity</u>	<u>Total Nitrate (g/l)</u>	<u>Critical Mass* (Kg Pu)</u>
(A)	46.4	2.05	175	1.08
(B)	50.4	2.28	194	1.17
(C)	75.0	2.10	209	1.74

\* Includes 4.6 w/o Pu<sup>240</sup>

With a four-inch air gap (a width 57% of the sphere radius) between the vessel core and a six-inch spherical concrete shell, and extending the results to the case of zero nitrate (a Pu-H<sub>2</sub>O mixture), the critical concentration is increased by about 40% as a result of the air gap. Care must be used in the interpretation of these experiments since the nitrate correction depends on the effective sphere size as well as the Pu concentration. These results indicate this particular reflector combination (air gap plus concrete) to be equivalent to a paraffin reflector about

TABLE I

CRITICALITY STUDIES WITH PLUTONIUM SOLUTIONS  
IN 14-INCH DIAMETER STAINLESS STEEL SPHERE

(Measured Sphere Volume 23.22 Liters; Wall Thickness: 0.044-inch)

Experiment Number	Date	Reflector* Condition	Pu Conc. (g/l)	Acid Molarity	Sp.Gr.	H <sub>2</sub> O (g/l)	Total NO <sub>2</sub> (g/l)	H/Pu Atomic Ratio	Critical Volume (l)	Critical Mass (Kg Pu)
1143142	10-30-62	B	54.2	2.55	1.170	901	214	452.5	22.52	1.22
1143143	10-31-62	B	52.1	2.31	1.163	909	197	473.8	22.96	1.20
1143144	11- 1-62	B	49.6	2.27	1.172	926	193	506.6	23.35	1.16
1143145	11- 2-62	C	118.0	1.88	1.288	927	239	212.8	22.24	2.62
1143146	11- 5-62	C	115.0	1.95	1.266	912	240	214.6	22.23	2.56
1143147	11- 6-62	C	106.0	2.01	1.251	906	234	231.4	22.27	2.36
1143148	11- 6-62	C	98.2	1.83	1.230	915	215	251.8	22.38	2.20
1143149	11- 7-62	C	88.3	1.98	1.217	915	214	280.4	22.57	1.99
1143150	11- 8-62	C	81.7	2.07	1.205	906	214	300.4	22.80	1.86
1143151	11- 8-62	C	73.4	2.11	1.189	905	207	334.2	23.37	1.72
1143152	11- 9-62	A	73.3	2.08	1.177	895	206	330.9	19.77	1.45
1143153	11-12-62	A	59.6	2.03	1.177	926	188	420.6	20.82	1.24

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TABLE I (CONT'D)

Experiment Number	Date	Reflector* Condition	Pu Conc. (g/lb)	Acid Molarity	H <sub>2</sub> O (g/lb)	Total NO <sub>3</sub> (g/lb)	H/Pu Atomic Ratio	Critical Volume (l)	Critical Mass (kg Pu)
1143154	11-13-62	A	52.4	2.07	921	183	475.8	22.07 +.02	1.16
1143155	11-14-62	A	47.0	2.05	920	176	530.0	23.08 +.05	1.08

\* A = 10-inch hemispherical concrete shell (one-half reflected).

B = Six-inch spherical concrete shell separated from the core by a four-inch air gap.

C = Six-inch hemispherical concrete shell separated from the core by a four-inch air gap (one-half reflected).

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0.7-inch thick - less than a "nominal reflector" of one-inch thickness.

Critical mass studies were begun with an 11.5-inch diameter stainless steel sphere reflected with water. The measured volume of this sphere is 12.95 liters (about one-half the volume of the 14-inch sphere); the average thickness of the vessel wall is 0.049 inches. The 11.5-inch diameter sphere will permit extending the criticality data to higher plutonium concentrations with the vessel in the reflected state. This vessel was especially designed with an off center mounting of the control and safety rods, and contains provisions for a re-entrant tube to facilitate flux measurements along the axial diameter of the unit.

#### Experiments with Plutonium Oxide-Plastic Mixtures

Further work was done in preparation for the installation of the remotely operated split table machine in the second hood of the critical assembly room.

The mechanical components for the control and safety rod drives were completed; four units are available, two designed for poison insertion, and two designed for rapid removal of fuel (fuel bearing control or safety rod). The air motor and centrifugal clutch for automatically separating the table halves in the event of loss of electrical power were received. Wiring and control panel modifications proceeded during the month with the installation of the control rod switches and indicators in the control room.

A rough draft of the Hazards Summary Report for the Split-Table Machine was completed, and as soon as copies are available, these will be sent to reviewers for comments.

#### Instrumentation

Rod drop tests are now being run regularly at the Critical Mass Laboratory. The photomultiplier tube anode current from a scintillation probe is recorded on a high speed recorder as the rod is dropped. The difference between the neutron level before and after the drop is used to calculate the rod worth. A proposed model of a critical approach meter was simulated on the analog computer along with a typical critical experiment. Although the simulation needs further refinement, the results provided some incentive for further investigations towards developing a critical approach meter.

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Mass Spectrometry

A series of NBS uranium isotopic standards were measured on the heavy-element mass spectrometer for this program. A preliminary review of these measurements indicates a significant shift in instrumental bias during the month. Several attempts to obtain isotopic analyses on samples of PRTR fuel elements were failures, apparently because the chemical specifications of the sample solutions were not met by Analytical Laboratories.

Input Data Code for GAM - Tempest Chain

Development of the GAMTEM code has proceeded. This code, utilizing the GAM-Tempest combination, will provide multigroup constants representing heterogeneous systems in multigroup diffusion calculations. The coding of the main program, subroutines, and modifications to the Tempest, GAM-I, and P<sub>3</sub> codes, have been completed. The debugging of the supporting subprograms and subroutines is in progress.

Buckling of Partially Filled Spheres

Several major changes have been made in the two-dimensional partial difference code in an effort to get more accurate results. The analytic flux solution for a hemisphere has been used to estimate the accuracy of a difference equation necessary to describe the system. It was found that it is reasonable to use the maximum number of terms in the difference series for estimating derivations.

Since a constant flux assumption over a small volume element about the ij<sup>th</sup> point proved inadequate, and it is generally impossible to get a two-dimensional lattice in which the flux at ij is the average of the flux over the volume around the point, another approach is being used. The new technique uses the eight points surrounding ij to fit a quadratic equation in each dimension, then integrates and averages the flux for an approximation of the function

$$\bar{\phi} = \frac{\int \phi \, dV}{\int dV}$$

This, of course, destroys the usual eigenvalue form of the matrix equation, as now off diagonal terms have a buckling term. Debugging is now in progress on this last and very lengthy algebraic refinement.

Consulting Services on Nuclear Safety - Criticality HazardsNuclear Safety in HLO

Specification M-1, "Rules for Storage and Handling of UO<sub>2</sub> and Pu-Al Fuel Rods", in the Plutonium Recycle Critical Facility was revised and re-issued. The revision includes rules for handling individual fuel rods. Improved limits were possible, since use was also made of the data from the experiments conducted earlier this year with 1.8 w/o Pu-Al alloy rods in establishing the technical basis for the revised nuclear safety specification.

Nuclear Safety in CPD

A specification to cover the degreasing and pressing of plutonium metal turnings in Hoods HC4OD and HC4OB of the 234-5 Building was reviewed for CPD. The hoods contain three processing stations and 15 storage locations. Loose turnings are limited to 1.5 Kg of Pu/unit mass and briquetted turnings are limited to 4.3 Kg/unit mass. The total capacity of the two hoods is 61.6 Kg. Nuclear safety is based on assuring a 14-inch minimum spacing between unit masses and limiting the quantity of hydrogenous liquids in the hoods.

In establishing the technical basis for the specification, consideration was given of the fact that the maximum briquette density was 14.0 g/cc, rather than full Pu metal density, and that the diameter of the briquette was fixed at 2.7 inches.

Participation on the Recuplex Deactivation Hazards Review Committee and the Project 880 (new Recuplex) Hazards Review Committee continued throughout the month.

NEUTRON CROSS SECTION PROGRAMRotating-Crystal Spectrometer

Tests of the prototype rotating-crystal spectrometer were completed using the triple-axis spectrometer facility at 105-KE. The series of experiments which were performed included measurements of energy resolution, intensities both in the incident monochromatic beam and in the elastically scattered flux from a vanadium target. Measurements were made at varying distances between crystal, target, and detector. A poor signal-to-noise ratio was obtained in the scattering experiments. Much of the problem was shown to be due to fast neutrons which penetrated the 4 to 8 inches of temporary detector shielding. A new crystal rotator which will permit

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operation under vacuum and which has a number of other improvements has been designed and is being constructed.

#### Scattering-Law Measurements for Light Water at Elevated Temperatures

The thin window, high temperature, water sample for inelastic neutron scattering measurements was tested during the month. Measurements indicate that the sample container will provide a uniform 30-mil thickness of water to within one mil. Temperature variations across the sample have been reduced to less than one degree C when operating at 95 C.

Scattering measurements have not been started because of a reactor outage and the attendant loss of at least one week due to disassembling the spectrometer for reactor thermocouple maintenance.

#### Crystal Reflectivity

The (0002) crystal planes of beryllium have a high reflectivity for slow neutrons and are thus very useful for scattering measurements using the triple-axis crystal spectrometer. However, there exist conditions under which the crystal simultaneously "reflects" normally forbidden "half-order" neutrons from the (0001) planes. This "double Bragg scattering" effect may lead to substantial contamination of the neutron beam, especially for neutron energies of a few tenths of an ev. Some of our past measurements on room-temperature water required substantial corrections for this effect. In order to avoid this difficulty in future measurements, the condition for double Bragg scattering for arbitrary crystal orientation has been formulated. A Fortran program to perform the calculations is being written.

#### Fast-Neutron Cross Sections

A further series of measurements of fast-neutron cross sections using the pulsed-beam time-of-flight technique was completed. New measurements were made on ten elements: C, S, Cl, Ti, Cr, Ni, Zn, As, Cd, and I, and previous measurements on Al, K, and Fe were repeated. Of the above elements, As and I had not been previously measured at all over the energy range of 3 to 14 Mev. A total of 33 elements have now been measured on this program. During most of the measurements it was necessary to operate the Van de Graaff at the reduced voltage of 1.6 Mev because of voltage breakdown in the accelerator. The reduced deuteron energy has made it necessary to revise certain features of the data-processing program before the data can be processed.

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Samples of Be, C, Si, Cl (in  $\text{CCl}_4$ ) and Hg were obtained or prepared for total cross-section measurements. Samples of Rb, Cs, and Ga were received for sample preparation here. Orders have also been placed for samples of 9 rare earth elements and for Pd, Hf, and Au. In addition, requests have been made for the loan of 28 samples of separated isotopes from the Stable Isotope Cross Section Pool at ORNL for future measurements.

#### Instrumentation

A new pulse shape discriminator for fast neutron measurements was demonstrated in principle. The signal is doubly differentiated, and the different pulse shapes cause a crossing of the zero axis at different times. It is a principle that has not been applied to pulse shape discriminators before. Several engineering problems need a solution before the system can be used operationally.

The 1024-channel analyzer was returned from 100-KE reactor where it has been used to obtain test spectra for evaluating the rotating chopper used with the analyzer. Development work is now under way to convert the analyzer to 6144-channel capacity.

#### REACTOR DEVELOPMENT - O4 PROGRAM

##### PLUTONIUM RECYCLE

##### Lattice Parameters for Low Exposure PuAl Fuel

The final results for the thermal flux as a function of position have been obtained using a  $P_3$  code for the low-exposure PuAl lattices. The results for the PuAl lattices are being compared with the experimental activation traverses obtained earlier. The thermal utilization,  $f_{P_3}$ , for each lattice has also been obtained from the  $P_3$  code. A value for the multiplication factor has been calculated from the expression  $k_{\infty} = \bar{\eta} f_{P_3}'$  for the poisoned PuAl lattices. The value for  $\bar{\eta}$  used for this most simple model is the Maxwellian average for  $\bar{\eta}$  for the PuAl fuel at room temperature, and  $f_{P_3}'$  is the thermal utilization for the poisoned lattice. Resonance absorption in  $\text{Pu}^{240}$  has been ignored. The results are quoted below along with the experimental results.

<u>Lattice</u>	<u><math>k_{\infty} = f_{P_3}' \bar{\eta}</math></u>	<u><math>k_{\infty}</math> (experimental)</u>
10-1/2	1.016	1.000
8-3/8	0.999	1.000
6-1/2	0.998	1.000

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Although the agreement between the calculated and experimental values is fortuitous since the physical model is vastly over-simplified, the calculations will be useful for this type of lattice, for which  $k_{\infty}$  is close to unity and the concentration of  $\text{Pu}^{240}$  in the plutonium is low.

#### High Exposure PuAl Lattice Studies

The fabrication of the high-exposure (20.6 w/o  $\text{Pu}^{240}$ ) PuAl fuel rods and foils is now complete. This material has been transferred to the 305-B Building.

The relative plutonium content of 19 individual rods which could be used for the 20-inch central cell, have been measured by comparing their reactivity coefficients in the PCTR. The results on 19 rods indicate a maximum variation in plutonium content of 7.9%. One of the rods was much more reactive than the others. If that one is neglected, the maximum variation of the 18 rods was 4.9%. The weights of the rods were the same within .3%. The relative plutonium concentrations derived from the reactivity measurements, correlate very well with those given by chemical analyses of the core material from which these fuel elements were fabricated.

Reactivity measurements are now being taken on some of the 33-inch buffer and 20-inch separable fuel elements.

#### Low Exposure $\text{PuO}_2$ - $\text{UO}_2$ Lattice Studies

Work is in progress by Plutonium Fuels Development Operation on the preparation of the ceramic pellets for the mixed oxide fuel elements for PCTR and FRCF experiments. During the present month, personnel of PFDO have developed pressing techniques and determined the sintering characteristics of the powder.

#### The Critical Facility

##### a) Startup Experiments

An appropriation request has been written for the purchase of a 40-kilowatt heater and for its installation in the moderator system of the FRCF. This heater is for temperature coefficient measurements of various loadings in the FRCF, which will allow temperature corrections to the data.

The drawings for the hardware for the void,  $\text{H}_2\text{O}$ , and  $\text{D}_2\text{O}$  substitution experiments have been completed. The job is now in the shops.

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b) Irradiated Fuel Experiments

After the startup of the PRCF, measurements are to be made on fuel elements that have been irradiated to various exposures in the PRTR. The measurements will include reactivity determinations for evaluation of burnup in the fuel elements. The photo-neutron effect in the PRCF, due to the high gamma activity of the fuel elements, is expected to influence significantly the methods of determining reactivities. This problem is being investigated.

The subcritical flux level and equivalent power level of the PRCF are functions of fuel exposure, E, cooling or decay time of the fuel, and the subcritical multiplication of the PRCF. The subcritical power level of the PRCF for  $k_{eff} = 0.999$ , a fuel element exposure of 100 MWD, and a cooling period of 100 days is approximately one watt. The equivalent power levels, P, for different exposures and multiplication are given by

$$P = \left( \frac{10^{-5} E}{1 - k_{eff}} \right) \text{ watts where E is in MWD.}$$

The cooling time dependence is not a simple function.

The significance of this large subcritical power level ( $10^4$  higher than with PuBe source of the PRCF) is evident in the behavior of the PRCF flux level for  $k_{eff} > 1$ . Independent of the actual period of the reactor, the initial apparent period associated with the photoneutron source is approximately one second. The flux level is actually a linear function of time. For the fuel element cited above this would yield a power level of 100 watts (maximum allowable at present) in 100 sec. This is not sufficient time to measure periods in the normal manner.

Several possibilities of determining  $k_{eff}$  and hence PRCF reactivity are being considered. The burnup effects may be evaluated in terms of calibrated control rod worths instead of period measurements or subcritical measurements. The latter have long time constants, but are being investigated also.

The use of heavy-element gamma shielding does not seem too practical unless light-water cooling is used to remove the thermal energy of the irradiated fuel elements. This conclusion is based upon a line source approximation of the fuel cluster. In this approximation about 50% of the  $(\gamma, n)$  reactions occurs within the cooling thimble. Since a gamma shield must be outside the thimble, the shield would at best

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reduce the quoted subcritical power level by one-half watt.

Fuel Temperature Coefficient of  $k_{\infty}$  for Plutonium-Aluminum Fuel

Some further work has been done on the analysis of the experiment of Smith<sup>(1)</sup> in which 19-rod clusters of both low and high exposure PuAl fuel were heated. Since the low and high exposure clusters differed significantly only in Pu<sup>240</sup> content, the difference in the change in the neutron multiplication factors of the two lattices as a function of temperature is due primarily to the difference in the resonance absorption rates in Pu<sup>240</sup> in the two lattices. Approximate values for the difference in the change in the neutron multiplication factors as a function of temperature have been obtained from the data.

The same quantity has been obtained as a function of temperature from calculated values of the effective resonance integral for the two clusters. The model of the clusters used in this calculation utilized the "rubber band" surface and the actual volume to obtain an average chord length in the cluster. Dresner's wide-resonance formula<sup>(2)</sup> was used in the calculation of the effective resonance integrals.

The preliminary results indicate that the calculated values of the difference in the change in the multiplication were systematically lower than the experimental values by about thirty percent.

Pu<sup>240</sup> Effective Resonance Integral Experiment

A report on the effective resonance integral experiment for Pu<sup>240</sup> has been completed. The manuscript is now being cleared for publication in the open technical literature. It will be submitted to Nuclear Science and Engineering upon completion of the clearance procedures.

Theoretical Scattering Kernels for Water

Although some reduction in the discrepancies between Nelkin's scattering kernel for water and the Hanford and Chalk River experiments is achieved by modifying the basic constants of Nelkin's model as indicated by experiments, the discrepancies remain uncomfortably large. Nelkin's model approximates the density of states of water by a set of infinitely sharp

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- (1) Smith, R. I. Physics Research Quarterly Report, January, February, March, 1962, 71, April 16, 1962.
  - (2) Dresner, L. Resonance Absorption in Nuclear Reactors. New York: Pergamon Press, 1960.

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resonances, while experimentally the resonances are relatively broad. Consequently, the effect of a broad resonance structure is being studied in the hope of obtaining a model that will more closely agree with experiment. Since detailed scattering measurements on water have been made only at 20 C and 150 C, and only over limited ranges of energy and momentum transfer, a reasonably good theoretical model is required to interpolate between these temperatures and to extrapolate to energy regions presently inaccessible to experiment, so that one can predict the moderating effects of water for typical reactor applications.

#### Integration of the Egelstaff S-Function

In further study of the numerical schemes for integrating the Egelstaff S-function over scattering angle, we find by use of the ideal gas model, that a Gaussian Quadrature Method integrated on a logarithmic scale is superior to both the Gaussian Quadrature Formula on a linear scale and Simpson's Rule employed on a logarithmic grid. The Gaussian logarithmic scheme seems to combine the advantages of the log scale and the Gaussian technique to give better results than those obtained by either alone.

In addition, as a further check on numerical accuracy, we have coded the analytic expression for the first Legendre moment scattering cross section for an ideal gas, and are in the process of comparing this with results obtained by various methods of numerical integration of the Egelstaff S-function multiplied by the first Legendre polynomial.

We are also developing a program to integrate the analytic expression for the first moment over final neutron energy. This calculates  $\bar{\mu}(E_0)$  which is required for preparing input for the thermalization routine of RBU. Previously  $\bar{\mu}(E_0)$  has been obtained from evaluating the analytic expression. However, for certain ranges of the parameters the numerical accuracy has been poor and possibly a numerical integration will yield better results.

#### Plutonium Utilization Studies

The comparison of uranium and plutonium fuels for compact space power reactors is now being extended to a Li-7 cooled unit. To carry out this comparison requires the addition of Li-7 cross sections to the G-2 nuclear data tape. The transfer of the Li-7 data from the RBU library to the G-2 tape is presently being worked on. To obtain a proper assessment of the Pu/U comparison for compact power reactors, a series of check calculations for the GODIVA U-235 assembly and the JEZEBEL Pu assembly have been carried out using G-2. Additional calculations for these assemblies via the  $S_n$  code are also being performed to obtain comparisons of diffusion and transport theory results.

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A preliminary study of a two-zone, fast spectrum, 30 MW space power unit has been concluded. A core of this type may have some nuclear design advantages compared to a single-zone core, and more detailed future investigations of this concept might be warranted.

#### Phoenix Fuels for Compact, Water Moderated Reactors

A large portion of the beginning-of-life calculations for a plutonium-fueled, Zr-H<sub>2</sub>O assembly has been completed. So far, only a single Pu composite consisting of 90% Pu-239 and 10% Pu-240 has been investigated in detail. The range of Pu loadings is very large, however, from 5 to 150 kg total loading in a 500 liter core volume. Different L/D ratios of the core have been assumed and initial  $k_{eff}$ 's have been determined. As reported previously,  $k_{eff}$  is quite flat over an appreciable range of reactor loadings. The behavior which can now be discerned shows  $k_{eff}$  rising at first as the fuel loading is increased. A very flat maximum then results followed by a shallow dip. This dip is due to the presence of Pu-240, and the spectrum hardening as the fuel inventory rises. Upon further addition of Pu,  $k_{eff}$  again begins to rise. This delayed increase in  $k_{eff}$  is probably due to high lying fission resonances in Pu-239 and the extreme hard spectrum resulting from the very high fuel inventories.

A set of representative power distributions has been examined for various plutonium loadings. These power distributions show no unique or unexpected behavior. As the core loading increases and the core diffusion length decreases, the power density rises sharply at the core reflector interface.

Additional beginning of life calculations have been carried out for selected loadings of some steel-water cores. These results are still quite incomplete.

Different Pu composites and core burnups are presently being considered.

#### Code Development

##### SIGMA-3C, SIGMA-3H

Two bugs have turned up in the similar portions of these two programs. One has been eliminated while the other is still being worked on.

##### CALX

With the elimination of a bug in the SIGMA-3C routine the effective K given by the SIGMA subroutine of CALX differs from that given by HFN by only 0.12 percent for the test case presently being run.

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RBU

A method of calculating the diffusion coefficient during Monte Carlo execution has been developed. Comparison of the new method with another older method previously used in the Monte Carlo shows the older method to be incorrect. The new method, along with the improved thermalization technique and several minor alterations, is being inserted into the program.

Analysis of a Pu-H<sub>2</sub>O reactor cell in slab geometry using the Monte Carlo and diffusion portions of RBU revealed a basic limitation of the Monte Carlo. If the reactor cell is made up of very small regions, it is improbable in certain situations to have a collision occur before crossing a boundary. Thus one may spend most of the time, particularly at high neutron energies where the mean free path is large, transporting a monoenergetic neutron through regions of the cell. While this is physically correct, large amounts of time are spent calculating this neutron migration; consequently, even simple cells of this type require relatively long computing time.

Updated Cross Section Libraries

The new RBU Basic Library data tape has been made and utilizing two versions of BARNs, new TEMPEST and GAM-1 libraries have been made.

In order to establish some degree of confidence in these data, preliminary tests are being performed utilizing the new GAM-1 - TEMPEST libraries.

Spatial Resonance Self-Shielding

Coding of program GROUSS, which computes group self-shielding factors, has been completed and checkout is in progress. The program produces single level Breit-Wigner cross sections in fine energy detail of resolved resonances and at specified energy bands in the unresolved region performs Doppler broadening by direct numerical integration of the cross sections times the relative velocity probabilities, applies parametric spatial flux depression factors, and uses 1/E flux weighting to determine group cross sections.

Theory-Experiment Correlation for Program GROUSS

Two PCTR experiments (natural uranium, tube-in-tube and 2.5" solid slug) are being analyzed by P-3 and S<sub>n</sub> methods to check the self-shielding factors produced by program GROUSS. The P-3 method failed for the tube-in-tube air-cooled cell.

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The range of  $\Sigma_a(\text{fuel})$  was from very large to very small (transparent to black) and the fuel scattering taken as:

$$\Sigma_s = \Sigma_{\text{POTENTIAL}},$$

$$\Sigma_s = \Sigma_a, \text{ and}$$

$$\Sigma_s = 2 \Sigma_a .$$

### Instrumentation and Systems Studies

The second generation liquid effluent monitor for gamma emitters was accurately calibrated and installed at PRTR. Minimum detectable sensitivity was determined to be  $10^{-5}$   $\mu\text{c/ml}$  for  $\text{Cs}^{137}$  in water solution. Drawings of the instrument and probe were prepared. The original experimental unit installed at PRTR continued to perform reliably.

Development continued on a preamplifier for use with fission counters for high flux and temperature locations at the PRCF. At present, the design appears to be satisfactory and should provide a better signal-to-noise ratio than was possible previously.

The prepared scope drawings for the underwater gamma scanning facility were reviewed with PRTR personnel and appropriate changes are being made.

Work has continued on the problem of obtaining quantitative measurements of the fuel assembly vibrations which have been encountered in the PRTR. Special sensing coils and the external excitation and readout circuitry for conducting tests at temperatures to  $500^\circ\text{F}$  have been assembled and tested and are awaiting completion of the high temperature mockup being built by Equipment Development Operation.

Cross-spectrum analysis of the test data obtained during the PRTR kinetics test in August was attempted using the EASE analog computer. The analysis confirms the previous power spectrum analysis and indicates that a larger data signal-to-noise ratio is required to provide significant kinetics information. Instrumentation is being installed to measure moderator level and galvanometer chamber flux simultaneously.

### HIGH TEMPERATURE REACTOR PHYSICS PROGRAM

Efforts to reduce the cost of the HTLTR to \$1.9 million are continuing with the design scope reduced to achieve this goal. The maximum temperature of the driver-reflector has been reduced to  $1000^\circ\text{C}$ , which permits

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the use of Inconel instead of exotic metals or ceramics for control and safety components, thermocouple sheaths, etc. The BSR housings will probably be cooled to allow motors and latches to be inside the reactor-gas seal. The HCR system is not being designed to scram rapidly because of possible breakage and the problem of providing a driving force (springs or air cylinders) with high temperature materials. However, if the fuel is designed to provide a negative prompt Doppler coefficient, the control rods should not be needed as a fast shutdown device.

Instrumentation is being oriented to an on-line data logger system. The capabilities of this system are desirable unless the cost becomes excessive.

The neutron source for critical approaches and startup will be an accelerator-type generator. Pu-Be sources and low level detectors cannot safely be operated at 1000°C; thus a strong source outside of the reactor is needed to provide enough flux to a detector which is also outside of the reactor. The problem of short target lifetime of typical neutron generators has now been solved by the manufacturers of these devices; so that a generator now appears practical. A yield of  $10^{10}$  to  $10^{11}$  neutrons/second can be obtained from neutron generators priced at \$20,000-\$30,000.

#### NEUTRON FLUX MONITORS

Progress was made in preparing for the experiment to determine the neutron temperature,  $T$ , and the spectral parameter,  $r$ , in the test facility which will also be used for irradiating the experimental regenerating detectors. Aluminum foils were prepared on which cobalt is to be deposited and cadmium covers were fabricated to permit cadmium ratio determinations. The irradiation sample containers were made using high purity aluminum components. The necessary quantity of U-235, containing no U-236, was found to be available, and the necessary Pu-239, essentially free of Pu-240, has already been obtained. Efforts were made to establish the chemical processing steps necessary so irradiated samples of U-235 and Pu-239 can be analyzed in a mass spectrometer.

#### NONDESTRUCTIVE TESTING RESEARCH

##### Electromagnetic Testing

The electronic units being fabricated and checked out on-site for use in the multiparameter eddy current testing equipment are nearing completion. Some changes in circuit design are being made which were found to be necessary as a result of tests of individual units. Additional data on

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eddy current test response to standard notches in 3/16 and 1/4 inch diameter tubing are being obtained for use in the broadband work. Additional data were obtained in the measurement of the diffusion of eddy currents to permit completion of a set of models showing the diffusion pattern.

The two crystal oscillators which had been constructed for the multiparameter eddy current test equipment proved to be quite unstable when tested. Therefore, several new oscillator circuits were breadboarded and tested. One design proved to be very stable and exhibited good signal waveform and high amplitude. The oscillators are being modified in accordance with the new design.

Measurements in the eddy current diffusion study were continued. Enough data have been obtained to construct a three dimensional model of the eddy current distribution which results when a square current wave is applied to a cylindrical drive coil. The three dimensional model is being constructed.

A dual channel tubing tester is being fabricated which is expected to permit the recording of test data during an eddy current tubing test in such a way that information concerning the depth of the tubing irregularities causing the signals will be shown on the record.

One of the two 400 Kc tubing testers, Model 1001, is being modified to operate at 250 Kc for use in testing 1/4" 304L stainless steel tubing with 0.049 inch wall. This modification is being made for field application, but data on notched tubing standards are being obtained which are pertinent to the broadband eddy current study.

Assistance was provided in the examination of 3/16 inch diameter tubing standards received from a tubing fabricator who is fabricating tubing for use in N Reactor. Comparison measurements were made using the 400 Kc eddy current tubing tester and Hanford electro-machined notch tubing standards.

#### Heat Transfer Testing

A technical interchange with Automation Industries, Inc., has proved beneficial. A reprint of a recent article describing HAPO heat transfer testing work has been sent to them, and we have received two reports describing their work.

Automation Industries' main heat transfer testing program emphasis has been on theoretical and experimental evaluation of applications in measuring material properties, such as density, porosity, heat treatment and hardness, and imperfections and crystal variations. The main limitation in their work has been due to the use of marginal experimental equipment. Although some

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consideration has been given measurement of material properties, the Hanford heat transfer testing program emphasis has thus far been concentrated on the development of instrumentation for detecting various structural defects in fuel elements.

#### Zirconium Hydride Detection

An eddy current method was demonstrated to be capable of detecting hydrided areas in Zircaloy-2. Improvements were made in the equipment being used in these studies. This resulted in improved detection of hydrided areas in sections of Zircaloy-2 process tubes.

Cooling samples to 77° K reduces regions of ambiguity in the instrument reading versus hydride concentration curve which result when the samples are at room temperature. However, the room temperature measurements can certainly be used to detect hydride, and would be more convenient for application to actual field tests. Therefore, equipment is being developed for both purposes. An insulated box was fabricated so that large samples could be submerged in liquid nitrogen. Subsequent tests on sections of Zircaloy-2 process tubes containing 2000 and 5000 ppm hydrided areas showed that the relative increases in readings (which can be caused by several factors, including an increase in resistivity) over the hydrided areas were larger at 77°K than they were at room temperature. At room temperature, the increase in reading for the area containing 2000 ppm was larger than that for the 5000 ppm area. This apparent anomaly was reduced when the tubes were submerged in liquid nitrogen; the increase readings for the two areas were then the same. A number of factors could be responsible for such an anomaly. Determination of these factors will require extensive destructive examination of the samples. Several samples of hydrided Zircaloy-2 suitable for destructive examination have been obtained. However, these samples are small and modification of the eddy current equipment will be necessary prior to measurements on them. A new, small-sized eddy current probe for use at a frequency of 470 Kc has been designed and fabricated. This probe will reduce the effect of sample curvature on the instrument readings. A v-block was fabricated to maintain the probe in the proper position when testing tubing. Inductance and capacitance of the probe are too great for application at the high frequencies that are desirable when testing thin samples. It will be necessary to fabricate a new probe for use with the small samples that were obtained for destructive analysis.

Several oscillators and bridge circuits have been used in the experiments thus far. None of these have had the exceptional stability required; drift and other changes cause some difficulty when comparing readings from various sets of samples. Improved equipment will be needed for future measurements.

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USAEC-AECL COOPERATIVE PROGRAM

Nondestructive Testing of Sheath Tubing

A first draft of a "Tentative Recommended Practice for Immersed Ultrasonic Testing of Zircaloy Fuel Element Sheath Tubing Using Lamb-Waves" has been completed. Preparation of electro-machined standards recommended in the procedure were found to be facilitated by use of wider electrode material than that used to date. Tests were also completed on notch depth studies demonstrating the need for a compromise in selecting the parameters for the test as set forth in the recommended practice. Correlation studies demonstrating the features of the proposed test on naturally occurring discontinuities are in process; as is the extension of the test to thinner walled (0.017") material. Analytical studies have been directed toward the goal of numerically computing, by machine program, the relationships between phase velocity and the fd product for the first twelve Lamb modes.

The rough draft document on recommended testing practices sets forth the various parameters that have been established by test work on the program to date. Further work is continuing on the theoretical and experimental bases for selection of these test parameters. These results, together with the results of test correlation studies now underway, will be included in a more complete document to be prepared later.

Prior reports have discussed the use of electro-machined notches for primary calibration benchmarks, and some problems in fabricating narrow deep notches. These difficulties appear to be eliminated by increasing the electrode thickness from 1 mil to 3.5 mils. With the thicker electrode, good quality transverse notches were obtained at depths from 10 mils through 17.5 mils, which is one-half of the wall thickness of the tubing originally under investigation. Replica material was cleanly removed from the wider notches and good depth measurements were obtained.

To check the parameters selected for the ultrasonic test, ultrasonic response measurements were made on a complete set of carefully fabricated notches. The completed set of electro-machined notches includes both transverse and longitudinal notches varying in 1/10 wall thickness steps from 0.015 mils to 17.5 mils. Sets have been completed both in material with 0.680" I.D. x 0.035" thick wall, and 0.600" O.D. x 0.017" thick wall. Measurements are completed on the 0.035" thick wall tubing, and are in progress and continuing on the thinner walled tubing.

Further work was completed comparing shear propagation (at a nominal  $45^\circ$  angle) to supposedly Lamb-wave mode propagation for detection of longitudinal discontinuities. The results confirm that the  $45^\circ$  angle shear propagation appears to offer the best compromise. Though signals from surface and outside surface imperfections always appear at different time intervals and are not similar for various depth notches because of the zig-zag propagation for  $45^\circ$  shear, these difficulties are more tractable than the confusing problems encountered when Lamb-wave modes are supposedly used. The generation of usable Lamb wave modes continues to appear problematical for the diameter and wall thickness of tubing under consideration. As reported previously, nominal Lamb-wave mode angles give non-linear response to varying notch depth, the response curves are abrupt and steeply changing, and the welter of indication signals with their difficulty of interpretation appear to make a practical longitudinal test using Lamb-modes improbable. Consequently, for the longitudinal test on 0.680" I.D. by 0.035" thick wall tubing, it is recommended that a point-focused transducer operating at a frequency of 5 Mc and adjusted to provide an entry angle of  $45^\circ$  be used.

For the transverse discontinuity test, the completed tests reaffirm previously indicated parameters. In this case, a Lamb mode is desirable and usable. The most favorable transverse test appears to be at 10 Mc, using a point-focused transducer at an entry angle of about 21 degrees which propagates the 4th symmetrical Lamb mode.

Though the completed test data in this instance were obtained with only one of the many commercially available ultrasonic test instruments, previous work comparing the various instruments demonstrated that similar responses would be obtained in every case. In performing the experiments using the  $45^\circ$  degree shear propagation for the longitudinal test, it was observed that the return or reflected signals appeared to propagate in a zig-zag manner. At one time, from the plate studies using Schlieren imaging, it appeared probable that the reflected energy of a propagated Lamb wave mode returned in a Lamb mode also. This deduction was based on the appearance of diffraction patterns in the water leakage beams. However, since the reflections were from the entire plate edge (representative of a through discontinuity), it would appear this is only a special case, and reflections from smaller, shallower discontinuities do not return as Lamb wave modes.

Work is progressing on the evaluation of the proposed ultrasonic sheath tube test using naturally occurring discontinuities. Nine tubes initially selected from a lot of 275 as likely candidates having discontinuities of interest have been completely ultrasonically tested (two transverse scans, and two longitudinal scans each from opposite directions) and fluorescent

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penetrant tested. For this preliminary evaluation, all ultrasonic indications 50% or greater of the amplitude of the standard, were recorded and marked on the tubes. Using production established procedures for the fluorescent penetrant test, no penetrant indications of any kind were found. By altering the production procedure (shorter emulsification time), the sensitivity of the penetrant test was increased and some correlation was found with the ultrasonic indications. Sectioning will reveal the nature and extent of the discontinuities.

To provide insight into the fundamental problems involved in ultrasonic propagation in tubes, attention continued to be applied to analytical studies. In order that Lamb wave phase velocity versus frequency-thickness curves for Zircaloy can be obtained more accurately for any values of longitudinal and shear velocity, a numerical computer program is being developed. The program is designed to provide tables of solutions to the first twelve Lamb modes. Concurrent with this work particle vibration and wave structure during Lamb wave propagation had been partially studied. Previously it was reported that the frequency, particle displacement, and wave amplitude equations were continuous for all phase velocities and frequency-thickness products. Recently, however, it has been found that the wave amplitude equations are only valid for phase velocities slightly above and greater than the longitudinal velocity,  $V_L$ . The system of four wave fronts leading to the amplitude expressions does not appear to be a valid wave model in the neighborhood of  $V_L$  and below. Pending the completion of the numerical program for providing tables of the frequency equation, the wave properties for phase velocities near, at, and below  $V_L$  must be studied before more complete propagation models are explained. In order that certain other anomalies be explained, it may also be necessary to study the problem of the liquid loaded plate which more nearly approximates the actual Lamb-wave propagation condition.

A topical report, HW-75292, has been issued on the optical Schlieren system for ultrasound imaging. This document will be distributed to those receiving USAEC/AECL Cooperative Program reports.

#### BIOLOGY AND MEDICINE - O6 PROGRAM

##### Atmospheric Physics

Four additional atmospheric dispersion experiments were conducted during the month, utilizing the elevated source at a height of 185 feet on the meteorology tower, bringing the total for this series of tests to eighteen. Dosages of zinc sulfide at 1.5 meters height were measured to distances of one mile from the tower base. Meteorological conditions were neutral and unstable with wind speeds ranging from seven to thirty miles per hour.

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These data constituted a reasonable set for machine reduction, and processing was in progress at month end.

Calculations of the flux of zinc sulfide tracer material through the surface formed by the horizontal and vertical sampling grids progressed for selected experiments in the "30 Series". The reduction in mass passing through successive planes downwind is attributed to deposition on the ground surface and vegetation and provides the basis for ultimately obtaining a mass balance from other direct deposition measurements. The rise of the plume centerline with distance continues to be an important factor in the deposition estimates.

First analysis of the diffusion data obtained at Vandenberg Air Force base was completed, adding considerably to our understanding of dispersion processes in the marine layer along the rugged California coastline. More comprehensive analyses cannot be made until temperature and wind fluctuation data are received from the Air Force. Regression equations were completed for the decrease of normalized peak exposure with distance and the increase of plume width with distance for each test series. Good consistency was found between the Vandenberg, Hanford, and Cape Canaveral data when atmospheric density stratification for each test was taken into account. However, two conditions unique to the Vandenberg data cannot be compared directly, 1) the ducting phenomena occurring during daytime summer regimes and 2) the topographic effect of the Santa Inez Valley during stable conditions.

Precipitation scavenging work was plagued by unsuitable weather conditions during the month. An attempted experiment on the 6th failed due to poor wind conditions and another experiment on the 12th produced only marginal data.

#### Dosimetry

The shadow shield whole body counter was taken to Seattle and set up in the Northwest Research Institute of the Swedish Hospital. This was done under the HLO contract with Swedish Hospital. Four experiments were performed. In the first, six patients being treated with an artificial kidney were measured to determine the change in their body burden of potassium as a result of the treatment. These patients are connected to the artificial kidney once or twice a week and their blood circulated through it to remove acids, excess potassium, and other poisons. The typical decrease in potassium, according to our measurements, was about 15 grams, or about 10% of the total in the body. The measurements were a particular stringent test of the whole body counter. Our results were said to be about what was expected, but chemical analysis of the fluids

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from the artificial kidney are not yet available for direct comparison.

In the second experiments, patients having known tumors and suspected metastases were given 5-iododeoxyuridine tagged with I-131 and then scanned differentially with the whole body counter. The hope, of course, was that the tagged compound would either concentrate or be held longer in the tumors than in normal tissues so that scanning would locate the tumor; experiments on animals had indicated that this would be the case. For this experiment we built a slit system for the scintillation crystal to narrow its field of view. The slits were also made so they could be positioned at several angles with respect to the line of motion of the subject through the counter. Two or more runs of a subject through the counter would serve to locate a source within the body. In tests with point sources, the source could be located to within about half an inch. In the patients the activity was diffused throughout different organs, so only the organs could be located. Concentrations of radioactivity were found in several of the patients. Beyond this, it is more difficult to summarize the results of this experiment. Probably the best summary is to quote the physician in charge of the experiments, who said he had learned a lot from it. Since this was the first trial of the tagged compound in humans, this is the best that could be hoped for.

In the third experiment, the slit system was used to see if there was any difference in the distribution of K-40 and K-42 in the body. The experiment was performed because of our interest in the possible effect of the result on the calibration of whole body counters. The experiment is not yet completed. Incidental to this experiment, the shadow shield counter was calibrated again for potassium. The result was a few percent different from earlier results. It was a few percent different, but in the other direction, from the value needed to explain some small differences found this summer. These small differences are not of crucial importance. They are probably explained by the fact that each result was obtained with a different scintillation crystal--all nominally identical, but practically slightly different.

The last experiment was to calibrate the shadow shield counter for Zn-65. The work is not finished yet.

The Van de Graaff operated satisfactorily until near the end of the month when symptoms of the trouble we had this summer, which had disappeared spontaneously, reappeared.

A detailed intercomparison of the paraffin and the polyethylene double moderator systems was made in order to calibrate the latter. It was decided that more data points are needed to give the desired accuracy of calibration.

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Another pulse shape discrimination circuit described in the literature was built and tested. It appears to be no better than the circuits we already have.

Our PuBe sources are in the process of being recanned by Mound Laboratory. This is being done one-at-a-time so that adequate intercomparisons can be made in order to preserve our standardizations. One source, M-710, appeared to change in neutron emission by 0.2%. Source M-596 appears to have changed a negligible amount.

A rotational trainee began a study of LiI scintillation crystals aimed at development of a new fast neutron spectrometer. Usually such crystals are used at liquid nitrogen temperature; the present study was at room temperature.

#### Radiation Instruments

Experiments started on a method to permit direct external recharging of the dosimeter used in the single trip point (50 mr) signalling personnel dose meter. One experimental dose meter was loaned to Radiation Protection Operation for their evaluation testing to determine its usefulness in Hanford personnel dosimetry. A second experimental dose meter was modified to use a neutron sensitive sensor and two dose meters, one gamma sensitive, were simultaneously irradiated in a test pile. The modified unit definitely detected the neutrons; however, more data will be required before a true neutron sensitivity can be determined. The basic dose meter solid state circuit is proving to be quite versatile.

The field model of the gamma background compensated beta-gamma hand and shoe counter was partly completed. The instrument employs scintillation detectors and all solid state circuitry.

General requirements were established with Biology personnel regarding thyroid monitoring instrumentation for use in experiments.

Design was completed for a gravity feed mechanism to load and unload samples from the experimental automatic sample changer. Necessary components for the experimental mockup were ordered.

Progress continued on the experimental portable mast system being developed for use by Atmospheric Physics Operation. A circuit was developed to change the print-out rate of the printer at the option of the operator. As designed, either continuous printing or selected single data block, of twelve, printing can be used. The circuit should eliminate paper tape changing during an experimental run. All data will, of course, be continuously

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punched out for record. Development was started on a servo-type dc amplifier to be used in the thermocouple temperature measuring portion of the system. The necessary machining and fabrication were completed and a preliminary bench test was successful.

A new solid state reset circuit, for use in the combination alpha-beta-gamma hand and shoe counters, was designed and tested successfully.

A special solid state power supply, rated at 0-30 VDC and 0-25 amperes, was designed and will be fabricated for experimental use. The design was carried out since no commercial unit with the required capabilities could be obtained.

A constant current supply for use with hot wire anemometers was designed for use in Atmospheric Physics Operation experiments. Calibration and metering circuits were included.

In support of Atmospheric Physics work regarding the detection of filter-entrapped microgram quantities of beryllium, further calculations indicated that the  $(\alpha, n\gamma)$  reaction is most promising. With a Po-210 alpha source, gamma and neutron detectors, and coincidence circuits, calculations indicate the required sensitivity is feasible. The relatively short half-life of Po-210 is a disadvantage, but procurement of a commercially prepared Po-210 source was started in order to carry out experimental tests of the proposed detection scheme.

The data handling problems associated with meteorology wind measurements were better defined. Instrumentation is needed to determine a running average of the wind vector in a horizontal plane over a 5-20 minute period, and to measure the variation of the instantaneous wind vector about this average.

The design of the core driving circuit for the 400-channel analyzer for the Van de Graaff facility has been completed. Output pulse is a three to four microsecond, 250 milliampere pulse. A 250 nanosecond rise time and 120 nanosecond fall time are associated with the pulse. Work is still continuing on the sense amplifier for the core memory. A trial circuit was constructed but proved to be inadequate during a four day test run.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Program

The mass spectrometer for this program provided isotopic analyses of

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program samples as received this month. The results of the repeated analyses of a natural uranium isotopic standard during the month indicate that the instrument bias changed significantly from about -0.5 percent to -1.7 percent in the measurement of the  $U^{235}/U^{238}$  ratio. The reason for the shift in bias is not understood; however, some malfunctions of electronic components of the mass spectrometer occurred during this period of time.

#### TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month. There was one unscheduled shutdown caused by electronic failure.

The 20% Pu-240 Pu-Al fuel elements were sorted for Pu content by reactivity measurements. The results agreed well with the chemical analyses.

The PCTR ion chambers were checked for linearity at levels up to 100 watts. All chambers performed satisfactorily.

Operation of the TTR was on an intermittent basis during the month. There was one unscheduled shutdown as a result of faulty bypassing technique.

The TTR was made available to the University of Washington Graduate Center on a two nights a week basis during the month.

Installation of the new safety sheet system was completed during the month. The safety sheets are now held out by magnetic clutches, and in case of a trip of the safety circuit or a power failure, the sheets drop in by gravity.

The TTR ion chambers were checked for linearity of output with increasing neutron flux. The TTR galvanometer and logarithmic amplifier chambers were slightly non-linear at PCTR power levels exceeding 50 watts and were replaced by tested chambers. Two new chambers were checked and were linear to 100 watts, the maximum power level used in the test.

A digital voltmeter has been used to measure flux transients which occur after insertion of the safety rods of the TTR. Previously these measurements were made using a chart recorder to record the transient. It was then necessary to read the numbers off the chart. Also, the response of the chart pen was not fast enough to accurately record the initial transient.

The voltmeter is arranged with other equipment so that the readings begin automatically when the rod is dropped and occur at equal intervals of time. The rapidity of readings is limited by the time it takes for a

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typewriter to type out the reading. This is approximately 1 sec per reading.

CUSTOMER WORK

Weather Forecasting and Meteorological Service

Consultation service was rendered on meteorological and climatological aspects of 1) low altitude sampling of fallout to CR&D and 2) oxides of nitrogen release in 300 Area to IHO for FPD.

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

Weather Summary

<u>Type of Forecast</u>	<u>Number Made</u>	<u>% Reliability</u>
8-Hour Production	90	79.2
24-Hour General	60	81.1
Special	179	83.2

November was considerably warmer and a little drier than normal. There was a high wind with a peak gust of 57 miles per hour, the strongest so far this year, on the 19th.

Instrumentation and Systems Studies

The automatic conveyor-type laundry contamination monitor is in continuous use at the Hanford Laundry Facility. In six weeks of such operation, the only downtime necessary was for the replacement of a defective high voltage adjustment potentiometer. A spare alpha detection probe and a spare beta-gamma channel preamplifier were completed and delivered. The Laundry Facility maintenance technician was shown how to re-cover alpha detection probes to provide a light-tight shield, and the general maintenance and instruction manual was completed and is being typed in rough draft form.

A special GO or NO-GO liquid conductivity monitor, all solid state with electronic trips, was designed and fabricated for use at the 234-5 Building to determine the presence of plutonium-bearing solutions.

A vacuum pump is being added to the field-model, continuous, coincidence-count alpha air monitor which completed another month of satisfactory

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operation. The instrument, designed and fabricated for Radiation Protection Operation, was originally scheduled to be used with building vacuum lines; however, the test location decided upon by RPO required the addition of a vacuum pump. The complete technical report was typed, reviewed, and is in process of being cleared for issuance as a formal report.

Tests with miniature halogen-quenched G.M. tubes to drive long cables were made in an effort to devise a satisfactory G.M. detector system for Coolant Systems Development, HLO. A solid state preamplifier, with feedback stabilization and dynamic cable impedance matching, was designed and tested. The designed system can easily drive 200 feet of coaxial cable.

Preliminary calculations were made to determine the feasibility of measuring plutonium content in scrap materials for Finished Products Chemical Technology, CPD. For homogeneous samples with identical geometry, it appears that relatively accurate measurements can be made; however, for non-uniform cartons, the correlation between measured activity and plutonium content would be difficult. Further work awaits detailed container information from CPD personnel.

The tape punch developed for Fuels Development Operation was modified and is now in operation at the K-East underwater measurement facility. The punch is now capable of recording fuel element wall thickness and diameter alternately, thus halving the time required for making measurements.

A second punch system was assembled and installed in 333 Bldg. for Quality Control Engineering, FPD. This system is also used to record fuel element dimensions.

Work on the evaluation of micro-displacement readout systems to be used by Physical Metallurgy Operation for in-reactor creep measurements has continued during November. Calibration data from the model 801-D translator are undergoing computer processing and the data from the 801-C translator have been processed and are being correlated for incorporation into the evaluation report for this system.

Advice and consultation were provided the NPR Field Engineering Operation on technical questions arising during an evaluation of the eddy current equipment and testing procedures employed by a vendor supplying 3/16" O.D. x 0.035" wall stainless steel tubing for NPR. A visit was made to the vendor's plant in Pennsylvania, and a report discussing the pertinent aspects of this trip was issued.

A method of limiting the charge accumulated on the FPD autoclave controller integrating capacitor during startup operations was tested during the month.

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Several startups were made with little, if any, overshoot after the proper controller settings were found. The tests were made on an unloaded vessel to eliminate the possibility of ruining fuel elements in the event that out-of-standard operation occurred during the tests. Further tests are needed to establish the proper controller characteristics for a loaded vessel although only minor changes are expected to be necessary. A multi-point recorder was used to measure the six vessel temperatures (three process and three wall temperatures) and the controller output during a number of startup and setpoint change tests in an attempt to determine the transient behavior of the various process temperatures. Analysis of the data is in progress.

Startup and acceptance tests on the Minneapolis-Honeywell 60-point data logger, to be used for the recording and analysis of the uranium swelling program irradiation tests data, were successfully completed. With the exception of the previously waived specifications concerning temperature readout, the data logger met all specifications. Temperature readout will be in °F instead of the originally specified °C. The data logger has automatic log cycle intervals of one through 24 hours. In addition to the periodic log cycles, the uranium swelling program requires that logging commence during any reactor transient or deviation from temperature setpoint. To accomplish this task, external detection circuitry is being developed. Scan and high-low alarm features can be incorporated into the data logger providing another mode of operation whereby between regular log cycles, all points are scanned at the rate of seven points per second and only "out-of-limits" data are printed. A transducer is being developed which will economically convert heater power up to five kw to a proportional 0-100 millivolt d-c signal. The voltage to the heater will not be pure sine wave since SCR heater control will be used.

The Hanford test reactor is being simulated on the EASE analog computer at the request of Advanced Engineering, IPD. It is desired to record the peak fuel temperatures reached during nuclear excursions resulting from the insertion of a stringer of enriched uranium fuel plugs into the core while the reactor is operating at its equilibrium power level.

A cost estimate was made of the Ground Water Analog project for Chemical Effluents Technology. Assistance was given by writing the appropriation request and the purchase specifications for equipment to be used in the analog simulation.

As reported last month, the analog simulation of the CPD Gorton tracer lathe showed a number of discrepancies with the expected results. Rechecking of the calculations and rechecking of the simulation and wiring disclosed a number of errors. After their correction and some additional

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changes, the system was finally in a form where previously observed instabilities were overcome. The final setup was used to investigate semi-automatic plotting of Nyquist diagrams for complete checkout of systems. This was accomplished with the Boonshaft and Fuchs transfer function analyzer and a Moseley X-Y recorder. It was found that this method provides an accurate and very rapid check on the system under investigation.

A digital program to calculate cylindrical heat coefficients for analog simulations was used during the month. Values of coefficients calculated were used in analog computer simulations.

### Optics

Modifications to a new 1-1/8 inch diameter borescope were completed. These modifications permit photography through the borescope using a 35 mm camera. The unit was tested thoroughly in mockup reactor tubes to calibrate the focus adjustments. The focus changed greatly with the addition of sections to the borescope. Some sections required adjustments in directions opposite to others. This makes it necessary to put the borescope sections on in a predetermined order so that precise focus adjustments can be made. The unit was designed for a Leica camera back which was on hand. A different camera back with reflex view finder and range finder has been ordered which will permit accurate focusing with much less work and in less time than required with the Leica.

Fabrication and design continued on the camera which will be used by Testing Methods Engineering for photography of the inside surfaces of two inch and 3/4 inch I.D. tubes. Components are now on hand for the assembly of the probe for the large diameter bores.

During the four-week period (October 28-November 25) included in this report, a total of 408 manhours shop work was performed.

The work performed during this month included:

1. A thorough cleaning and reconditioning of the vacuum system.
2. Fabrication and assembly of a camera unit for use on a process tube borescope by Irradiation Testing Operation, IPD.
3. Repair of one process tube borescope.
4. Repair of one crane periscope head for Redox Operation.
5. Fabrication of components of the Fuel Element Bore Camera.
6. Fabrication of three quartz scintillation discs for Process Control Development.
7. Aluminizing six mica sheets for the Tube Shop, FPD.

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8. Repair of one Opton microscope for Radiometallurgy Operation, 327 Bldg.
9. Modification of one pyrometer for Manufacturing Maintenance, FPD.
10. Repair of an underwater periscope at 105-F Bldg.
11. Fabrication of six film holders for Radiological Development and Calibrations Operation.

#### Physical Testing

Normal activity in testing service work was experienced; accelerated activity is momentarily anticipated upon receipt of the K-reactor replacement process tubes. A total of 4,517 tests were made on 5,656 items representing 25,300 feet of material. As in past months, tubular components continue to constitute the single largest area of activity in testing. Twenty-six different components representing most of the HAPO operating departments and service organizations and a number of AEC contractors were provided services. Advice was given on sixty-two different occasions on general testing theory and applications.

Successful operation of one autoclave in the tube test shop was achieved with all operating procedures in accordance with Code approved practice. Excellent oxide films were obtained on PRTR process tubes (both regular and loop tubes) and on KER process tubes. The successful autoclaving of the PRTR process tubes marked the completion of testing and treatment of all spare PRTR tubes; the tubes were subsequently straightened to remove minor bowing normally encountered and have been placed in Spare Parts ready for reactor use.

As follow-up on the eddy current tests on instrument lead lines run last month, eddy current tests were made on new replacement tubing. Of the tubes made by two suppliers, the material of one supplier still contained a high percentage of reject tubing, while the second appeared to have produced largely acceptable tubing. To assure uniformity and conformity in quality and testing, the standard used for the tests at Hanford is to be correlated and integrated into the supplier's test program.

Assistance was provided at 105-KW on an emergency outage involving an expansion joint in the reactor downcomer system. A fluorescent penetrant examination was conducted under SWP conditions on the expansion joint. The joint is a complex assembly consisting of a bellows exterior with flow straightening vanes on the inside. Numerous cracks were located that were not visually apparent. Repairs were made and a follow-up examination disclosed additional cracks generated by the repairs. Final repairs were successfully made and the joint returned to service within a minimum down time.

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The validity of our results in radiography of water plant pump impellers was substantiated by destructive evaluations conducted by the pump supplier.

Test work continued on the evaluation of the DR cross-header and associated Parker fittings. The tests conducted included: fluorescent penetrant, ultrasonic, hardness, micrometric measurements, microscopic, spectrochemical, pressure tests, metallography, flattening, and torque. An elaborate data presentation system giving pictorially the location of discontinuities as discovered and the location of test coupons for the entire header system has been evolved and is being implemented. Close liaison is in effect with the responsible IPD engineers so that test information as developed can be evaluated immediately.

The increased utilization of eddy currents on practical testing problems was demonstrated in sorting mixed lots of NPR stainless steel and Inconel tube fittings. The simplicity of the test (momentary application of a probe to the part) and the confidence in clearly delineating the different metals made the eddy current test particularly effective. Another eddy current development was initiated toward finding cracks in the roots of threaded parts. Neither ultrasonics nor fluorescent penetrants are effective in this case and it appears that eddy current testing may prove effective. Preliminary tests have substantiated this and more refined measurements will be made to define the limits of detection for the eddy current method.

Two developments assist the production of N-fuel elements. A routine test has been established for evaluating progressive deterioration of extrusion mandrels using magnetic particle testing. Records are kept of the development of discontinuities so decisions can be made on replacement of mandrels. The second development, also associated with the extrusion process, has to do with the measurement of the internal contours of mild steel fuel element extrusion shells. A gamma-ray technique, utilizing Ir-192 gives the desired degree of latitude and allows precise measurement of wall thickness and shape to indicate when the shells need to be replaced.

Miscellaneous work continued in assistance on N-reactor problems. Two items are worthy of note. One, a follow-up on side-bend weld evaluations, concerning the relation of nucleating discontinuity size to the size of the opening obtained upon bending. A definite relationship, as was anticipated, was found between the angle of the original discontinuity and the size of the subsequent opening. If the nucleating discontinuity had an angle of 0-30 degrees, it opened up about 1/3 larger; for an angle of 30-60 degrees, about twice larger; and for angles of 60-90 degrees,

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about three times larger. Knowledge of this relationship will guide a more realistic evaluation of the condition of existing NFR primary loop piping. The second item of interest concerns the section of pipe currently being pressure fatigue tested at Southwest Research Institute. After the discovery of indications ultrasonically, similar pipe was examined on plant. Upon sectioning, this proved to be of different manufacture than the records indicated. It is possible the pipe under test at SRI is not the correct material. Alternately, sectioning of more samples on plant suggest that the indications found might be arising from laminations in the base metal. A clearer picture will be available when the SRI sample fails and is sectioned.

Analog Computer Facility Operation

Eighty-four percent of the GEDA and ninety percent of the EASE equipment were in good operating condition during the month.

Computer utilization was as follows:

<u>GEDA</u>	<u>EASE</u>	
119	99	Hours Up
17	37	Hours Scheduled Downtime
0	0	Hours Unscheduled Downtime
<u>0</u>	<u>0</u>	Hours Idle
136	136	Hours Total

Difficulties with the temperature control for the oven on the EASE computer, and difficulties with a digital voltmeter were corrected. Institution of a preventive maintenance vacuum tube noise check promises to reduce instabilities in the analog amplifiers and multipliers and also to lessen the burden on maintenance.

Instrument Evaluation

All 65 Model II Scintrans, as off-site fabricated, have now been tested and placed in service at various Hanford locations. Radiation Protection Operation was advised that spare scintillation alpha probes should be fabricated for stand-by use with the instruments.

The two alpha-only, scintillation, solid-state, hand counters, which were locally fabricated, have been in continuous, trouble-free use for two and one-half months. The general design appears to be quite satisfactory.

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Twenty-eight of the thirty portable, solid-state circuitry, BF<sub>3</sub> detector neutron monitors fabricated off-site have now been placed in service through the Radiation Protection portable instrument pool.

Thorough evaluation tests were continued on one prototype combined alpha-beta-gamma hand and shoe counter of seven being fabricated in Seattle. Some cross-channel interference and an inadequate alpha detection sensitivity have been noted along with the usual minor "component" problems typical with a prototype. Further work will be necessary before the other six units can be finished.

Purchase and test specifications were completed at the request of Radiation Protection Operation for the off-site fabrication of \$8,000 worth of portable, scintillation, solid-state, alpha "poppy" survey instruments.

Evaluation tests continued on the experimental, portable, solid state, G. M. monitor which uses a rechargeable battery and a loudspeaker circuit. Some positive feedback problems were noted from the speaker circuit.

Tests with a scintillation alpha probe covered with two layers of some new commercial double-aluminum coated Mylar indicated an unacceptable detection sensitivity as compared with the usual covering.

*Paul F. Gast*

Manager  
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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION  
RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Ground-Water Temperature Studies

Reinvestigation of ground-water conditions beneath 100-B Area was undertaken to determine the extent to which leakage volume has decreased as a result of major repair work recently completed on the effluent pipe lines and retention basins. Radioisotope analyses, temperature and elevation data were essentially identical to that noted a year ago with only slight changes evident in ground-water elevations. These investigations will be repeated in January, 1963, at which time similar river-stage conditions should exist as during the original survey. It may be that a longer period than originally anticipated will be required before reduced effluent system leakage is reflected in ground-water observations.

Characteristics of 100-Area Soils

Mechanical and chemical analysis of 100 Area soils is in progress to characterize the local soils and to aid in the selection of sites within each of the areas which are best suited for disposal of reactor wastes. Results of particle size analysis of 11 well samples from 100-F and H Areas were evaluated.

Disposal of NPR Decontamination Wastes

Studies were conducted to determine the leaching characteristics of adsorbed isotopes from sludges of treated NPR wastes as a result of subsequent additions of waste slurries from different decontamination processes. Cobalt-60 was used in experiments with simulated wastes where each type sludge was mixed for 16 hours with the supernatant portion of a different type waste.

The sludge from the phosphoric acid waste was leached by supernatant solutions from each of the other type wastes. The maximum leaching from this sludge of 3.5 percent of the Co-60 was by the supernate of the three-step wastes. The sludges from both types of citrate wastes were also leached, having 0.5 to 2.0 percent of the Co-60 extracted. The two-step and three-step sludges were

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not only unleached but scavenged additional Co-60 (~ 1 percent) from the supernatant portions of the phosphoric acid and citrate wastes.

Thus, serious leaching in the crib is not expected since the contact between sludge and supernatant solutions will be much less in the crib than in these experiments.

#### Carbon-14 Decontamination Studies - Coolant Gas Drier Condensate

Four drier bed condensate samples were received and analyzed to determine the C-14 contents and other components in these waste solutions. The data indicate that the primary radioisotope in this waste is H-3 (250-500  $\mu\text{c}/\text{ml}$ ) and C-14 is a minor component. Based on these analyses, operating times and volumes of condensate generated, the maximum output of C-14 was two curies per month at a K Reactor and 0.2 curies per month at D Reactor.

A 90 percent C-14 decontamination of K Reactor condensates (0.5-11  $\mu\text{c}$  C-14/ml) has been obtained by distillation from acidified condensates. The addition of  $\text{KMnO}_4$ ,  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  or  $\text{KIO}_4$  to the acidified condensate did not improve decontamination.

The D Reactor condensate (0.05  $\mu\text{c}$  C-14/ml) was effectively decontaminated by IRA-410 ion exchanger. Seventy-seven column volumes of the condensate were passed through the exchanger with less than one percent C-14 breakthrough.

#### Effluent Monitoring

A draft of the instructions and servicing manual for the As-76 monitor was completed. The as-built drawings of the electronic system also were completed.

The performances of both the arsenic and iodine monitors were uneventful during the month. Neither instrument showed an appreciable increase in activity when a rupture occurred, but this was due to the shutting off of the pump providing the samples to the monitors. The iodine monitor did indicate a sharp 20 percent increase in activity on a second rupture. This occurred about two hours prior to reactor shutdown. The reactor shutdown was signaled by a Panellit reading.

#### Reactor Studies

During this report period the fuel elements in the aluminum reactor tube using deionized cooling water were discharged and new elements

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were reloaded. This operation provided an opportunity to estimate the source of some of the radioisotopes (i.e., whether they originated from the tube surface or the fuel element surface) by comparing the effluent activities before and after discharge, and the effluent activity build-up observed upon returning the tube to service. Evaluation of these data indicates that more Na-24, Cr-51, La-140, and Np-239 come from the fuel element than from the tube, while more Sc-46, Mn-56, Zn-65 and Ga-72 come from the tube than from the fuel element. Promethium-32, Cu-64 and As-76 appear to be produced in nearly equal amounts from the two surfaces. Therefore, for radioisotope reduction methods to be effective, the radioisotope production at both surfaces must be inhibited.

During the past month the Water Treatment Pilot Plant was operated at alum feed rates to give a zeta potential of the floc near zero. This has required the addition of about 7 ppm alum rather than the 18 ppm presently being used for the regular reactor process water. Because of this control and a low filter flow rate excellent quality water was produced, and the As-76 concentration in the effluent was only one-half that of the control tube using regular process water. No significant difference was observed between the P-32 concentrations in the two tubes.

#### SEPARATIONS PROCESSES

##### Solid State Electromigration in Metals

Study of electromigration of Fe-59 in cerium has been extended to include runs of 4 and 70 hours duration, for comparison with the 21.5-hour run reported in the October monthly report (HW-75376 C).

Comparing the profile of gamma activity in the 1/4 x 1/6 x 6-inch cerium rods after the three runs leads to the conclusion that both Fe-59 and Co-60 (impurity in the Fe-59 tracer) undergo migration in the manner to be expected for diffusion under a linear potential gradient. In the four-hour run depletion of gamma activity was observed at the cathode end and a corresponding enrichment at the anode end, but the gamma activity remained unchanged over an appreciable length near the center. With longer treatment the depleted zone increases in length and the concentration of the impurities increases in the enriched zone. In the 21.5-hour run, 70 percent of the total gamma activity was found in a 2 cm length at the anode end. In the 70-hour run, 90 percent had migrated into this 2 cm segment. In both runs the residual activity near the center of the rod was Co-60, implying more rapid migration of iron than cobalt.

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These data have been supplemented by spectrographic analyses for Fe, Cu, Ni, Mn, and Mg. Indications from these measurements, and from work reported by T.A. Henrie, are that Fe, Co, Ni, C, and possibly Cu, can be expected to migrate toward the anode while Mo, Mn, and Mg do not migrate.

#### Ion Exchange Contactors

Dense bed resin pumping techniques are being investigated as a means of improving reliability and reproducibility of resin movement in semi-continuous ion exchange contactors. Fundamental studies made during the past year showed that stresses set up in resin beds are a function of how force is applied to achieve resin movement. Plug-type solid flow is more readily achieved by physically removing resin at the downstream end of a conduit than by attempting to force liquid through the bed to achieve hydraulic conveyance. Using this principle, large (3/4 to 1 inch) ball check valves operating submerged in a dense resin bed were successfully combined with a reciprocating bellows to operate as a solids pump on 20-40 mesh Permutit SK resin. The ball check arrangement permits the major portion of the resin to be "sucked" into the pulsing bellows as a plug. At a frequency of 10 cpm and an amplitude of 1-3/8 inch, a resin movement of over 75 percent of the nominal bellows displacement was observed. The resin movement is reliable and reproducible as demonstrated by on-off-on trials. The largest increase in pressure noted around a 22-foot by 4-inch-diameter loop was one psi at a point 25 inches below the suction inlet to the pulser. The lowest pressure in the bellows appeared to be about 6.5 psi vacuum.

#### Iodine Removal Processes

Studies of the adsorption of I-131 on tube walls continued. The molecular diffusion equation for gases in laminar flow will predict iodine deposition on the walls of small diameter (5/16-inch) tubing with reasonable accuracy. The length for 50 percent deposition for laminar flow ranged from about 0.5 cm at low velocities (about 80 cm/min) to 50 cm at about 5000 cm/min. The influence of turbulence at Reynolds numbers 3000 and above was to increase deposition for a given iodine residence time in the tube over that for an equal residence time in laminar flow. Although 50 percent deposition occurred in a much greater tube length (up to 250 cm for  $N_{Re}$  of 10,000), the residence time for an increment of iodine for 50 percent deposition was appreciably shorter than when lower Reynolds numbers were employed.

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### Purex Demineralizer Studies

New resins of the type used in the Purex demineralizers made demineralized water having a specific resistance greater than 50,000 ohm-cm for about 54 hours at a flow rate comparable to the 105 gpm average flow rate used by each of the plant units. A test made on resin removed from the demineralizers produced water of the same quality for only two hours.

The used anion resin was subjected to several cycles of a brine (15 percent NaCl), acid (2 percent  $H_2SO_4$ ) and caustic (8 percent NaOH) treatment in an attempt to remove organic matter fouling the resin. The initial brine effluent was colored, indicating that some organic matter may have been removed. A test is planned to determine if the brine-acid-caustic treatment improved the resin's capacity for removing strong acids.

### Denitration of Purex LWV with Formaldehyde

Batch denitration of LWV with formaldehyde was investigated in the pilot plant unit. Commercial-grade formaldehyde solution was continuously added to 25-liter batches of hot (100 C) LWV at rates ranging from 0.48 to 1.89 moles per minute. After addition of four liters of formaldehyde solution, the mixture was held at 100 C for two hours. Nitrate destruction ranged from 1.4 to 2.0 moles of nitrate destroyed per mole of formaldehyde fed. The reaction was complete about one hour after formaldehyde addition was stopped. When foaming was produced by the addition of 0.4 gram of DBP per liter of LWV, the foam height reached a maximum of 78 inches above the initial liquid level at a formaldehyde addition rate of 5.6 moles/min/sq.ft of vessel cross section.

### Denitration of Purex LWV with Sugar

Foaming was produced in the pilot plant unit during batch denitration with sugar by the addition of 0.4 gram of DBP per liter of LWV. The amount of foam was found to increase as sugar addition rates were increased. At sugar rates of 0.06 and 0.14 moles/min/sq.ft of vessel cross section, the foam height reached a maximum of 27 and 53 inches, respectively, above the initial liquid level. Under similar conditions, the addition of 0.2 gram of Dow Corning Anti-Foam B per liter of LWV reduced foam levels by about a factor of two.

Attempts to use sodium nitrite as a means of decreasing the induction period for the LWV - sugar reaction were not successful. Sodium nitrite concentrations of 0.01 M in the LWV or 0.01 M to [redacted] in the sugar solution did not change the length of the induction period.

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WASTE MANAGEMENT AND FISSION PRODUCT EXTRACTION

Solvent Extraction of Strontium and Rare Earths with D2EHPA

Laboratory Studies - Batch contact studies were made to test the effect of various FTW constituents on the extraction of cerium by D2EHPA-TBP-Soltrol systems. The results confirm the observations made in "cold" pulse column studies since they indicate that some, as yet unidentified, interaction between Cr(III) and Ce(III) occurs which greatly reduces the extraction of Ce(III). Specific interpretation of the data in terms of kinetic or equilibrium relationships is not yet possible since data obtained with column solutions are in apparent anomaly with laboratory-prepared solutions. The interaction effect is decreased as the total citrate concentration in the feed is increased. Additional studies are being performed.

Tracer-level mini-mixer settler runs were made to test various aspects of the current flowsheet for D2EHPA extraction of strontium and rare earths from Purex FTW. Strontium and cerium losses in the extraction column were not significantly increased when solvent previously washed with 0.5 M oxalic acid at 60 C (proposed for solvent clean-up) was used. The extraction column strontium loss increased about 15-fold (0.24 to 3.4 percent) when TBP was omitted from the solvent. Absence of TBP from the solvent had no effect on strontium behavior in the partitioning column. Cerium loss in the extraction column was decreased about two-fold by increasing the "free" citric acid concentration in the feed from 0.05 to 0.1 molar. At tracer level, yttrium was readily extracted (four percent loss) under extraction column conditions. Only about 20 percent of the extracted yttrium was removed under strip column conditions. Batch contacts of solvent containing yttrium with 0.5 M oxalic acid at either 25 or 60 C did not remove the yttrium effectively.

Scouting experiments demonstrated that feed solutions suitable for D2EHPA-Soltrol extraction of strontium and cerium can be prepared from Redox Process acidic waste. Solutions stable with respect to solids formation at pH values in the range 3.9 to 5.2 were prepared from synthetic Redox waste diluted by a factor of two and made one molar in citrate. Cerium and strontium distribution ratios between such feed solutions and D2EHPA-Soltrol solvent were high enough to indicate chemical feasibility of a countercurrent extraction process for recovery of these elements.

Engineering Studies - Cerium extraction from a simple, sodium nitrate feed is much more efficient than from a feed simulating formaldehyde-treated waste (FTW). In an attempt to clarify this behavior, the

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FTW components - iron, aluminum, chromium-nickel, and sulfate - were added singly and separately to a "standard" sodium nitrate-citrate feed adjusted to a pH of about 4. Each of the metal ions added was pre-complexed with an equal molarity of citrate. The feeds were run under identical conditions in a pulse column operated at 45 C. The cerium waste losses in all runs except those made with chromium-nickel-containing feeds were less than two percent, while a run with chromium-nickel alone gave a loss of 9.3 percent. A feed containing all of the FTW components made in a similar method (precomplexed metal ions) gave a loss of 4.8 percent.

The product from the above series of runs was combined and used for 1B and 1C column runs. The performance of these columns was excellent, with strontium waste losses of two percent or less in the 1B column and cerium losses as low as two percent in the 1C column. These results disagree somewhat with earlier data which showed losses of 20 to 30 percent for both strontium and cerium with top interface (aqueous phase continuous) operation. Part of the improvement may have been due to operation at more favorable pulse frequencies, but some seems to be due to different physical properties of the system. For example, in these current runs the stable operating amplitude-frequency product was increased by 20 to 40 percent over that obtained in the earlier runs made under comparable conditions. The ability to predict and counteract unfavorable changes in the physical properties of the various systems in the D2EHPA process remains the biggest problem still to be solved.

Plant Assistance Studies - Hot Cell studies were aimed at determining the effect of organic materials on the pH of neutralized waste stored in mild steel tanks. In particular, relatively large quantities of tartrate, hydroxyacetate, citrate, EDTA, etc., are employed as complexing agents for iron or fission products in the Purex strontium recovery operation and in the Hot Semiworks; these materials ultimately find their way to the waste storage tanks, where the organics will be decomposed by radiolysis. Experiments have accordingly been performed in which tartrate-complexed LWV was made alkaline and the pH followed as a function of time. These results, extended over a two-month period, indicate that the pH will decrease from its initial value of about 10.5 and will eventually level off at a value of about 7.5 to 8.

A report, "Fission Product Generation and Decay Calculations," updating and extending a similar report issued in 1957, was completed.

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Solvent Extraction of Cesium

Laboratory Studies - A solvent extraction process was evolved during the month for the simultaneous recovery of fission product cesium, strontium, and rare earths from acidic Purex waste. If promising preliminary laboratory results are corroborated by additional testing, the new process could make possible extraction of all three of these heat-generating species in a single B-Plant solvent extraction battery, eliminating need for separate capital equipment for cesium recovery. The solvent employed is a mixture of BAMBP (4-sec. butyl-alpha methyl benzyl phenol), D2EHPA (di-2-ethyl hexyl phosphoric acid), and Soltrol (a kerosene-type diluent); the key to the successful cesium extraction is a synergistic effect of D2EHPA on BAMBP. Thus, while D2EHPA alone does not extract cesium and BAMBP is ineffective below a very alkaline pH of about 12, the mixture extracts cesium well over a broad pH range from about 3 to 14. Cesium, strontium, and rare earths are co-extracted at about pH 5 but may be separated by selective stripping. Other phenols and acid alkyl phosphates are expected to exhibit similar behavior.

A report summarizing certain phases of the laboratory investigation of dipicrylamine as a cesium extractant has been completed and issued as HW-75184, "Solvent Extraction of Cesium by Dipicrylamine, II - Solubility, Radiation Stability, Extraction Kinetics and Disengaging Behavior," by L.A. Bray, October 8, 1962.

Engineering Studies - The use of BAMBP to extract cesium from a synthetic Purex waste supernate solution buffered to 0.2 M free NaOH was successfully demonstrated during the month. The BAMBP was diluted to a nominal 0.75 M solution in Soltrol-170. The pilot plant equipment was the same as that used in recent DPA-NB (dipicrylamine-nitrobenzene) studies, viz., a 3-inch-diameter glass column packed with nine feet of 3/4-inch stainless steel Raschig rings. The column could either be pulsed or agitated by air introduced a few inches below the packing.

In brief, the results indicated that supernate flow rates as high as 760 gph/ft<sup>2</sup> could be obtained, yielding HTU's ranging from 4.5 ft. unpulsed to 2.4 ft. with one scfh air agitation and 2.2 ft. with a pulse applied at 45 cycles/min (one inch amplitude). HTU's on the order of 1.5 to 1.6 ft. were obtained at supernate flow rates of 300 gph/ft<sup>2</sup> with pulsing applied at 60 to 70 cycles/min, while an HTU of 1.8 ft. was obtained at the same throughput with one scfh air.

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The results demonstrated a supernate capacity at least twice that obtained with the DPA-NB flowsheet with HTU's at comparable capacities approximately one-half as great. Solvent requirements were only 10 to 20 percent of the DPA process because of the high cesium distribution ratios (typically 20 to 40).

In the early runs, 0.06 to 0.1 M sodium was found in the organic product. Scrub studies are currently underway to determine a satisfactory method of removing this extracted sodium by using weak buffer acids. Early results indicate that a sodium decontamination factor of at least ten can be obtained by scrubbing the product with 0.25 M boric acid at a scrub A/O ratio of 0.2. No appreciable cesium reflux was encountered.

#### Ion Exchange Recovery of Cesium

Laboratory Studies - The adsorption of niobium from Purex LWW waste by clinoptilolite was investigated to provide data for estimating the heat generation in a column of clinoptilolite planned for test removal of cesium from actual LWW. A simulated LWW solution containing 6 M  $H^+$  and 0.00018 M Nb was made by dissolving powdered niobium metal in a nitric acid-hydrofluoric acid mixture and adding this to other chemicals normally found in LWW. A fission product mixture was added to provide Nb-95 tracer. Results of column experiments indicated that the addition of citric acid (to 0.1 M) to the waste reduced the niobium adsorption three-fold. Gamma scanning of the exchanger in a column indicated that the adsorbed niobium was evenly distributed.

The removal of sodium and zirconium-niobium from clinoptilolite with ammonium oxalate was studied. The ammonium oxalate would replace the oxalic acid and ammonium hydroxide wash steps in the flowsheet for the removal of cesium from Purex FTW. A solution of 0.1 M  $(NH_4)_2C_2O_4$  removed 98 percent of the sorbed sodium in eight column volumes as compared to ten column volumes of 0.5 M  $H_2C_2O_4$ . Cesium loss was not increased significantly. About 50 percent of the sorbed zirconium-niobium was removed by the ammonium oxalate. With the addition of citric acid to the column influent decreasing zirconium-niobium loading to less than ten percent of that in the waste and part of that loaded not being eluted by ammonium carbonate, a zirconium-niobium DF from cesium of greater than 100 is indicated. In addition to simplifying the process, use of ammonium oxalate in place of oxalic acid and ammonium hydroxide will reduce essential material costs about 50 percent.

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Engineering Studies - Linde AW-400 (14-30 mesh) has a higher capacity than clinoptilolite (20-50 mesh) for sorption of cesium from Purex waste supernates; at a five percent breakthrough level, the AW-400 zeolite has a capacity three-fold higher than clinoptilolite. Two adsorption runs were completed with Purex supernate diluted 1:1 with water - the first as a feed input (undiluted basis) of one gpm/ft<sup>2</sup> (two column volumes per hour) and the second at 0.5 gpm/ft<sup>2</sup> (one column volume per hour). Both columns were 23 inches high and four inches in diameter. One percent breakthrough occurred at 21 and 9 column volumes at flow rates of 0.5 and one gpm/ft<sup>2</sup>, respectively.

The initial breakthrough data clearly indicate that column residence time plays an important role in the removal of cesium from this system.

#### Cesium Precipitation Studies

B-Cell operations were limited to experiments with dilute, aged, clarified LWW due to delays experienced in obtaining a supply of current material. Tests with the aged feed of the phosphotungstate precipitation process for cesium removal gave satisfactory recoveries and demonstrated that cesium itself does not decompose the precipitate. Problems previously encountered may have been caused by reactions between the sodium hydroxide washes and the solids present in normal LWW, which could decrease the effective sodium hydroxide concentration and lead to incomplete cesium phosphotungstate dissolution. Additional runs with fresh LWW will be required to verify this interpretation and firm up a flowsheet for Purex Head-End testing.

#### Fission Product Packaging

Strontium Sorption on Zeolites - Results of laboratory column experiments show that 30-35 mesh Linde 4A zeolite can be loaded to 2.4 meq of strontium per gram of zeolite at room temperature in 4.2 hours at a flow of 12 column volumes per hour or in 11.7 hours at 3 column volumes per hour. The higher flow rate requires 67 percent of the effluent to be recycled to recover 99 percent of the strontium. At the lower flow rate 28 percent of the effluent must be recycled for the same recovery. Strontium breakthrough reaches 80 to 90 percent at the end of the loading cycle. The influent solution used in these experiments contained 0.2 M Na<sup>+</sup>, 0.035 M Sr<sup>++</sup>, and 0.010 M Ca<sup>++</sup>, all as nitrates.

Studies on the effect of elevated temperature on packaging materials are continuing. Linde 4A and 13X zeolites were loaded with Sr-85

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and subjected to temperatures of 885 C and 1000 C, respectively, for 1-1/2 hours while drawing a stream of heated air through the exchanger. The 4A lost 0.047 percent and the 13 X 0.013 percent of the loaded Sr-85. Elution with 1 M HNO<sub>3</sub> of the zeolites heated to 885 C removed 95 percent of the Sr-85 from the 4A in 30 column volumes and 86 percent from the 13X in 75 column volumes. When 4A was heated to 1000 C, the elution rate was much slower, but 96 percent of the Sr-85 was eluted with 90 column volumes. A 25 percent volume shrinkage was observed after heating these exchangers to 1000 C.

Through-Drying of Zeolites - Studies continued on the hot gas through-drying step for stabilization of fission-product-loaded inorganic zeolites. Air at a temperature of 800 F, a flow rate of 30 scfm, and a dewpoint of -80 F, was used to dry a water-saturated bed of Molecular Sieves®. Moisture content of the zeolite at the downstream end of an 8-inch-diameter, 36-inch-deep bed was reduced to 0.4 w/o in five hours. Experiments to date show that after about three hours under the above drying conditions, the moisture removal rate becomes limited by the moisture diffusion rate within the particle.

Preparation of Glasses from Zeolites - Further studies on the formation of glasses by fusion of cesium- or strontium-loaded inorganic zeolites with LiF-SiO<sub>2</sub>-B<sub>2</sub>O<sub>3</sub> mixtures were made. From the standpoint of resisting shattering by thermal shock, the best glass produced contained 35, 5 and 60 percent by weight, respectively, of dried zeolite, LiF and B<sub>2</sub>O<sub>3</sub>. The powder mixture containing this high boron oxide content swells appreciably in the temperature range 425 - 650 C. Fusion occurs at about 650 C. Four percent appears about the minimum LiF content for fusion as currently done. The solidified glass has about the same volume as the bed volume of the zeolite pellets. Hot 6 M HNO<sub>3</sub> readily slurries the glass. There was no apparent difference in the quality of glass produced with cesium-loaded as compared to strontium-loaded zeolite.

Attempts to incorporate cerium into vitreous solids by fusing cerium oxalate-LiF-B<sub>2</sub>O<sub>3</sub> mixtures were not successful.

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### Pm-146/Pm-147 Ratio in Tank 103-A Sludge

A sample of promethium was recovered from Purex 103-A sludge and exhaustively purified for determination of its Pm-146/Pm-147 isotopic ratio. The value found was in close agreement with that determined earlier for Oak Ridge purified promethium (presumably of Arco origin) and corresponded to  $3.05 \times 10^{-7}$  0.75 Mev gammas and  $2.46 \times 10^{-7}$  0.45 Mev gammas per Pm-147 beta. Consequently, a 250 thermal watt heat source would require about one-half inch of lead to shield to a radiation level of 200 mr/hr at one foot. This small amount of shielding may be compared with 4-1/2 inches of lead required for an Sr-90 source of similar rating.

### In-Tank Solidification

Studies of the circulation pattern in the 10-foot diameter model of the Purex waste storage tanks were completed. Three important conclusions were drawn from velocity profile data made at circulation rates ranging from 40 to 180 gpm:

1. The liquid flows from the centrally located circulator along the surface to the tank periphery before moving to the bottom and back to the circulator inlet. The only region of downflow is a relatively narrow annular band next to the tank wall.
2. The total "turnover" volume of liquid is about twenty times the actual circulated volume, as the result of induced circulation.
3. Both the circulation pattern and the ratio of total "turnover" volume to circulated volume are nearly independent of circulation rate over the range of rates studied.

Point velocities in the 75 ft. diameter plant tanks with a 10,000 gpm circulation rate were estimated on the basis of the model studies. These results, together with previously reported solidification studies in a 4-foot-diameter tank, predict successful solidification operations in the plant tanks.

Design of a 4-foot-diameter model conical bottom tank was completed. The tank was fabricated and installation in 321 Building is now underway. Solidification tests in this model, using synthetic 1W solution, are the next phase of the program.

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EQUIPMENT AND MATERIALS

Stress Cracking in Mild Steel

Exposure of large (3 ft. x 3 ft. x 3/8 in.) mild steel weldments in synthetic Purex alkaline waste was continued. To determine the effects of nitrite on stress cracking susceptibility, two weldments are currently being exposed to 50 percent  $\text{NaNO}_3$  - 1 M  $\text{NaNO}_2$  solution. In previous tests, all weldments exposed in 50 percent  $\text{NaNO}_3$  developed stress cracks.

Laboratory tests with stressed and notched C-rings of ASTM A53-55T (0.11 percent C) and A106-55T (0.22 percent C) show both materials are susceptible to stress cracking in 50 percent  $\text{NaNO}_3$ . Plastic deformation and heat treatment appear to be contributing factors. The failure of large weldments under conditions which do not produce cracking in small weldments appears also to be associated with greater plastic deformation.

Decarburization of mild steel test specimens prior to preparation of photomicrographs was found to increase greatly the clarity of cracks present. Small cracks ordinarily difficult to detect are readily discernible by this method.

Corrosion of "Rigimesh" Wire Filter

Samples of Rigimesh® 304 stainless steel wire filter were vacuum annealed and air cooled in an attempt to decrease the corrosion by nitric acid. After exposure of the annealed filter to boiling 65 w/o  $\text{HNO}_3$  for 120 hours, the smallest wires present had been corroded to about half of their original thickness. This represents a substantial improvement over the unannealed material.

Deposition of Metals by Vapor Phase Reduction

A layer of tungsten metal was deposited, by vapor phase reduction, on the interior surface of a small (one-inch I.D.) ceramic crucible. The deposit served as a satisfactory induction heating susceptor. A small amount of  $\text{UO}_2$  powder (-65 +200 mesh) was coated with tungsten by the same technique. Some of the particles were cemented together by the metal while others remained separate.

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PROCESS CONTROL DEVELOPMENT

Scintillating Glass Alpha Counter

The prototype in-line alpha particle counter with a scintillating glass detector was assembled and tested in the laboratory using dry plutonium alpha particle sources. The in-line counting system is comprised of the glass scintillator coupled to a 6655A photomultiplier (PM) tube. A charge-sensitive solid state preamplifier transmits the current pulses from the PM tube to the input to a linear amplifier. Count rate is read out on a conventional count rate meter.

Linearity and repeatability of the alpha counting system were both satisfactory using the dry alpha particle sources. Additional tests using standard plutonium solutions are needed to determine the lower detection limit prior to testing the device by installation of the system on a line of the Z plant waste treatment facility.

Neutron Detection Instrumentation

A  $\text{He}^3$  neutron detector has been tested and compared with the standard HAPO-made  $\text{BF}_3$  tubes. For equivalent detector volume, the  $\text{He}^3$  detector was found to be about nine times as sensitive to thermal neutrons and about 60 times as sensitive to fast neutrons as is the  $\text{BF}_3$  tube. Most of the difference in thermal neutron sensitivity is due to the higher gas pressure used in the  $\text{He}^3$  tube (six atmospheres compared to slightly less than one atmosphere). Although the  $\text{He}^3$  detectors are more expensive than the  $\text{BF}_3$  tubes, they are expected to find use in special applications for determining plutonium concentration in process streams. These detectors also have capability for resolution of neutron energy levels and thus may be suitable for some neutron spectrometry applications.

Fluid Flow Measurement

Advances in control instrumentation make it desirable to utilize the available inventory of electronic rotameters with equipment other than specialized rotameter electro-pneumatic transmitters, recorders, and controllers. A circuit was developed which makes it possible to use these rotameters with EMF output compatible with the newer solid state control and recording equipment. This circuit is composed of a regulated 60 cycle A.C. voltage

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excitation to an inductance resistance bridge, a ring demodulator, and a filtered D.C. output. Linearity of output with rotameter armature position is about one percent. Stability of the output with supply voltage variations of  $\pm 15$  volts in the 115V A.C. supply is better than one percent.

#### C-Column Studies

Following final calibrations and system check-out, a series of 48 runs was initiated in the experimental C-Column to provide additional data for mathematical model development. Fourteen runs were completed successfully. Two runs were terminated because of electronic control instrumentation malfunctions; these difficulties represent the first failures of the column control devices during about one and one-half years of service. Investigation of the problem pointed up the need to maintain an ambient temperature in the instrument cabinets of about 90 F or less.

The use of Soltrol diluent required a recalibration of the gamma absorptiometer. The calibration data was incorporated into the Data Reduction Code, and data from the five initial runs were completely processed. A computer routine was written to store all primary data on magnetic tape, resulting in improved availability of information for future analysis and substantial reduction in storage space required for data cards.

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REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

PuO<sub>2</sub>-UO<sub>2</sub> electrolytic co-deposition from a KCl-LiCl melt at 550 C was achieved by electrolyzing with an O<sub>2</sub>-Cl<sub>2</sub> sparge. It is hoped that these conditions will yield high-density, near-stoichiometric crystals and reasonably good decontamination from the rare earths. Enrichment factors for plutonium as high as 1.7 were measured, and deposits containing up to 6 weight percent PuO<sub>2</sub> were prepared. X-ray diffraction studies indicate that at least 70 percent of the PuO<sub>2</sub> content of these deposits is present as a solid solution with UO<sub>2</sub>. No separate PuO<sub>2</sub> phase was detected.

High Temperature Absorption Spectrometry

The setting-up of the gloved hood and associated equipment to be used in the spectrophotometric study of the chemistry of plutonium in fused salts was completed in August. Since then, experiments have been run with uranium to eliminate difficulties in experimental techniques and to obtain data which will be useful in later experiments involving both uranium and plutonium. The equipment assembly includes a Cary 14H Spectrophotometer which is positioned around the outside of the gloved hood.

In the experiments done so far, the spectrum of U(IV) as prepared in a variety of ways has been measured in LiCl-KCl melts at various temperatures. The spectra agreed well with each other, regardless of the preparative procedure, lending added confidence in the reliability of the equipment and of the data which will be obtained in future work.

Spectra of a species believed to be uranium(V) were also obtained. The spectra show strong absorption peaks at about 1530, 790, and 630 mμ. This species was obtained in a concentration of about 0.1 w/o by (a) reacting UO<sub>2</sub> with a melt containing about 10 w/o uranium(VI), and (b) H<sub>2</sub>-HCl sparging a 10 w/o uranium(VI) melt at 550 C. It was also found, in smaller concentration, after allowing a melt containing uranium(IV) and uranium(VI) to stand under a helium atmosphere, and after reaction of water with uranium(IV)-bearing melts. The species is converted to uranium(IV) via a rapid first order reaction on H<sub>2</sub>-HCl sparging at 400 C and reacts rapidly with O<sub>2</sub> and Cl<sub>2</sub> - further evidence of uranium(V).

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RADIOACTIVE RESIDUE FIXATIONZeolite Properties

Study of zeolite equilibria continued. Equilibrium curves from zero to 100 percent cesium loading in the sodium-cesium system at 25 C were determined for the synthetic zeolites Linde AW-300, AW-400, AW-500, 13X, 4AXW, and Norton Zeolon and the natural zeolites clinoptilolite, erionite, and phillipsite. Previous results were confined to less than ten percent zeolite loading.

Cesium mass action coefficients,  $\frac{(\text{Cs zeolite}) (\text{Na solution})}{(\text{Na zeolite}) (\text{Cs solution})}$ , were obtained experimentally. A rational thermodynamic equilibrium constant was derived for each zeolite by correction of mass action coefficients for cesium and sodium activity on the zeolite and in the equilibrium solution. The rational thermodynamic equilibrium constant, unlike the molal thermodynamic equilibrium constant, is reflective of zeolite cesium selectivity.

Equilibrium constants obtained at 25 C were 0.323, 0.355, 11.1, 17.4, 26.4, 29.4, 32.9, 39.0, and 51.9 for Linde 4AXW, Linde 13X, Linde AW-300, Norton Zeolon, phillipsite, Linde AW-500, erionite, Linde AW-400, and clinoptilolite, respectively.

Condensate Treatment

MPP Run 33 evaluating the decontamination ability of a bed consisting of a mixture of strong acid cation resin and clinoptilolite, both in the hydrogen form, followed by a bed of weak-base anion exchange resin in the hydroxyl form was started. Preliminary information indicates that about 10 to 40 percent of the ruthenium is being removed by the mixed cation exchange bed, and about 90 to 95 percent of the remaining ruthenium is being removed by the anion exchange bed. The initial high efficiency ruthenium removal experienced with strong-base anion resins was not obtained with the weak-base anion resin.

Calcination of Radioactive Wastes

A successful full-level pot calcination run was made during the month in the A-Cell pilot-scale calcination equipment, bringing the total number of full-level runs to date to four (two each spray and pot). The object was to determine the effect of alkaline earth addition on the evolution of sulfate (which is corrosive to the off-gas equipment) and any possible effect of such addition on ruthenium volatilization.

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The LWV currently available for calcination studies is high in sodium content and requires addition of excess sulfate to promote nitrate destruction (due to the high thermal stability of sodium nitrate) and produce a meltable composition. Unfortunately, much of the sulfate volatilizes and corrodes the off-gas line and condenser when the addition is made as sulfuric acid. Use of magnesium sulfate should overcome this difficulty - since it should provide sulfate, as needed, to "complex" sodium while not undergoing direct decomposition. The 14-hour run was made with 29.5 liters of 95 gal/ton full-level LWV. While analytical data are not complete, operation was very smooth, and few, if any, sulfate fumes were observed. About 20 percent of the feed ruthenium was found in the condensate trap, about the same as in previous runs. As with previous runs, no detectable activity passed the off-gas filters.

#### Eighteen-Inch Radiant-Heat Spray Calciner

Shake down tests of the 18-inch-diameter by 10-foot-long spray calciner were completed during the month. The feedstock was a simulated Purex FTW with sulfate added to form a meltable calcine. Encouraging findings include a very satisfactory performance of the cyclone system (only one percent of the calcine escaping to the filters) and a sodium decontamination factor of 10,000 from feed to condensate. A less satisfactory finding was a deposit of calcine on the reactor walls and in the length of horizontal off-gas line between the reactor and the cyclone.

#### WASTE CALCINATION DEMONSTRATION PROGRAM

The engineering flow diagram has been finalized pending comment by ORNL personnel. Detailed design of tankage is well along, and scoping of the specialized equipment such as the evaporator, fractionator, and instrument system is near completion.

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BIOLOGY AND MEDICINE - O6 PROGRAM

TERRESTRIAL ECOLOGY - EARTH SCIENCES

Hydrology and Geology

Work is in progress on determining the reliability of surveying data on Hanford wells. These data are needed as primary collection points on the project analog. Accuracy requirements on both horizontal and vertical control were provided the Field Survey Unit, and they are examining the survey data to determine which wells meet these requirements. In the event that a considerable number of wells do not meet accuracy specifications, a statistically designed spot-checking method may be required to determine further the accuracy of past surveys.

Well 699-20-E12, located east of the "Wye" barricade and one mile from the Columbia River, shows no variations in water temperature with depth. Because of the uniform temperature, it was believed that there was considerable vertical movement of water within the well. Several piezometer tubes recently installed within the well showed the head in the bottom of the well to be 25 feet greater than the head at the water table. Earlier drawdown and recovery tests also indicated the lower aquifer to be sufficiently permeable to result in vertical flow from the bottom of the well to the top. Temperature measurements made after piezometers were installed showed a decrease of about 2 C at the water table. The presence of tritium in earlier samples from the well also indicates the source of the ground water in the lower aquifer is probably the 200 Areas.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Radiation Chemistry

The first moment of an electron spin resonance (ESR), first-derivative spectrum can be used as a quantitative measure of the number of unpaired spins (e.g., free radicals) in a sample and has some advantages over double integration of the derivative spectra. This arises from the fact that the first moment is proportional only to the number of unpaired spins in the sample and the modulation amplitude but is independent of line shape. In order to measure the first moments of spectra rapidly, an analytical balance was converted to a moment balance which can determine these moments gravimetrically using cut-outs of the spectra recorded on paper. The balance was patterned after one in Dr. A. Müller's laboratory in Karlsruhe and was calibrated with known moments.

In order to extend the radiation chemistry studies on monomeric amino acids to the polymeric forms of the various amino acids, a radical scavenging dye is needed which is stable at high pH since these polymeric acids are soluble only in the high pH range. Tropeoline O appears to be satisfactory for this purpose. It is readily available as a biological stain, non-toxic in small amounts [it is a major component of (I Food Orange 8)], and can be readily purified. Studies were completed which verified that Beer's Law is valid over the high pH range and the protection index at pH of 11.8 was determined with respect to alcohol at 2, 23 and 40 C.

#### Uranium Ore Inhalation Studies

The normal uranium content of rat tissues has been reported to be about 0.02  $\mu\text{g}$  uranium per gram of tissue. In order to accurately measure these levels by alpha energy analysis, about 0.3  $\mu\text{g}$  uranium is required, or a sample size of at least 15 grams. Since chemical treatment will disturb the parent-daughter relationship of the uranium decay chain, an alpha energy analyzer is required which can utilize ashed samples. These criteria are met by a newly-developed British large area alpha spectrometer. Work is in progress to construct one of these instruments for use on this program.

#### RADIOISOTOPES AS PARTICLES AND VOLATILES

##### Particle Deposition in Conduits

Seven additional turbulent deposition experiments were completed using the 1-1/4 inch diameter, 60-foot long, vertical tube. The maximum deposition of the ZnS particles was 60 weight percent at a flow rate of 14 cfm. All results were within the limits of confidence on deposition constants established earlier for 1/2-inch diameter tubes and the correlation equation. The experimental errors being introduced are nevertheless larger than desirable, and efforts were continued to adapt rapid, accurate fluorometric determinations to measuring the tube inlet and outlet concentrations. Recent calibrations and reproducibility checks of a fluorometric procedure give promise that better speed and accuracy can be achieved than for the gravimetric methods used to date.

*E. R. Irish*  
for Manager  
Chemical Research and Development

WH Reas:cf

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## BIOLOGY OPERATION

## A. ORGANIZATION AND PERSONNEL

No significant changes occurred during November.

## B. TECHNICAL ACTIVITIES

## FISSIONABLE MATERIALS - O2 PROGRAM

Effect of Reactor Effluent on Aquatic Organisms

A study to determine the toxicity of two reactor tube decontaminants, BISULF-16 and SULFAM-3 on young cichlids, Aequidens portalegrensis, has been initiated. Exploratory tests to bracket concentration values of SULFAM-3 for probit analysis showed fish could tolerate 100 ppm but not 200 ppm in sanitary water. However, in raw water the fish are able to tolerate 200 ppm, apparently because of the greater buffering capacity of raw water compared to sanitary water. At 400 ppm in river water, 100% mortality is observed.

Columnaris

Salmon and river fish collected from the McNary spawning channel and from the Rainbow area all failed to show evidence of columnaris infection.

Sampling of trout from the 100-KE monitoring troughs failed to show a correlation between the concentration of reactor effluent and the incidence of columnaris infection. These samplings do, however, indicate a correlation between the incidence of this disease in certain troughs. An attempt will be made to identify columnaris as a contaminant on the wall of the tanks.

\*(See page D-6)

## BIOLOGY AND MEDICINE - O6 PROGRAM

## METABOLISM, TOXICITY AND TRANSFER OF RADIOACTIVE MATERIALS

Salmon

The fifth and last aerial survey of chinook salmon spawning in the Columbia River between Richland and Priest Rapids was made on November 19. A total of 1,261 nests were observed during the fall, the second highest number recorded since salmon spawning census began in 1947. The Midway region, upstream from the reactor areas, contributed over 40% of the total number observed. The high proportion of salmon spawning there may be the result of a partial barrier to upstream migration created by Priest Rapids Dam.

Population Dynamics - Waterfowl

Wintering waterfowl populations within the Hanford Reservation increased to about 130,000 ducks and geese during the month. This is a greater number than were present at this time last year and is probably due to greater amounts of food available due to current weather conditions.

Zinc

Pilot tests to determine excretion of  $Zn^{65}$  by three-year-old trout ingesting 880  $\mu$ c showed less than 0.2% of the dose in the urine over a period of 3-4 days and about 40-50% is absorbed through the gastrointestinal tract. The unaccountable amount of 4-15% in this material balance study is assumed to be excreted primarily by the gill tissue.

Zinc-Cadmium

In vitro studies on the transfer of  $Zn^{65}$  and  $Cd^{115}$  across Visking membranes reveal that the elements behave independently of each other. Cadmium migrates across the membrane more rapidly than does zinc. When an everted rat intestinal sac is substituted for the Visking membrane, an interaction does appear to exist between the zinc and cadmium. Both of the ions are readily removed from the incubation medium by the mucosal surface of the everted sac, but only slowly transported to the solution inside the sac. Additional experiments are planned to investigate the kinetic behavior of the transport of both zinc and cadmium in the everted intestinal sacs.

Copper

In rats exposed to from 700 to 900 r whole-body X-ray, there was a two to threefold decrease in urinary copper on the second and third day following irradiation. Analyses of samples from later time periods are in progress. It is possible that this decreased copper excretion, which occurs despite an increased urine volume, may be due to the lower intake during this interval.

Strontium

High levels of an "Erythropoiesis Stimulating Factor" were noted in an  $F_1$  generation pig on the 625  $\mu$ c  $Sr^{90}$ /day level shortly before death. Excellent results were obtained with the polycythemic mouse assay method. A "Purified Erythropoietin Standard" has now been obtained and will be used to quantitate the levels of the factor in plasma of various animals in future test series.

Additional pigs of various ages were administered single oral doses of  $Sr^{90}$  and  $Ca^{45}$  to evaluate further the effect of age on Ca-Sr discrimination.

Iodine

Two of three cows fed 5  $\mu$ c of  $I^{131}$  daily for over a month calved. The  $I^{131}$  burdens in the thyroid of the calves were one-third and two-thirds that of the dams. (These values are considerably less than that described by Gorbman and coworkers who noted that calves' thyroids showed two times as much  $I^{131}$  as their dams 24 hours following a single tracer dose.) Following calving, both cows manifested an increase in thyroidal  $I^{131}$ .

Seventeen ewes remaining in the two groups of sheep given a single 3 mc dose of  $I^{131}$  in 1958 and 1959 are the subject of a reproductive study. In order to define their state of hypothyroidism a 25  $\mu$ c tracer dose was given. The peak thyroid uptake at about 50 hours was 3 to 20 per cent in these animals, compared with a 44 per cent uptake in control ewes of the same age. All of the ewes have shown at least one heat period.

Neptunium

The gastrointestinal absorption of neptunium-237 nitrate in the (VI), (V), and (IV) valence states has been determined in the rat. For valence (VI), 0.45 + 0.33 per cent was absorbed, for valence (V) 0.26 + 0.19 per cent, and for valence (IV) 0.1 + 0.1 per cent. These are felt to be quite reliable values. Somewhat similar results previously reported were obtained from feeding citrate solutions in which the valence state was highly uncertain.

Plutonium

A two-year-old female miniature swine that received 1.3  $\mu\text{c}$  of  $\text{Pu}^{239}$ /kg body weight at one year of age was euthanized because of severe skeletal lesions, including multiple fractures of the humeri and femur. These fractures probably all occurred at about the same time. One femoral head was separated and showed severe necrosis of long standing. Severe lesions, including possible fracture and healing with exostosis were evident at the distal end of several ribs. The site of these lesions corresponds with location of costochondral junction at the time the animal was injected. Radiographic lesions notes at several locations also included both sclerotic areas and areas of bone dissolution. Severe disorganization of the trabecular bone was apparent.

These osseous lesions are the most severe noted to date in any of the miniature swine with burdens of bone-seeking radionuclides. They are much more severe than those seen in males injected at an earlier date. The reason for this difference is not readily apparent. Other animals injected at the same time as this female are now undergoing radiographic examination.

Inhalation Studies

Seventy days after depositing 100  $\mu\text{c}$  to 2 mc  $\text{Ce}^{144}\text{O}_2$  by inhalation, four dogs appear normal except for leukopenia and a 16 per cent drop in potassium concentration of the blood serum compared with the controls. There were no changes in levels of transaminase, lactic dehydrogenase, lipase, and sodium in blood serum. Systolic blood pressure is unchanged. The concentration of  $\text{CO}_2$  in arterial blood increased 12 per cent in three dogs given the highest doses of  $\text{Ce}^{144}$ , 700  $\mu\text{c}$  to 2 mc. Blood oxygen levels are unchanged. In other dogs studied 200 days following exposure to  $\text{Ce}^{144}\text{O}_2$  aerosols, the effective half-life for retention of  $\text{Ce-Pr}^{144}$  is about 230 days. Radiation dosage measurements were performed in a phantom dog to determine the magnitude of the whole-body exposure following deposition of  $\text{Ce}^{144}$  in the lungs. Initial results indicate that the whole-body dose is very low and that biological effects seen in dogs following inhalation of  $\text{Ce}^{144}\text{O}_2$  can be attributed to irradiation of the lung, and to a smaller extent, the liver to which a small fraction of the  $\text{Ce-Pr}^{144}$  is translocated.

Preliminary findings indicate that uranium ore dust collected from the Dawn Mining Company at Ford, Washington, has radioactivity levels too low for use in animal inhalation studies. Pitchblende and carnotite ores are being obtained from the Grand Junction Office of the A.E.C.

It has been difficult to eliminate ascarids from the dog colony because they are transmitted across the placenta in bitches to the fetuses. However, puppies born to second generation colony bitches, that were treated immediately following their birth, are apparently free of ascarids. Therefore, we are hopeful of eventually having a truly parasite-free dog colony.

Preliminary results indicate that synthesis of fatty acids from acetate occurs in lung tissue homogenates. These results are particularly interesting since lung has been ignored in most biochemical studies.

#### Alligators

Alligators were exposed to 1500 to 9000 r X-radiation for determination of the LD<sub>50</sub> dose. Three weeks after exposure there are no deaths, but there is evidence of a leukopenia. There are no other effects and no indication of the typical radiation syndrome seen in other species.

#### Radiation Protective Agents

A number of manganous chelates were tested for their ability to protect animals against whole-body X-ray exposures of 875 r. Mn DTPA was the only one which afforded significant protection at this radiation level.

Mice given 950 r X-ray and protected by injection of rat bone marrow cells were studied over a period of 10 weeks following irradiation for the development of serum hemagglutinin titer. By the 10th week all surviving animals registered both anti-host and anti-graft hemagglutinins. This is thought to be the first direct demonstration of such serum anti-bodies.

Attempts to protect whole-body-X-irradiated (850 r) LAF mice by treatment with DNA preparations were unsuccessful. Ten animals were treated with 0.1 mg of LAF spleen DNA, intravenously, 30 minutes prior to irradiation and treated intraperitoneally with the same DNA dosage at 2 hours and at daily intervals for 8 days subsequent to radiation. One out of these ten animals survived for 15 days. Another group of ten animals were similarly treated except that the DNA was prepared from Fisher strain rat spleen. All animals were dead within 14 days. Another group of ten animals were similarly treated with mouse spleen DNA except that the pre-irradiation treatment was omitted. One out of ten of these animals survived for 15 days. Five animals were similarly treated with calf thymus DNA. All were dead within 14 days. Further efforts will be made to isolate highly polymerized RNA for protection studies.

#### Cellular Studies

A previous report indicated that less glucose is absorbed into yeast cells grown in D<sub>2</sub>O than in cells grown in H<sub>2</sub>O. To determine whether this was caused by a differential utilization of the glucose in metabolic processes or to a differential absorption of the glucose an experiment was set up using the metabolic poison, iodoacetate. In the present experiment where glucose metabolism was prevented, the same lower absorption of glucose into the D<sub>2</sub>O system was observed. A similar test was attempted using cyanide, but the strain of yeast which was selected proved insensitive to the poison.

Plant Studies

Bean plants were exposed to a large volume of very dilute  $I^{131}$  delivered as a very fine mist. When the amount of  $I^{131}$  associated with the different leaves was corrected for the weight of these leaves, there was no significant difference in the amount of  $I^{131}$  retained. Stem tissue was significantly lower which can be accounted for by the lower surface area of the stem.

While benzamidazole has not, in our hands, produced any enhancement of K-uptake in intact plants, we have now demonstrated enhancement in excised barley roots. The relation of the root uptake to the whole plant uptake is as yet not clear.

Columbia River Limnology

Concentrations of sodium, chloride and nitrate in the Columbia River increased during the month of October. Phytoplankton populations, however, remained relatively stable.

Rattlesnake Springs Limnology

Water samples from five different environments within the Rattlesnake Springs Facilities was analyzed for chemical properties. The water samples were collected from a spring area, stream, stream impoundment and two ponds adjacent to the impoundment. Calcium decreased about one-third between the spring source and impoundment from 46 to 29 ppm and Ca levels in the ponds were about one-half that in the impoundment. The phosphate level in one pond was three times greater than in the other. The pond with higher phosphate contained about 5 to 30 times more Mg, Na, K, NH<sub>4</sub>, SO<sub>4</sub>, Cl and total solids than water from the impoundment or second pond. Causes of these differences will be investigated.

Plant Ecology

Water losses from undisturbed soil under sagebrush communities during October were comparable to water losses from soil maintained in metal enclosed columns (1 dm diameter x 2 dm deep) under field conditions. This indicates validity of this method for radionuclide cycling field studies.

Fallout

Radioiodine concentrations in thyroids of North American deer remained nearly constant throughout the month, maintaining a plateau which started in mid-October. Values at various locations were as follow:

Location	No. Samples	$I^{131}$ /g wet thyroid (nc)		
		Range	Mean	SD
Washington				
Hanford deer	3	3.0 - 7.6	5.6	2.4
Cascade deer	15	1.7 - 4.7	3.3	1.4
Cascade elk	30	3.0 - 7.5	7.2	2.6
California deer	8	0.91- 2.3	1.6	0.42
Maryland deer	7	0.93- 1.7	1.3	0.29
Alaska reindeer	8	0.37- 0.58	0.54	0.09

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These samples were generally similar in rank and  $^{131}$  concentrations to those obtained from similar locations one year ago.

#### Radiation Effects on Insects

The hypothesis that X rays adversely affect cell division rather than a neurosecretory mechanism was supported by observing the effects of X-radiation upon development of immature European meal moths (Ephestia). When young or middle-aged larvae were exposed to about 20 kr X ray, metamorphosis to adults was inhibited and most deaths occurred at the larva-pupa transition which is a critical developmental stage involving much cell division.

Twenty minute exposure of Tribolium confusum pupae to increased atmospheric oxygen produced no adverse effects. When pupae were exposed to 2.5 kr X ray in the presence of increased oxygen, metamorphic success was less than when exposed in air.

\* Population Dynamics - Waterfowl (omitted from page D-1)

Wintering waterfowl populations within the Hanford Reservation increased to about 130,000 ducks and geese during the month. This is a greater number than were present at this time last year and is probably due to greater amounts of food available due to current weather conditions.

  
Manager  
BIOLOGY OPERATION

H. A. Kornberg:es

## C. Lectures

## a. Papers Presented at Society Meetings and Symposiums

Northwest Section Meeting of Society of Experimental Biology and Medicine, November 17, 1962, Vancouver, B.C., Canada:

Bustad, L. K. and S. Marks. Thyroid neoplasms in sheep fed radiiodine.

Casey, H. W., R. O. McClellan, W. J. Clarke, and L. K. Bustad.  $^{131}\text{I}$  labeled Rose Bengal dye as a liver function test in sheep.

Erdman, H. E. Arrested development in X-rayed larvae of Ephestia kuehniella Zeller.

Mahlum, D. D. Effect of neptunium-237 on liver lipids.

McClellan, R. O., J. R. McKenney and L. K. Bustad. Changes in calcium- $\text{Sr}^{90}$  discrimination with age in young miniature swine.

Tombropoulos, E. G. Removal of inhaled radioactive particles from the lungs of rats and dogs.

Wood, D. H., E. E. Elefson, and L. K. Bustad. Thyroid uptake of radiiodine following various routes of administration.

McClellan, R. O. Hematological changes in miniature swine ingesting  $\text{Sr}^{90}$  daily. Fifth Annual Meeting of the American Society of Hematology at Columbus, Ohio, November 26-28, 1962.

## b. Seminars (Off-Site and Local)

Bustad, L. K. Physio-pathological response to radiation. Veterinary Toxicology class at Washington State University, November 2, 1962.

Mahlum, D.D. Some aspects of the biological function of DNA. Occupational Medical Operation (local), November 29, 1962.

Stuart, B.O. Biological effects of radiation. Radiation Monitoring Training Class (IPD - local), November 1, 1962.

## c. Seminars (Biology)

Case, A. C. Liquid scintillation counting. November 6, 1962.

Cushing, C. E. Ecology of a lake-stream system. November 6, 1962.

Nelson, R. W., Chem. Research and Development, HLO. Application of the analyses for water-flow soils. November 13, 1962.

Hanson, W. C. Fallout radiiodine in thyroids of natural population of animals. November 20, 1962.

Nakatani, R. E. Sampling tuna off Christmas Island. November 20, 1962.

C. Lectures (continued)

d. Miscellaneous (civic organizations, churches, high schools, etc.)

Hanson, W. C. Project Chariot. Kennewick First Presbyterian Church Men's Brotherhood, Kennewick, Washington, November 27, 1962.

Park, J. F. Care and Management of Laboratory Dogs. Kennel Club, Richland, Washington, November 7, 1962.

D. Publications

a. Documents (HW)

None

b. Open Literature

Erdman, H. E. 1962. Beginning of reproduction determined by age of the female flour beetle Tribolium confusum. Naturwissenschaften 49(18): 428.

Mraz, F. R. 1962. Calcium and strontium uptake by rat liver and kidney Mitochondria. Proc. Soc. Exptl. Biol. and Med. III, 429.

Thompson, R. C. 1962. Resume of the Hanford Symposium on the Biology of the Transuranic Elements. Atompraxis

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BT-762

APPLIED MATHEMATICS OPERATION  
MONTHLY REPORT - NOVEMBER, 1962

ORGANIZATION AND PERSONNEL

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

OPERATIONS RESEARCH ACTIVITIES

Lectures and supplementary materials were prepared for BTC #302, Sessions 13 and 15. These sessions are devoted to the use of the OR type approaches to business problems. The lecture for Session 13 was given during the month. That for Session 15 will be given during December.

Work on updating an incomplete HAPO production-cost model was continued from last month. This revision should be completed during December.

The Benton Regional Planning Commission's economic survey of the Benton County part of the Tri-City Area is to begin in the near future. A review of the Commission's survey plans (to be conducted essentially by Ebasco Services) indicates that the data to be collected by the Commission will in large measure overlap with the local data required for our study of the HAPO economic relationship to the Tri-City Area. Since the Commission's data will be available to us, it would appear unwise and a needless expense to duplicate its local data collection. Consequently, work on our study will be suspended until the Commission's survey results become available to us for our modeling purposes.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Since the "dry" blending process has been instituted at the feed site in the preparation of enriched fuel cores, a sample has been taken from each ingot received at HAPO and measured for reactivity to guard against the possibility, existing in the dry blending process, that an isolated ingot, not meeting specifications, would be accepted. This has imposed a burden on the measurement station. A study showed that cores could be measured in groups of at least three, and possibly more, with the individual cores being re-measured only if the combined reactivity value is outside some pre-determined test limits. The recommendation for compositing measurements in this way was adopted, thus reducing the number of measurements required by a considerable amount

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Available rupture data for fuel elements canned in components from two vendors were analysed in order to: (1) assess the present status of the vendor evaluation; and (2) determine what might be the status of the evaluation upon exhaustion of available components from the one vendor. Additional comments on the validity of the test procedure were offered.

A pilot plant test was run in which a fresh batch of Diversey 514, used in the component cleaning process, was prepared, and 600 components were cleaned in batches of 10 over a period of time. Every 4th batch was measured for wettability characteristics, and simultaneously, analyses were made of solution composition. The resulting data were used to evaluate solution life.

In using the uranium contamination tester under development, background corrections must be made for each fuel element. Extensive background counting data were analysed for randomness. Also, various methods of making corrections for background were proposed, and the properties of each discussed.

Data pertaining to two further characteristics measured in the hot die sizing experiment were analysed. These characteristics were internal bond strength, measured by stud pull, and the thickness of the Al-Ni diffusion layer. An additional characteristic, residual can wall thickness, is currently under investigation. Also in connection with this canning process, initial data from the second designed experiment are being analysed. This experiment was concerned with the end bonding process.

An analysis of recent warp data from 140 NPR fuel extrusions, presumably coextruded under similar process conditions, showed the presence of strong cycles and trends in the data. A closer look is being given the data to hypothesize what might account for this behavior. Also, the feasibility of setting up control charts on warp is under investigation.

#### Irradiation Processing Department

In gathering information needed for the development of the Simulation Model, additional analytical reports were developed. These give information on times between outages, causes of outages, and lengths of outages. The information will be used to construct a probabilistic model describing the outage situation, a necessary first ingredient in the Simulation Model. Concurrently with this, contacts are being made with appropriate personnel to arrive at realistic craft-set requirements for each type of work performed during an outage. This latter step is necessary in view of absence of good data which give the craft-set requirements.

Badge and pencil dosimeter data for two recent months were analysed. A procedure has been set up to analyse these data routinely for the next few months.

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Consulting assistance was provided in connection with testing the reliability of ball drops in the N reactor.

Work continued on the problem of estimating defect frequency and size distribution in connection with welded primary piping for the NPR Project. A digital computer program was written to accept new crack data from primary pipe weld guided bend tests for various groupings, and return estimates of parameters occurring in length and frequency distributions. A second program to estimate parameters in crack depth distributions failed to yield reasonable estimates. A least squares approach using the NELLY Program will be tried.

The problem of devising a more accurate and reliable theory for processing borescope data obtained from in-reactor tubing is under study. Several physical and mathematical approximations existing in the present theory are being replaced by more realistic expressions.

#### Chemical Processing Department

The correlation between boomerang sample density, measured on every part, and part density, measured on a sample of total production, was examined in order to evaluate the use of the boomerang sample density as a control tool.

As a result of an evaluation of the existing method of setting limits for standard samples in the CPD analytical laboratories, a change in procedure was recommended and adopted which makes the control program more responsive to current laboratory precisions and accuracies.

A clarification was made of the method of computing individual isotope estimation error from multiple channel gamma scans as requested.

Based on a preliminary study, further experimentation was proposed to better define the relationship between the amount of excess reducing agent used in button production and resulting button density.

An analysis is being made to assess the measurement errors when different gauges are used in the measurement of part dimensions.

A rough draft report is being prepared in connection with assessing the risks associated with the shipment of radioactive materials by rail. The report, which contains many tables summarizing various types of data, will be of great use in finding the risks involved in a given situation.

Work continued on the refinement and programming of a mathematical model of spare parts and general inventory control.

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### Relations and Occupational Health Operation

Preparations were made for, and presentations were made at, seven staff meetings in connection with reporting the results of the 1962 HAPO Attitude Survey to Management.

### STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HL

#### 2000 Program

##### Pulse Column Facility

The analysis was completed of data from an experiment to estimate the organic zero shift of the gamma absorptiometer to be used for analyzing feed stream concentrations in future pulse column experiments. Work continued on the power spectrum estimation problem in connection with the characterization of mid column uranium concentration variability under supposedly equilibrium operating conditions. A digital filter is being constructed which will remove a low frequency spike in the spectrum prior to the use of the spectral analysis estimation routine.

#### 3000 Program

##### Machining Development

A report is being written which will explain the development and use of the EDPM program that generates the magnetic tape input to the experimental 8-u contour lathe.

#### 4000 Program

##### Ceramic Fuels Development

Computations were made to determine the theoretical particle sizes and proportionate mix factors necessary to produce a high density fuel element.

##### Non-Destructive Testing

Analytical studies continued on the problem of determining the propagation phenomena of disturbances in elastic media. An EDPM program is nearing completion which will compute the pertinent parameters which characterize the various modes of behavior of large slabs of homogeneous materials.

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5-E

5000 Program

Actinide Element Research

Work continues on the problem of indexing hexagonal crystals. The computer program for the indexing of cubic crystals is being modified to increase the accuracy of the indexing and also to speed up its execution time.

Computation and Statistical Analysis

A new input routine for program GEM was written, debugged, and has worked satisfactorily on several cases. This input routine will handle multiple detector spectra and also is an improvement over earlier versions in its method of identifying individual cases. The mathematical section of the formal report describing the GEM program was completed.

The IRA Mark II programming is nearing completion with debugging of the data reduction routines already in progress. IRA 335 (data analysis routine used in GEM Program) is 95% programmed and debugging will start as soon as data are available from the previous IRA Mark II pass.

Graphing of program data was continued to establish the sensitivity levels of various analytical procedures.

A set of tables was computed which list the expected lengths of confidence intervals for a sample net counting rate when this rate is estimated as the difference of a sample and a background counting rate. The table will be included in the formal report, "Fixed Time Count Rate Estimation With Background Corrections".

General

Instrumentation

The analysis of mass spectrometer data on three gas standards was completed. The total variation in data was resolved into between run components on a within week basis, individual peak components, and experimental error. The results of the analysis will provide an estimate of the precision of a quantitative analysis of a gas sample based on the comparison with a known standard previously analysed on the same instrument. Analysis was begun of data from two more standards which have been run repeatedly in the past several months on a single mass spectrometer according to a designed experimental plan.

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### Atmospheric Diffusion Studies

Further work was done toward developing a mathematical model to explain the lateral dispersion in concentration data of the Green Glow diffusion experiments. Current efforts are directed toward fitting a folded bivariate normal distribution to tower sampler concentration data at a given distance downwind from the source.

### OTHER ACTIVITIES

J. B. Goebel presented a paper describing the indexing of cubic crystals with X-ray diffraction data on the digital computer at a meeting of the Society of Industrial and Applied Mathematics at Portland, Oregon, on November 3, 1962.

W. L. Nicholson participated in advance degree recruiting for the General Electric Company on three midwestern university campuses during the week of November 12 to 16.

B. B. Field visited the AEC Office of Forecasting and Analysis in Washington, D. C, to explore areas of mutual work interest, and attended the 22nd National Meeting of the Operations Research Society of America in Philadelphia. The meeting program was primarily devoted to problems of defense planning (including disarmament questions), corporate business planning, and urban planning.

A. D. Wiggins participated in advanced degree recruiting at the University of California on November 26, 27 and 28 and Stanford University on November 29 and 30.

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REACTOR DEVELOPMENT - O4 PROGRAMPLUTONIUM RECYCLE PROGRAMIdealized U-235 Study

The final draft of HW-72219, Uranium Price Schedules and Bred Fuel Values was completed and is ready for typing as a formal report. This report establishes the relationship that plutonium values in thermal reactors are proportional to the price of fully-enriched uranium and not to the alternative cost of U-235 burnup in slightly enriched uranium.

Uranium Price Schedule Computations

The incentive to complete HW-74762, a document describing the impact on fuel costs of uranium price schedule calculations in general, has increased because of the AEC's tentative approval of toll separations. It is likely that the schedule of charges for enriched uranium now in effect would not apply in a toll separations system. The reasons are that each customer may have a different feed composition, value his feed differently, require a different product composition, and/or have a small inventory of material so that it would not be worthwhile for the cascade operator to alter the system substantially. It is likely, therefore, that the charges to each customer will be based on a non-optimum waste composition and a separative duty cost that will depend on the amount and the composition of the product; presumably each customer would pay his share of the plant overhead.

These considerations mean that the actual cost of enriched uranium will be calculated by specifying a feed cost, a feed composition, a separative duty cost, and a tails composition. (A tails value can be specified in addition, but this is equivalent to reducing the price of the feed.) Present computations assume that the tails composition is optimized and, therefore, is a function of the other variables. In the calculation programmed as the UCOST code, all of these items are independent variables; therefore, the code is well suited for toll separations calculations.

It is planned that HW-74762 will contain the fundamentals of uranium isotopic separation, a discussion of present and projected (i.e., toll separation) pricing policies, and the details of the UCOST computer code. The general impact on fuel costs of toll separations enrichment costs will be calculated. These calculations will consider several different interest rates on the fuel to reflect the financing systems of the various utilities.

Generalized Nuclear Parameters Study

The nuclear parameters study is designed to determine the relative importance of plutonium's nuclear properties. Previous work has shown that there is a value of alpha greater than zero for which the plutonium value is a maximum.

(See Programming Monthly Report - October 1962.) In order to determine that this is due to the fertility of Pu-240, a series of experiments was made in which Pu-240's absorption cross section was varied along with the fission cross sections of Pu-239 and Pu-241. These results are shown in Table I.

Table I indicates primarily that a variation in the cross section of Pu-240 is more effective if eta is small and that the optimum value of eta becomes less when Pu-240's cross section is increased. For eta values of  $\approx 1.5$  (0.8 of standard), the maximum value ratio ( $V/V_0$ ) is achieved with a Pu-240 cross section ratio  $(\sigma^a/\sigma_0^a)_{240}$  greater than 2. For eta values of  $\approx 1.88$  (i.e., standard), the maximum value ratio is between 1 and 2 of the ratio  $(\sigma^a/\sigma_0^a)_{240}$ . While for an eta value of 2.23 (1.2 of standard), the maximum value ratio is between 0.5 and 1 of the ratio  $(\sigma^a/\sigma_0^a)_{240}$ . The interdependence between the value of Pu-240 yielding maximum fuel values and the eta values of Pu-239 and Pu-241 is, however, not nearly as pronounced in this study as was expected. It is probable that this effect would be greater if Pu-241's cross section were held constant because Pu-242 is, unlike Pu-240, a parasite.

It is planned to extend the nuclear parameters study with cases in which only Pu-239's cross sections are varied and cases in which alpha is varied by changing  $\sigma^a$  with  $\sigma^f$  constant.

#### Economic Incentives in Fuel Element Development

The relative incentives to increase exposure or lower fuel element fabrication costs were discussed and tabulated for a sample  $UO_2$  fueled PWR in last month's report. This type of analysis has been extended to other reactor types and fueling methods.

For a given reactor type and fuel element fabrication cost, there exists an optimum final exposure which will yield minimum fuel cost. Figure 1 shows, for a sample reactor, the optimum exposure plotted against fabrication cost. Also included are minimum fuel costs corresponding to the optimum exposure. When the optimum exposure exceeds the durability of the fuel element, incentive exists both to increase the fuel durability and to reduce fuel fabrication cost. This situation is represented by the area below and to the right of the optimum exposure line.

On the optimum line there exists no incentive to extend fuel exposure for the particular fabrication cost. The only incentive is to reduce the fabrication cost, thus, attaining a lower minimum fuel cost. The lowering of cost may be accompanied by simultaneous reduction in exposure, which will maintain the optimum exposure.

When a fuel element is used whose durability far exceeds the optimum exposure represented by the area above and to the right of the optimum performance line, incentive exists to reduce the fabrication cost by decreasing the durability; thus, reducing the minimum fuel cost while approaching the optimum exposure.

TABLE I

## NUCLEAR PARAMETERS STUDY

## THE EFFECT OF Pu-240 CROSS SECTION ON THE VALUE OF PLUTONIUM

	$(\sigma^a/\sigma_o^a)_{40}$		
	0.5	1.0	2.0
	$(\sigma^f/\sigma_o^f)_{49} = (\sigma^f/\sigma_o^f)_{41} = 0.8$		
$\eta$	1.49	1.50	1.52
$V/V_o$	0.553	0.600	0.647
$F/F_o$	1.19	1.22	1.25
	$(\sigma^f/\sigma_o^f)_{49} = (\sigma^f/\sigma_o^f)_{41} = 1.0$		
$\eta$	1.86	1.88	1.89
$V/V_o$	0.936	1.000	1.000
$F/F_o$	1.00	1.00	1.00
	$(\sigma^f/\sigma_o^f)_{49} = (\sigma^f/\sigma_o^f)_{41} = 1.2$		
$\eta$	2.23	2.25	2.26
$V/V_o$	1.055	1.073	1.051
$F/F_o$	0.83	0.81	0.81

## Definitions:

$\sigma^a$  = effective absorption cross section, barns

$\sigma^f$  = effective fission cross section, barns

$\eta$  = average number of fission neutrons produced/absorption in Pu-239 and Pu-241

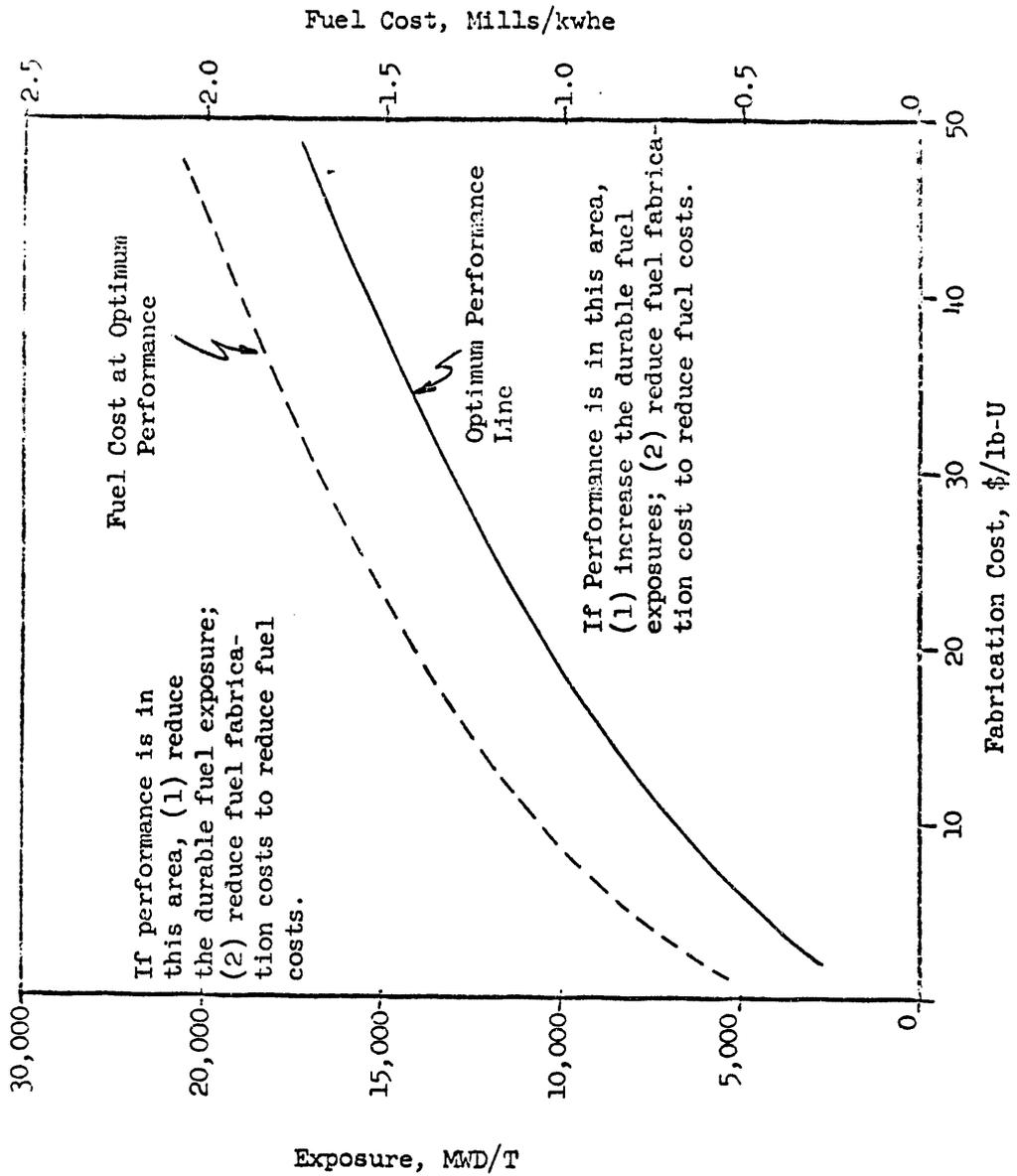
$V$  = plutonium value by the indifference method, \$/gram fissile

$F$  = reactor fuel cost, mills/kwh<sub>e</sub>

Subscript zero denotes the standard case.

FIGURE 1

Exposures and Fuel Cost Corresponding to Optimum Performance For Various Fabrication Costs



In this situation the reactor operator would be paying for much more durability than necessary. Figure 1 shows that incentives exist, but the figure does not show the relative incentive between lowering fabrication costs and extension of exposure. An investigation of relative incentives shows that very little incentive exists when the durable exposure is within 90 percent of optimum, but that incentives increase rapidly as the durable exposure decreases to 50 percent of optimum. Decreases in fabrication costs are rewarded with nearly linear decreases in minimum fuel cost as can be seen from Figure 1. This may not be true for reactors with conversion ratios near unity.

#### Combined Cycles Study

An audit of the combined cycles study of three reactor types has revealed a discrepancy in the handling of the parasitic absorption index calculated by JASON code. In effect, the cases were run with much lower amounts of parasitic material than originally intended. Fortunately, the discrepancy is not a random one but is patterned; thus, the existing results can be calibrated with a replicated experiment involving a moderate amount of machine time. In particular, the conclusions with regard to the interaction among clad material, fuel costs, and plutonium value appear to be very conservative. While the study indicated that plutonium values were greater with increasing amounts of parasitic cladding material, it is expected that all of the plutonium values were conservative as calculated. The JASON code is being corrected so that it properly handles the nonfuel absorptions.

#### Reduction of U-238 Spatial Concentrations

The indifference value method is being used to obtain plutonium values for reduced density plutonium in several reactors. The reactors chosen were optimized for burning plutonium of a composition rich in the fertile Pu-240 isotope. In general, these reactors are of a type where spatial self-shielding of the Pu-240 isotope cross section is minimal. Thus, they are able to utilize the fertility of the Pu-240 isotope in preference to U-238 when the U-238 spatial concentration is reduced. Plutonium values are obtained for these reactors by comparing fuel costs as a function of plutonium price for U-235 enriched and plutonium enriched cycles in each reactor. This system does not consider the alternative of exchanging plutonium between different reactors.

An improvement yet to be studied is to consider two separate reactors. This considers an optimized U-235-U-238 fueled reactor supplying plutonium to the other which is optimized as a plutonium burner. The plutonium value would be obtained for this reactor system by the simultaneous solution of the equations representing the fuel costs for the two reactors. The plutonium value obtained by this method might, and probably would, be different from that value obtained if the plutonium were recycled in the U-235-U-238 fueled reactor only.

Code Development

The objective of the CHAIN II edit routine is to compile tables of CHAIN MELEAGER data in a form that will supplement a formal report without further manual processing. To accomplish this, the calculating sequence of the REPORT GENERATOR PROGRAM (i.e., QUICK-PUVE-PHYSICS sequence designed to operate on CHAIN MELEAGER output) must be changed so that the plutonium values will be available when the physics summary is printed. Additional changes to clarify the printout are being made to make the results useful even if unaccompanied by written text. Two cross section tables, microscopic and macroscopic, have been incorporated in the code and are operable for the uranium and plutonium fueled cases. A separate subroutine, necessary for thorium fueled cases, is about 75 percent complete.

An option has been added to the ALTHAEA code involving the removal of fuel from the reactor to simulate reactor control with fissile control rods. This feature was added to permit study of reactor types similar to APWR in addition to conventionally controlled (poison rod) reactors. Revision of the MELEAGER code was begun for the following reasons:

1. To increase the computation speed since most of the computation time in any fuel cycle study is spent in MELEAGER.
2. To increase the amount and usefulness of the output.
3. To increase the versatility of the input options.
4. To consolidate several minor variations in the code into one master program.

JASON code has been modified so that either  $f$  (the thermal utilization factor) or SNF (the MELEAGER nonfuel absorption index) can be delivered to the MELEAGER code.

ADVANCED CONCEPT STUDIESSeparation of Hydrogen Isotopes by Photo-Excitation

Absorption of a quantum of energy by an atom or molecule leads to activation, ionization, or dissociation of the molecule. Dissociation of molecules of  $H_2$  and  $D_2$ , or their oxides, yields H or D atoms which may be removed from the reacting mixture by allowing them to pass through container walls made from appropriate materials. For example, heated iron is permeable to  $H^+$ . A study has been started to evaluate the economic potential for using irradiation of mixtures of H and D under conditions of temperature, pressure, and frequency such that separation of H from D may be realized. In general the H compounds require less energy for dissociation than their D homologs. Potential quantum yields and separation factors for mixtures of H and D, and mixtures of oxides of H and D as related to reacting system parameters may be estimated. Costs

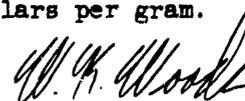
of such separation will be compared with existing process costs to determine future action. Experimental data for irradiation of hydrogen isotopes are extensive but do not include references to separation of irradiation-activated isotopes. Some experimental data relevant to quantum yields in systems at various compositions, temperatures, and pressures for incident irradiation of varying frequency may be required for realistic evaluation; these data would be obtained under conditions including product removal from the reacting system.

#### GENERAL

##### Values in Spent Fuels

In the June 1962 Monthly Report, brief mention was made of the possibility of ascribing values and credits for the U-236, Np-237, and Am-241 content of unprocessed spent fuels. This interest stemmed from the very high selling prices publicized earlier this year for two of these isotopes. These high selling prices could have a very significant effect on fuel cycle economics. In view of this possibility, a preliminary review was made for a number of elements and isotopes for which selling prices were known, in which an investment of neutrons had been made, or for which uses of the multigram quantities which may be available could be conceived. The approach here was assumed to be much like that in the mineral industries where raw ores or scrap materials are valued and sold on the basis of assay. Such values are sufficiently low to allow for total processing or refining costs, shipping, marketing, profit, etc. The problem in the present cases relates to assuming reasonable processing costs where value is known, plus assuming reasonable values where these are not known and finally, assuming reasonable values for those materials (such as U-236 and Pu-242) which are useful components in recycled fuel without need for separation.

The results of these considerations are shown in the following tables. Where figures have been published, such references are noted. All other figures are estimates which may be termed "considered guesses." Hopefully, they are reasonable. When the present or projected figures appeared out of line with respect to utility or value, adjusted figures have been used. There are practically no firm data today on the economics of routinely producing most of these elements or isotopes. In many cases, the economics could be complicated by special conditions of waste processing and multi-product integration. Efforts at obtaining improved cost figures on some of these materials are just getting underway at HAPO. The figures, as shown, must therefore be regarded as reasonable guesses and subject to significant changes as the further studies develop more precise information. The original objective has, however, been realized in that it is shown that with certain reasonable assumptions, there are values in spent fuels so high that the significant effects on fuel processing economics requires further consideration in the studies of fuel cycle analysis. Since heat source applications appear at this time to be an attractive field of use for most of these by-products; values, where appropriate, are shown as dollars per thermal watt as well as dollars per gram.



Manager,  
Programming

WK Woods:lg

SOME ELEMENTS AND ISOTOPES OF SPECIAL VALUE IN DISCHARGED FUEL FROM POWER REACTORS

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Isotope	Expected Use	Price Data		Assumed Future Value (d) \$/Gram	Assumed Prodn. Cost \$/Gram	Est. Value in Fuel \$/Gram
		\$	Calculated to \$/Gram			
Kr-85	Special Radiation Source	15/c	6090	500	400	100
Sr-90	Heat Source	0.75/c(a)	108	35	20	15
Tc-99	Corrosion Inhibitor	90/gm(b)	90	50	40	10
Rh(f)	Ind. & Elec.	4.50/gm	4.50	5.00	3.00	2.00
Ru(f)	Ind. & Elec.	1.80/gm	1.80	2.00	1.00	1.00
Pd(f)	Ind. & Elec.	0.75/gm	0.75	1.00	0.50	0.50
Xe(f)	Special Light Source	35/liter(g)	6.00	2.00	1.00	1.00
Ca-137	Heat Source	0.50/c(a)	49	20	10	10
Pm-147	Heat Source	1630/watt(c)	570	75	45	30
U-236	Target for Np-237	-	-	20	0	20
Np-237	Target for Pu-238	500/gm(b)	500	200	100	100
Pu-238	Heat Source	1600/watt(c)	880	500	300	200
Am-241	Target for Cm-242	1500/gm(b)	1500	200	100	100
Pu-242	Target for Am-243	-	-	50	0	50
Cm-242	Decays to Yield Pu-238(e)	145/watt(c)	17500	400	250	150
Am-243	Target for Cm-244	-	-	500	300	200
Cm-244	Heat Source	-	-	1000	600	400

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(a) Nucleonics Week 4/5/62 AEC prices per curie.

(b) Atomic Industrial Reporter 3/7/62 AEC prices.

(c) Nucleonics, pg. 70, "Radionuclide Power for Space Missions," D. G. Harvey and J. G. Morse, April, 1961.

(d) Pure isotope or element in aqueous solution (except for Kr, Xe, Rh, Pd, and Ru).

(e) Cm-242 is also being considered as a heat source.

(f) May be mixed isotopes, essentially stable (except Pu); some have high fission yields, especially from Pu-239.

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SOME PROPERTIES AND PRELIMINARY RESULTS ON VALUE OF ISOTOPES IN SPENT FUEL

<u>Isotope</u>	<u>Half-Life, Years</u>	<u>Cross-Section Barns</u>	<u>U-235 Fission Yield, %</u>	<u>Specific</u>		<u>Grams Formed per Ton @ 20,000 MWD/T</u>	<u>Estimated Value in Spent Fuel \$/Gram</u>	<u>Estimated Value \$/Ton Spent Fuel</u>	
				<u>Power Watts/Gram</u>	<u>U-235 Yield, %</u>				
Kr-85	10.4	15	0.3	0.54		25	100	2,500	
Sr-90	28	1	5.8	0.95		665	15	9,970	
Tc-99	210,000	22	6.3	--		521	10	5,210	
Rh	Stable	150	2.9	--		215	2.00	430	
Ru	Stable(1/1 yr Ru-106)	2.5	17.6	--		1637	1.00	1,637	
Pd	Stable	8	1.5	--		176	0.50	88	
Xe	Stable	35	22.6	--		4086	1.00	4,086	
Cs-137	30	0.1	6.0	0.42		976	10	9,760	
Pm-147	2.6	230	2.6	0.36		286	30	8,580	
U-236	"Stable"	6	--	--		3500	20	7,000	
Np-237	"Stable"	170	--	--		15	100	1,500	
Pu-238	90	400	--	0.56		--	200	--	
Am-241	458	800	--	--		50	100	5,000	
Pu-242	380,000	23	--	--		400	50	20,000	
Cm-242	163 <u>days</u>	20	--	120		--	150	--	
Am-243	7,650	74	--	--		--	200	--	
Cm-244	17.6	15	--	2.8		--	400	--	
<b>TOTAL</b>								<b>\$75,761</b>	
=								<b>\$37.88/lb</b>	
=								<b>\$53.50/kg</b>	

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RADIATION PROTECTION OPERATION  
REPORT FOR THE MONTH OF NOVEMBER 1962

A. ORGANIZATION AND PERSONNEL

Nancy F. Kirkland transferred from the Construction Engineering and Utilities Operation to Environmental Studies and Evaluation, replacing Joyce W. Clay who resigned from the Company. Colleen S. Ellison transferred from the Finance and Administration Operation to Composite Dose Studies and Evaluation, replacing Mary Jo McLean who has been granted a leave of absence. John P. Corley transferred from the Irradiation Processing Department to Environmental Studies and Evaluation.

B. ACTIVITIES

Occupational Exposure Experience

There were no new plutonium deposition cases confirmed by bioassay analyses during the month. The total number of plutonium deposition cases that have occurred at Hanford is 310, of which 226 are currently employed.

Twenty-one plutonium internal deposition cases of record which had been previously evaluated in excess of ten percent of the maximum permissible body burden (0.04  $\mu\text{c}$  soluble plutonium) were re-evaluated. This completes the re-evaluation of all cases of record greater than ten percent of the MPBB.

A CPD process operator received a plutonium contaminated injury at the 234-5 Building while machining a plutonium metal casting. Examination of the injury with the wound counter showed approximately  $5 \times 10^{-2}$   $\mu\text{c}$  of plutonium. Excision of tissue by the industrial physician reduced the plutonium contamination at the wound site to about  $4 \times 10^{-3}$   $\mu\text{c}$  (approximately 10 percent of the MPBB for bone). In prior years, the same employee had received two other plutonium contaminated injuries to his hands, both requiring medical excision of tissue. The medical action was successful in removing the contamination from an injury that occurred in 1961, but in June 1960, about  $9 \times 10^{-3}$   $\mu\text{c}$  plutonium (approximately 20 percent of the MPBB for bone) remained at the wound site after the excision. Because of the location of the injury on the knuckle of the index finger, no further excision was made. DTPA was administered and evaluation of bioassay analyses indicated internal deposition of < 10 percent. Subsequent examinations of the injury with the wound counter, including examination of the area at the time of the most recent injury, have shown no measurable decrease in the amount of plutonium at the wound site.

A second CPD process operator received a plutonium contaminated injury at the 234-5 Building when he struck a rotating lathe tool with his hand. Examination with the wound counter showed about  $1 \times 10^{-2}$   $\mu\text{c}$

which was reduced to  $1 \times 10^{-3}$   $\mu\text{c}$  of plutonium (approximately 3 percent of the MPBB for bone) by surgical excision of tissue from the wound site.

During the month there were seven incidents in CFD facilities involving eleven employees and five incidents in HLO facilities involving ten employees that required special bioassay sampling for plutonium analysis.

In the course of extended maintenance work on the primary piping system at PRTR, high dose rates and gross fission product contamination were encountered. The maximum dose rates obtained were 8 rads/hour to the extremities and a corresponding 1 rad/hour to the body during shim rod repairs. A dosage rate of 25 rads/hour was observed on contaminated oil in the primary pumps. The containment vessel was grossly contaminated during the maintenance work to greater than 180,000 c/m; however, decontamination efforts reduced these levels to less than 10,000 c/m.

Waste calcination operations were conducted in the 325-A High Level Radiochemistry Facility. It was necessary to replace the CWS filters on the A cell exhaust system because excessive contamination accumulated. One filter had a radiation measurement of 100 rads/hour. The air samples, in continuous operation on the other side of the CWS filter bank, did not indicate any contaminated emission to the atmosphere. Samples of the CWS filters were submitted to the laboratory for radiochemical analysis.

#### Environmental Experience

Concentrations of fallout materials in the air of the Pacific Northwest increased this month. Weekly average values for periods ending 11/2, 11/9, 11/16, and 11/23 were 5, 11, 8, and 8  $\mu\text{c}$  gross beta per  $\text{m}^3$  of air, respectively. As a result of the increased fallout, average concentrations of  $\text{I}^{131}$  in milk exceeded 100  $\mu\text{c}$ /liter for three of the farms and for the two composite samples collected. The highest concentration (550  $\mu\text{c}$ /liter) was observed at Ringold on November 27.

A total of 280 biological, produce, and food samples were obtained for radiochemical analysis. They include:

Milk	68 samples	167 gallons
Pasture grass	32 samples	64 pounds
Hay (baled)	3 samples	6 pounds
Oysters	3 samples	6 pounds
Ground round	2 samples	4 pounds
Honey	2 samples	4 quarts
Beef thyroids	45 samples	
Fish	56 samples	
Ducks	20 samples	
Duck heads	26 samples	(donated by local hunters)
Baby food	23 samples	

Studies and Improvements

A long-term study of the temperature and chemical effects on Columbia River water quality was begun. Initial effort was aimed at comparisons of: (a) integrated cross section temperatures vs. point temperature measurements, and (b) measurements above and below the plant.

Temperature traverses of the Columbia River thus far have confirmed previous data; i.e., no significant vertical variation occurs at this time of year outside the immediate mixing zone. No transverse variation has been observed above the plant. At this time of year and at the river flow rates for which data has been taken, the Priest Rapids gauge temperature recorder has given an accurate measurement of the water temperature. Downstream traverses to date have shown the expected bias toward the plant shore, with varying apparent heat losses.

The  $I^{131}$  uptake experiment with milk intake by volunteers was concluded and uptake from water was initiated. Preliminary analysis indicates that the average fractional uptake of  $I^{131}$  by the thyroid is about half that used by the ICRP. Individual uptake fractions range from about one-third to two-thirds of the ICRP value. Preliminary data on water ingested does not indicate a significant difference in uptake from the values found for milk.

One of the alpha, beta, gamma hand and shoe counters was delivered from the Instrument Laboratories, Inc., Seattle, Washington. Nucleonics Instrumentation is reviewing the instrument to determine whether it was fabricated in accordance with the RPO instrument specifications. Problems encountered in fabrication of this equipment are being applied to the instrument specifications for the beta-gamma, background corrected, hand and shoe counters.

An electronic system was assembled for emergency use to monitor radioiodine in milk. This system has a capability of detecting about  $5 \times 10^{-9}$  c/liter of  $I^{131}$  in a standard ten-gallon milk can. Available equipment in the Radiation Protection Operation and Nucleonics Instrumentation indicates that four additional systems of this type can be assembled within 24 hours to fulfill emergency needs that may develop. A report on the performance of the system is being prepared.

The neutron and gamma dose rates to be expected from high exposure plutonium metal were calculated for several work locations within the 234-5 Building. The effect of the plutonium isotopic composition on these dose rates was investigated. A report summarizing the calculations is in preparation.

Fabrication of air flow rate calibration devices for use with four-inch by eight-inch open-face and in-line building air samplers was completed during the month. Each calibration head includes a plastic "Brooks"

rotameter for air flow rate measurement. These inexpensive rotameters were calibrated with a standard calibrated rotameter and correction curves prepared.

The functional performance characteristics of an improved mechanized densitometer were designated and design to provide this equipment was initiated. An appropriation request for the necessary funds was prepared. The new densitometer will use solid state logic modules throughout. It will provide parity checks for payroll number reading, will automatically check the optical density evaluation reproducibility after each film reading, and will include a built-in audit to verify the readout card punch data.

The Calibrations' plutonium-beryllium neutron source number M-199 was repackaged at the Mound Laboratory and is now at the U. S. Bureau of Standards for certification. The source contains 39.28 grams of beryllium and 79.92 grams of plutonium. The neutron emission as measured by the Mound Laboratory is  $9.52 \times 10^6$  n/sec.

Examination of children for thyroid  $I^{131}$  measurements continued during November. Twelve examinations were performed. All results were less than 100 pc per thyroid. Less than 20 pc  $I^{131}$  (the detection limit for  $I^{131}$ ) were detected in one 2-1/2 year old female.

The chemical toxicity of metals was summarized from current literature. The threshold limit values and lethal dose were tabulated for lead, mercury, beryllium and uranium. Lethal doses of tritium, sodium-24,  $P^{32}$ ,  $As^{76}$ ,  $I^{131}$  and  $Ra^{226}$  were calculated.

The November 2 badge film was processed through the automatic densitometer with the best machine performance to date. Prior to X-ray coding, all badges were shaken to orient the film in the packet uniformly in relation to the lead coding tape. The net result was a payroll number reading efficiency of about 95%, compared to approximately 80% the previous month. All film now loaded in badges is pre-positioned within the packet prior to badge loading, which should make badge shaking unnecessary in the future.

The pencil dosimeter program now includes all areas on the single pencil system, using payroll numbers only. Master files have been established for the pencil dosimeter program, and are currently being set up for the ring dosimeter program.

#### C. VISITORS AND VISITS

Visitors consulting with members of the Radiation Protection staff during the month included:

K. E. Cowser        )  
R. M. Richardson) - Oak Ridge National Laboratory, Oak Ridge, Tennessee

M. Gras )  
J. Vertut ) - French Atomic Energy Commission, Saclay, France

K. Kummeneje - Royal Veterinary College, Oslo, Norway

G. H. Hansen )  
C. Ogden ) - Pollution Control Commission, Yakima, Washington

Lt. Comdr. A. Rockman - USN-DASA, Sandia Base, Albuquerque, New Mexico

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

E. C. Watson - Attended Annual Health Physics Review and met with Executive Board of Health Physics Society, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

A. R. Keene - Attended Annual Health Physics Review and attended Board of Directors meeting of the Health Physics Society, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

L. A. Carter - Attended meeting of Technical Advisory Board on Radiation Control, Seattle, Washington.

R. F. Foster - Conferred with members of the University of Washington Laboratory of Radiation Biology and attended Laboratory's 20th anniversary celebration.

L. G. Faust - Consulted with members of Reynolds Electrical and Engineering Co., Inc., Mercury, Nevada.

#### D. RELATIONS

Five suggestions were submitted by personnel of the Radiation Protection Operation and one was re-opened during November. Two suggestions were adopted; four were rejected. Five suggestions are pending evaluation.

Safety meetings were held throughout the Section during the month. Safety and housekeeping inspections continue to show employee cooperation.

An orientation lecture on radiation protection was presented to personnel of the 300 Area Reactor and Fuels Research and Development Operation, Biology research personnel, and Protective Equipment Decontamination Operation. Six persons attended the final session on Disaster Monitoring presented to IPD personnel. To date a total of 322 persons have attended this course.

E. SIGNIFICANT REPORTS

- HW-74307-10 - "Radiological Status of the Hanford Environs for October 1962" by R. F. Foster.
- HW-75076 - - "The Columbia River Environmental Monitoring Program" by R. H. Wilson.
- HW-75250 - - "A Manual of Emergency Procedures for Environmental Monitoring" by D. McConnon.
- HW-75697 - - "Monthly Report for November 1962 - Radiation Monitoring Operation" by A. J. Stevens.
- HW-SA-2785 - "Some Notes on Practical Neutron Dosimetry" by P. E. Bramson, G. W. R. Endres, R. H. Wilson and C. C. Gamertsfelder.

PERSONNEL DOSIMETRY AND RADIOLOGICAL RECORDS

<u>External Exposure Above Permissible Limits</u>	<u>November</u>	<u>1962 to Date</u>
Whole Body Penetrating	0	3
Whole Body Skin	0	3
Extremity	0	3
<u>Hanford Pocket Dosimeters</u>		
Dosimeters Processed	7,497	40,411
Lost Results	0	0
<u>Hanford Beta-Gamma Film Badge Dosimeters</u>		
Film Processed	9,832	116,091
Results - 100-300 mrad	249	3,401
- 300-500 mrad	30	328
- Over 500 mrad	5	111
Lost Results	14	400
Average Dose Per Film Packet - mrad (ow)	20.44	13.52
- mr (s)	39.29	30.64
<u>Hanford Neutron Film Badge Dosimeters</u>		
<u>Slow Neutron</u>		
Film Processed	2,739	18,608
Results - 50-100 mrem	2	31
- 100-300 mrem	0	43
- Over 300 mrem	0	2
Lost Results	14	109
<u>Fast Neutron</u>		
Film Read	725	4,810
Results - 50-100 mrem	3	433
- 100-300 mrem	158	882
- Over 300 mrem	9	75
Lost Results	11	57
<u>Hand Checks</u>		
Checks Taken - Alpha	26,890	414,743
- Beta-Gamma	79,167	607,974
<u>Skin Contamination</u>		
Plutonium	29	286
Fission Products	27	551
Uranium	37	49
Tritium	0	0
Thorium	2	2

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<u>Whole Body Counter</u>	<u>Male</u>	<u>Female</u>	<u>November</u>	<u>1962 to Date</u>
GE Employees				
Routine	2	0	2	156
Special	16	0	16	201
Terminal	4	0	4	96
Non-Routine	9	2	11	241
Non-Employees	16	9	25	102
Pre-Employment	0	0	0	8
	<u>47</u>	<u>11</u>	<u>58</u>	<u>804</u>

Bioassay

Confirmed Plutonium Deposition Cases	11	27*
Plutonium - Samples Assayed	405	3,699
- Results Above $2.2 \times 10^{-8}$ $\mu\text{c}/\text{sample}$	69	276
Fission Product - Samples Assayed	414	4,207
- Results Above $3.1 \times 10^{-5}$ $\mu\text{c}/\text{sample}$	3	18
Uranium - Samples Assayed	196	1,869
Biological - Samples Assayed	0	249
Strontium - Samples Assayed	0	299

<u>Tritium Samples</u>	<u>Maximum</u>	<u>Count</u>	<u>November Total</u>
Urine Samples > 5.0 $\mu\text{c}/\text{l}$	15.8	31	
< 1.0 $\mu\text{c}/\text{l}$		22	
Samples Assayed			88
D <sub>2</sub> O Samples			
Moderator	835.0	4	
Primary Coolant	0	0	
Reflector	762.53	4	
Samples Assayed			8
Other Water Samples			
Omega Seal	677.79 $\mu\text{c}/\text{ml}$		<u>61</u>
			157

Calibrations

	<u>Number of Units Calibrated</u>	
	<u>November</u>	<u>1962 to Date</u>
Portable Instruments		
CP Meter	1,022	11,114
Juno	256	3,023
GM	531	6,083
Other	206	2,035
Audits	<u>105</u>	<u>1,152</u>
	2,120	23,407

\* The total number of plutonium deposition cases that have occurred at Hanford is 310 of which 226 are currently employed.

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HW-75625

	<u>Number of Units Calibrated</u>	
	<u>November</u>	<u>1962 to Date</u>
Personnel Meters		
Badge Film	696	15,350
Pencils	0	12,670
Other	<u>354</u>	<u>4,630</u>
	1,050	33,150
Miscellaneous Special Services	264	9,607
Total Number of Calibrations	3,434	66,164

  
Manager  
RADIATION PROTECTION

AR Keene:AJS:ljw

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FINANCE AND ADMINISTRATIONACCOUNTINGCost Accounting

Preparation of the FY 1963 Midyear Budget Review was completed during the month. A request was made for additional research and development funds totaling \$793,000; of this amount, \$747,000 applies to the 04 Program and \$46,000 to the 06 Program. Additional capital equipment funds totaling \$345,000 were also requested. The details of the request categorized by major AEC programs are shown below:

(In thousands)	<u>Research &amp; Development</u>	<u>Capital Equipment</u>
02 Program	\$ 1 069	\$1 857
03 Program	175	110
04 Program	12 917	1 272
05 Program	1 375	120
06 Program	3 200	262
08 Program	100	--
Total	<u>\$18 836</u>	<u>\$3 621</u>

The Hanford Laboratories' control budgets for November were adjusted to reflect additional funds authorized by HOO-AEC as outlined in a revised Financial Plan. The increases in program funds are as follows:

	<u>Research &amp; Development</u>	<u>Capital Equipment</u>
<u>04 Program</u>		
Experimental Gas Cooled Reactor	\$ 59 000	\$ 1 000
Gas Cooled Reactor - Other	168 000	72 000
Euratom	5 000	
EBWR Program	400 000	
Neutron Flux Monitors		10 000
Waste Calcination Demonstration	10 000	130 000
<u>05 Program</u>		
Plutonium Physical Metallurgy		
Research	80 000	5 000
Radiation Effects on Metals	2 000	
<u>08 Program</u>		
Fission Products Production Study	100 000	
Total Increase	<u>\$324 000</u>	<u>\$218 000</u>

Data was submitted to Contract Accounting concerning the number of chemists and chemical engineers in Hanford Laboratories for use in determining the corporate membership fee in the American Chemical Society.

Activities for which special accounting codes were established during the month are described below:

<u>Accounting Code</u>	<u>Activity</u>
.6J	Phillips Petroleum Company - Consulting liaison in connection with IBM 7090 application.
.6K	Travelers Research Inc. - Shipment of 9,000 IBM cards containing atmospheric data. Billing was for shipping of the cards only, as the cards will be returned.
.6L	General Electric Laboratory - Fabrication of four glass cylinders from material provided by GEL. Estimated fabrication and shipping costs are \$960.

With the reorganization of Reactor and Fuels Research and Development Operation effective November 12, 1962, revised organization codes were established for the section. Fiscal year-to-date operating costs were recast to conform with the new organization structure.

New program codes established during the month were as follows:

<u>Code</u>	<u>Title</u>	<u>Comments</u>
.27	Metallic Fuel Element Development	New program sponsored by Division of Reactor Development
.33	EBWR Program	New program sponsored by Division of Reactor Development
.83	Plutonium Physical Metallurgy Research	New Program sponsored by Division of Physical Research

#### General Accounting

Following is a summary of the status of letters or agreements covering specific actions requiring AEC concurrence:

AT-269	Assistance to Washington State University	In Process
AT-271	Assistance to AEC Special Fellowship Program in Health Physics	In Process

Travel activity, as measured by the number of trips started, is now above like periods in the two previous fiscal years, as shown below:

Number of Trips Started - FY to Date

FY 1961	549
FY 1962	482
FY 1963	582

Hanford Laboratories' material investment at November 1, 1962, totaled \$26.4 million as detailed below:

(In thousands)

SS Material	\$24 713
Reactor and Other Special Materials	1 319
Spare Parts	<u>364 -1)</u>
	<u>\$26 396</u>

(1- Includes a reserve of \$79,335 established at 11-1-62.

The value of nuclear materials consumed in research this fiscal year to November 1, 1962 is \$2.6 million of which \$2.5 million are applicable to Hanford Laboratories and \$0.1 million to Fuels Preparation Department. The following is a detail by program for Hanford Laboratories' portion.

(In thousands)

2000 Program	\$ 849
3000 Program	409
4000 Program	<u>1 204</u>
	<u>\$2 462</u>

Laboratory Storage Pool activity for the month of November 1962 is summarized below:

<u>Equipment</u>	<u>Current Month</u>		<u>FY to Date</u>	
	<u>Qty</u>	<u>Value</u>	<u>Qty</u>	<u>Value</u>
Beginning Balance	1397	\$811 086	1081	\$562 200
Items Received	160	104 251	578	406 082
Items Withdrawn by Custodians	(10)	(2 236)	(56)	(30 859)
Equipment Transfers	(31)	(9 408)	(81)	(33 296)
Items Disposed of by Excess	(151)	(67 904)	(156)	(68 038)
Items Disposed of by PDR	(4)	(2 592)	(5)	(2 892)
Equipment on hand at 11-30-62	<u>1361</u>	<u>\$833 197</u>	<u>1361</u>	<u>\$833 197 -1)</u>

(1- Includes 135 items valued at \$64,536 which were on loan at November 30.

During the month 35 items valued at \$11,352 were loaned or transferred in lieu of purchases. This fiscal year 134 items valued at \$63,352 have been redirected to useful purposes with resulting elimination of planned purchases. Actual operating costs for the same period were \$4,525, indicating a net saving of \$58,827, which includes a substantial change from estimates made through October 31.

A summary of activity of material held at the Laboratory Storage Pool for five months ended November 30, 1962 follows:

Type of Material	Balance	Current Month		Fiscal Year		Balance
	6-30-62	Receipts	Disburs.	Receipts	Disburs.	11-30-62
<u>Reactor &amp; Other Special</u>						
Beryllium	\$ 592	\$	\$ 203	\$ 39	\$ 203	\$ 428
Hafnium	1 499				1 499	--
Gold	2 924			270	10	3 184
Silver	463			15	1	477
Platinum	5 601	579	962	18 964	5 006	19 559
Clean Scrap	636	506		2 118	648	2 106
Contam. Scrap	19 529	348		392	4 022	15 899
Palladium	2 535			178	27	2 686
Zirconium	122 320	16 444	618	16 691	43 866	95 145
Sub-total	<u>156 099</u>	<u>17 877</u>	<u>1 783</u>	<u>38 667</u>	<u>55 282</u>	<u>139 484</u>
<u>Other (Memo)</u>						
Hastelloy	82 231	--	3 323	--	5 227	77 004
UO <sub>2</sub>	111 622	--	17 728	--	88 996	22 626
Aluminum		2 001	--	13 287	--	15 288
Zirconium-R&D	12 791			1 769	12 900	1 660
Zirconium-Scrap	17 226	38	1 705	3 001	16 056	4 171
Graphite				11 000		11 000
Miscellaneous	12 696		959	2 177	1 866	11 006
Sub-total	<u>236 566</u>	<u>2 039</u>	<u>23 715</u>	<u>31 234</u>	<u>125 045</u>	<u>142 755</u>
Total Material	<u>\$392 665</u>	<u>\$19 916</u>	<u>\$25 498</u>	<u>\$69 901</u>	<u>\$180 327</u>	<u>\$282 239</u>

Total investment of equipment and material in custody of the Laboratory Storage Pool at November 30 is \$1,115,436.

The Laboratory Storage Pool has expanded its responsibility to serve all HAPO with respect to storage and loan instruments under provisions of existing Pool procedures and HAPO OPG 8.9. This action should increase the supply of usable instruments which are always in demand, should result in a saving of equipment funds, and may expedite research programs by having usable equipment immediately available.

Preparations were completed for the physical inventory of movable cataloged equipment in custody of Radiation Protection Operation to begin December 3, 1962. A Contract and Accounting Operation financial representative will be assigned to witness the physical count.

The physical inventory of movable property in the custody of Reactor and Fuels Research and Development Operation has revealed 25 unlocated items valued at \$11,160. This amount is a substantial increase from FY 1961 inventory results wherein eight missing items valued at \$1,524 were not located. Further search is being made.

Reconciliation of the annual HAPO physical inventory of reactor and other special materials taken in September was completed by Contract and Accounting Operation personnel and a report issued November 30, 1962. The inventory disclosed a deficit of \$80.90 for Hanford Laboratories from failure of custodians to properly document consumption of materials in experiments and/or tests. This deficit is relatively minor when compared with the total Hanford Laboratories' investment of \$1.4 million in these materials. There were no unaccounted for losses.

Final unitization was completed on project AEC-167 (PRTR) during the month. Total cost, \$14,315,479, covering 550 units of property was transferred from unclassified to classified accounts. The necessary input data sheets were prepared and submitted to Contract and Accounting Operation for recording the units of property in the EDP system. The unitization report is expected to be issued in January.

The inventory of heavy water at November 3, 1962 disclosed a gain of 297 pounds valued at \$4,088 attributed to recovery of material from an ion exchanger and some small analytical differences in scrap material purities. Scrap generated amounted to 400 pounds valued at \$1,627, resulting in a total net credit to cost of \$2,461. Heavy water accumulated for return to SROO as of November 3 amounted to 33,685 pounds valued at \$434,693.

Action during the month on projects is indicated below:

New Money Authorized Hanford Laboratories

CAH-867 Fuel Element Rupture Test Facility \$6 200

Physical Completion Notices Issued

\*CAH-866 Shielded Analytical Laboratory  
CGH-957 Small Particle Technology Laboratory

\*AEM Services Only

Construction Completion and Cost Closing Statements Issued

\*CAH-888 Biology Facility  
 \*CAH-927 Addition to Waste Treatment Demonstration Facility,  
 271-CR Building

\*AEM Services Only

The HAPO General Indirect Construction Expense Account and the Reserve for Close-Out Expense Account were reduced \$250,000 and \$300,000, respectively. Indirect expense was distributed among all projects active at October 31, 1962 and having estimated total cost of \$100,000 or more, based on indirect expense applied to these projects by General Electric Company. Reserve for Close-Out Expense was distributed among all PAC projects active at October 31, 1962 and having estimated total cost of \$100,000 or more, based on total cost to date. These reductions place reserves more in line with estimated future needs. Distribution of these reductions produced credits on Hanford Laboratories' projects as follows:

<u>Project No.</u>	<u>GICE</u>	<u>Close-Out</u>
CGH-857	\$1 700	\$ --
CAH-866	1 100	1 200
CAH-936	--	100
Total	<u>\$2 800</u>	<u>\$1 300</u>

New and revised OPGs issued in November are listed below:

<u>OPG No.</u>	<u>Title</u>
3.1.3	GE Educational Assistance Program
3.2.1	Wage Payments in Connection with Treatment for Industrial Injuries
3.2.2	Wage Payments in Connection with Personnel Cleanup

The following contracts were processed during the month:

DDR-156	Armour Research Foundation
SA -256	Public Utility District No. 1 of Franklin County
SA -257	Swedish Hospital
SA -259	Schwarzkoft Microanalytical Laboratory

The following Assistance to Hanford authorizations were issued during the month:

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HW-75625

ATH-HL-6-63-A	Plasma Electron Beam Welding Samples (GEL - Direct Conversion and Physics)	\$ 300
ATH-HL-7-63-A	Consultation Services - Dr. Sumio Yukawa (Large Steam Turbine-Generator Department - Materials and Processes Laboratory Section)	\$5 000

Personnel Accounting

Number of Hanford Laboratories Employees

<u>Changes During Month</u>	<u>Total</u>	<u>Exempt</u>	<u>Nonexempt</u>
Employees on payroll at beginning of month	1 630	697	933
Additions and transfers in	15	5	10
Removals and transfers out	<u>10</u>	<u>2</u>	<u>8</u>
Employees on payroll at end of month	<u>1 635</u>	<u>700</u>	<u>935</u>

Quartime Payments During Month

	<u>November</u>	<u>October</u>
Exempt	\$ 5 339	\$ 4 696
Nonexempt	<u>18 911</u>	<u>23 884</u>
Total	<u>\$ 24 250</u>	<u>\$ 28 580</u>

Gross Payroll Paid During Month

Exempt	\$ 660 249	\$ 655 917
Nonexempt	<u>506 774</u>	<u>507 562</u>
Total	<u>\$1 167 023</u>	<u>\$1 163 479</u>

Participation in Employee Benefit  
Plans at Month End

	<u>November</u>		<u>October</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
Pension	1 472	99.3	1 466	99.3
Insurance Plan - Personal	401		395	
- Dependent	1 232	99.8	1 229	99.8
U. S. Savings Bonds				
Stock Bonus Plan	157	42.8	157	43.0
Savings Plan	73	4.5	74	4.5
Savings and Security Plan	1 132	88.9	1 124	88.9
Good Neighbor Fund	1 180	72.0	1 169	71.7

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<u>Insurance Claims</u> <u>Employee Benefits</u>	<u>November</u>		<u>October</u>	
	<u>Number</u>	<u>Amount</u>	<u>Number</u>	<u>Amount</u>
Life Insurance	0	\$ 0	0	\$ 0
Weekly Sickness and Accident	8	623	10	849
Comprehensive Medical	48	3 895	53	3 876
 <u>Dependent Benefits</u>				
Comprehensive Medical	<u>111</u>	<u>9 022</u>	<u>110</u>	<u>10 733</u>
Total	<u>167</u>	<u>\$13 540</u>	<u>173</u>	<u>\$15 458</u>

TECHNICAL ADMINISTRATIONEmployee Relations

Thirteen nonexempt employment requisitions were filled during November with twelve remaining to be filled.

Professional Placement

Advanced Degree - Two Ph.D. applicants visited HAPO for employment interviews. One offer was extended; two acceptances and one rejection were received. Three offers are currently open.

BS/MS - Twenty-two program offers and two direct placement offers were extended. Offers rejected: one program and one direct placement. Current open offers: twenty-six program and three direct placement.

Technical Graduate Program - Three Technical Graduates were placed on permanent assignment. One new member was added to the roll. Current program members total 58.

Technical Information

A classification document, "Control of Information on the Columbia River," HW-75635, was issued.

ECONOMIC EVALUATIONS

General research was completed and specific data was compiled and analyzed for a comparative study of test reactor operating cost.

Actual commercial techniques of estimating nuclear fuel fabrication and total nuclear-electric power generating costs were studied and compared with the general literature on these subjects.

FACILITIES ENGINEERING

At month's end Facilities Engineering Operation was responsible for nine active projects, having total authorized funds in the amount of \$1,486,100. The total estimated cost of these projects is \$6,814,000. Expenditures on them through October 31, 1962, were \$876,000.

The following summarizes project activity in November:

Number of authorized projects at month end -----	9
Number of new projects authorized -----	0
Projects completed -----	2
CAH-866, Shielded Analytical Laboratory	
CGH-957, Small Particle Technology Laboratory	
New projects submitted to the AEC -----	1
CGH-991, Waste Calcination Demonstration in the FRPP	
New projects awaiting AEC authorization -----	5
CGH-974, Analog Simulation Facility	
CAH-982, Addition to the Radionuclide Facilities	
CAH-985, Addition to the 222-U Building	
CAH-986, 300 Area Retention Waste System Expansion	
CGH-991, Waste Calcination Demonstration in the FRPP	
Project proposals complete or nearing completion -----	4
Graphite Machine Shop	
Neutron Calibration Facility - 3745-A Building	
Irradiated Structural Materials Testing Facility	
Atmospheric Physics Building	

Pages appended to this report provide detailed project status information.

Services

Satisfactory progress was made in the engineering services provided on the jobs listed below:

- Helium Gas Loop power study
- Removal of 15 KVA transformer and power lines from poles near 325 building
- Increase in Arc Melt Furnace power supply, 306 building
- Emergency switchgear circuit breaker check
- 325 basement ventilation problem
- 108-F conference room noise level study
- 108-F ventilation equipment system study

Assistance with pressure system problems included:

- Design audit on in-reactor portion of the PRTR Rupture Loop
- Review of design of proposed Dynamic Materials Test Apparatus
- Small pressurized, high temperature ceramic fuel research furnace
- FRPP piping system review
- Irradiation Studies Loop (C-1) design

Plant engineering effort was expended on:

- Lighting panel for Laboratory 6A, 326
- Alternate power supply for 306 salt bath furnace
- Proposed second floor offices, 306
- Laboratory vacuum pump replacement, 325
- Relocation of two-ton monorail hoist, 326
- Ventilation modifications, 308
- Counting room conditioner, 329
- Building ventilation, 327
- Ventilation modifications, 3702
- Crib waste tank ventilation, 340
- Fire and evacuation alarm tie-in to PA system, 309
- Equipment procurement totaling \$30,500 was initiated; total value of materials and equipment on order is \$250,000. M & E lists for project CG-991 were issued.

Facilities Operation

Landlord costs for October were \$148,360 which represented about 89% of the forecast for the month. The total cost to date is \$523,718 which is 83% of the predicted. Improvement maintenance was \$12,025. Steam consumption continues to be significantly below the anticipated 91%.

The following tabulation summarizes waste disposal operations:

	<u>September</u>	<u>October</u>
Concrete barrels disposed	8	16
Loadluggers of waste disposal	49	48
Cribs waste, gallon	230,000	390,000

No basins exceeded radiation control limits.

About 18,500 gallons of "Dash" fuel element decontaminant were transported from PRTR to the 216 BC trench. To date, 138,000 gallons have been disposed in this 150,000 gallon capacity trench. Approval for the excavation of another such trench was obtained from Chemical Processing Department.

The Filter Plant (315 Building) was chlorinated to reduce algae buildup. The calibration of instruments was almost completed.

The emergency electrical power for the laboratory area was out of service because of a defective fuse for at least 20 hours. The circuitry is being reviewed for improvement of the reliability.

Drafting

The equivalent of 114 drawings were produced during the month for an average of 24 man-hours per drawing.

Major jobs in progress are - PRTR "As-Builts", PRTR Shim Rod Control, PRTR Cladding Cutter Assembly, Hi-Temp Vacuum Furnaces, Process Tube and Fuel Handling Carriage - NPR, Inhalation Studies Hood, Scintillation Scanner, FRPP Equipment Design, Fuel Element Identification System - PRTR, and Salt Cycle for "C" Cell.

Work performed by CE&UO and Bovay Engineers during the month for Hanford Laboratories Drafting Operation was 277 and 51 man-hours respectively. Work assigned during the month was 320 and 40 man-hours.

Construction Supervision

Activity during the month on construction work (J. A. Jones Company) being performed for Hanford Laboratories components is given below:

	<u>Unexpended Balance</u>
Orders outstanding beginning of month	\$ 74 930
Issued during the month (inc. suppl. & adj.)	162 024
J. A. Jones expenditures during month (incl. C.O. costs)	91 454
Balance at month's end	145 500
Orders closed during month	100 249

In addition work on seven maintenance work orders, having a total face value of \$23,377, issued to Plant forces was supervised.

1-11-68

UNCLASSIFIED

H-12

HW-75625

Construction and maintenance activities completed during November included:

108-F partition installation  
108-F exterior trim painting  
108-F interior painting  
242-B sample cask unloading station construction  
309 leaking wall repair, minus 14 foot level

*W Sale*  
Manager  
Finance and Administration

W Sale:whm

SEMI-MONTHLY PROJECT STATUS REPORT						HW-75625					
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62					
PROJ. NO.	TITLE					FUNDING					
CAH-822	Pressurized Gas Cooled Loop Facility					4141 Operating					
AUTHORIZED FUNDS	DESIGN \$	AEC \$	COST & COMM. TO		\$						
\$ 1,170,000	43,000	15,000	11-18-62		\$ 1,146,418(GE)						
	CONST. \$	GE \$	ESTIMATED TOTAL COST		\$						
	1,127,000	1,155,000			\$ 1,170,000						
STARTING DATES	DESIGN	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE						
	8-15-59	7-25-62*		4-29-60		WT'D.	SCHED.	ACTUAL			
	CONST. 10-17-60	DIR. COMP. DATE 12-31-62		CONST. 12-31-62							
ENGINEER	TRAO-MEEO - DP Schively					DESIGN	100	100	100		
<u>MANPOWER</u>					AVERAGE	ACCUM	MANDAYS	GE-TIT. II			
FIXED PRICE								AE-TIT. II			
COST PLUS FIXED FEE											
PLANT FORCES								CONST.	100	98	93
ARCHITECT-ENGINEER								PF	1.4	0	0
DESIGN ENGINEERING OPERATION								CPFF	22.3	100	98
GE FIELD ENGINEERING								FP	6.6	100	100
								Gov. Ed. 69.7	100	93	
SCOPE, PURPOSE, STATUS & PROGRESS											
Vendor has changed to Teflon impregnated bearing liners. Initial tests of these bearings in an assembled blower have not been successful. Cause of difficulty has not yet been determined.											
Insulation of loop piping has been resumed.											
* Initial authorization date was December 18, 1958											

PROJ. NO.	TITLE					FUNDING				
AUTHORIZED FUNDS	DESIGN \$	AEC \$	COST & COMM. TO		\$					
\$	CONST. \$	GE \$	ESTIMATED TOTAL COST		\$					
STARTING DATES	DESIGN	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE					
	CONST.	DIR. COMP. DATE		CONST.		WT'D.	SCHED.	ACTUAL		
ENGINEER						DESIGN	100			
<u>MANPOWER</u>					AVERAGE	ACCUM	MANDAYS	GE-TIT. II		
FIXED PRICE								AE-TIT. II		
COST PLUS FIXED FEE										
PLANT FORCES								CONST.	100	
ARCHITECT - ENGINEER								PF		
DESIGN ENGINEERING OPERATION								CPFF		
GE FIELD ENGINEERING								FP		
SCOPE, PURPOSE, STATUS & PROGRESS										

SEMI - MONTHLY PROJECT STATUS REPORT						HW- 75625	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62	
PROJ. NO.	TITLE					FUNDING	
CGH-857	Physical & Mechanical Properties Testing Cell - 327 Bldg.					0290	
AUTHORIZED FUNDS		DESIGN \$ 45,000	AEC \$	COST & COMM TO 11-11-62		\$ 368,909	
\$ 400,000		CONST. \$ 415,000	GE \$ 460,000	ESTIMATED TOTAL COST		\$ 410,000	
STARTING DATES	DESIGN 11-2-59	DATE AUTHORIZED 9-22-61*	EST'D. COMPL. DATES	DESIGN 3-15-61	PERCENT COMPLETE		
	CONST. 2-12-62	DIR. COMP. DATE 12-15-62		CONST. 12-15-62	WT'D.	SCHED.	ACTUAL
ENGINEER				FEO - DL Ballard			
<u>MANPOWER</u>				AVERAGE	ACCLM MANDAYS		
FIXED PRICE				10	700	DESIGN 100 100 100	
COST PLUS FIXED FEE						TITLE I	
PLANT FORCES						GE-TIT. II 100 100 100	
ARCHITECT-ENGINEER						AE-TIT. II	
DESIGN ENGINEERING OPERATION						CONST. 100 97 90	
GE FIELD ENGINEERING						PF	
						CPFF 18 97 91	
						FP	
						Equip. 82 97 90	
<b>SCOPE, PURPOSE, STATUS &amp; PROGRESS</b>							
<p>This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in the 327 Building.</p> <p>Status of individual items is as follows:</p> <p>Shop fabrication of cell tray is nearing completion. Installation of brackets for cell tray has started. The hydraulic lift system has been mounted; piping and electrical hookup is complete. All cell plugs and viewing windows have been installed. Essentially all plug mounted equipment has been installed.</p> <p>Fabrication of the dilatometer and annealing furnace have not been completed by the vendor. Delivery is now expected during January. Installation of these items of equipment will be accomplished, following close out of project, by the use of accrued funds.</p> <p>A work stoppage of construction crafts stopped work on this project November 19 through 23.</p> <p>* Original authorization for design was October 1, 1959.</p>							

SEMI-MONTHLY PROJECT STATUS REPORT						HW-75625	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62	
PROJ. NO.	TITLE				FUNDING		
CAH-916	Fuels Recycle Pilot Plant				4-62-d-3		
AUTHORIZED FUNDS		DESIGN \$ 500,000	AEC \$	COST & COMM. TO 11-11-62		\$ 499,900	
\$ 500,000		CONST. \$	GE \$ 500,000	ESTIMATED TOTAL COST		\$ 5,460,000***	
STARTING DATES	DESIGN 3-15-61	DATE AUTHORIZED 10-19-62**	EST'D. COMPL. DATES	DESIGN 11-15-62	PERCENT COMPLETE		
	CONST. 12-15-62*	DIR. COMP. DATE		CONST. 11-15-64	WT'D.	SCHED.	ACTUAL
ENGINEER							
FEO - RW Dascenzo							
MANPOWER				AVERAGE	ACCUM MANDAYS		
DESIGN ENGINEERING OPERATION				2	2270		
GE FIELD ENGINEERING							
						DESIGN	100
						TITLE I	11
						GE-TIT. II	89
						AE-TIT. II	100
						CONST.	100
						PF	0
						CPFF	0
						FP	0
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.</p> <p>All drawings have been approved for construction. The specifications are 100% complete. The cost package will be completed November 30, 1962.</p> <p>To date Rev. 4 of the project proposal for total project funds has not been approved by the Commission.</p> <p>* Estimated construction starting date for removal of burial ground fill.                  ** Original authorization for initiation of design was February 9, 1961                  October 19, 1962 is the authorization date for the last design supplement.                  *** Including transferred capital property valued at \$100,000.</p>							

PROJ. NO.	TITLE				FUNDING		
CAH-922	Burst Test Facility for Irradiated Zirconium Tubes				62-k		
AUTHORIZED FUNDS		DESIGN \$ 29,600	AEC \$	COST & COMM. TO 11-11-62		\$ 29,600	
\$ 29,600		CONST. \$	GE \$ 29,600	ESTIMATED TOTAL COST		\$ 289,000	
STARTING DATES	DESIGN 11-7-61	DATE AUTHORIZED 10-23-61	EST'D. COMPL. DATES	DESIGN 5-31-62	PERCENT COMPLETE		
	CONST. 12-15-62	DIR. COMP. DATE		CONST. 11-1-63	WT'D.	SCHED.	ACTUAL
ENGINEER							
FEO - DL Ballard							
MANPOWER				AVERAGE	ACCUM MANDAYS		
DESIGN ENGINEERING OPERATION				260	260		
GE FIELD ENGINEERING							
						DESIGN	100
						TITLE I	100
						GE-TIT. II	57
						AE-TIT. II	43
						CONST.	100
						PF	
						CPFF	
						FP	
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project will provide facilities to permit deliberate destructive testing of irradiated zirconium tubing. This will provide operating and tube life data not available because of the limited operating history of Zircaloy-2 pressure tubing in reactors.</p> <p>The project proposal was submitted to the Commission on July 2, 1962 and is awaiting approval.</p> <p>Recent developmental work has indicated the necessity of several design revisions to process equipment. These design revisions have not yet been completed.</p>							

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 75625		
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62		
PROJ. NO. CAH-936	TITLE Coolant Systems Development Laboratory 1706-KE Building Addition					FUNDING 62-k		
AUTHORIZED FUNDS		DESIGN \$ 9,000	AEC \$ 115,000	COST & COMM. TO 11-11-62		\$ 14,488(GE)		
\$ 130,000		CONST. \$ 121,000	GE \$ 15,000	ESTIMATED TOTAL COST		\$ 130,000		
STARTING DATES	DESIGN 9-8-61	DATE AUTHORIZED 4-5-62*	EST'D. COMPL. DATES	DESIGN 1-1-62	PERCENT COMPLETE			
	CONST. 5-1-62	DIR. COMP. DATE 12-31-62**		CONST. 3-15-63		WT'D.	SCHED.	ACTUAL
ENGINEER FEO - DL Ballard					DESIGN	100	100	100
MANPOWER					TITLE I			
FIXED PRICE					GE-TIT. II	100	100	100
COST PLUS FIXED FEE					AE-TIT. II			
PLANT FORCES					CONST.	100	100	73
ARCHITECT-ENGINEER					PF			
DESIGN ENGINEERING OPERATION					CPFF			
GE FIELD ENGINEERING					FP	100	100	73
** Corrected to correspond to Contractor's report.								
SCOPE, PURPOSE, STATUS & PROGRESS								
This project provides facilities for conduct of corrosion and decontamination studies for nuclear reactor coolant systems, by the addition of a laboratory facility on the west side of the 1706-KE Building. * Original authorization for design 8-9-61.								
Essentially no work has been performed on this job since week of November 12 due to lack of materials.								
Shipment of the H & V air washer is being held up due to a labor strike in Seattle.								
The Contractor now expects to receive the laboratory equipment from Metalab by January 15, 1963.								
** The Contractor has requested extension of his contract to January 30, 1963 based on receipt of laboratory equipment. The Commission is waiting for establishment of a more realistic completion date before extending project completion date.								

PROJ. NO. CGH-955	TITLE Reactivation of the H-1 Loop - 105-H Building					FUNDING 0490		
AUTHORIZED FUNDS		DESIGN \$ 10,000	AEC \$	COST & COMM. TO		\$ *		
\$ 10,000		CONST. \$	GE \$ 10,000	ESTIMATED TOTAL COST		\$		
STARTING DATES	DESIGN 4-15-62	DATE AUTHORIZED 3-29-62	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE			
	CONST.	DIR. COMP. DATE		CONST.		WT'D.	SCHED.	ACTUAL
ENGINEER FEO - OM Lyso					DESIGN	100		11
MANPOWER					TITLE I			11
FIXED PRICE					GE-TIT. II			
COST PLUS FIXED FEE					AE-TIT. II			
PLANT FORCES					CONST.	100		
ARCHITECT - ENGINEER					PF			
DESIGN ENGINEERING OPERATION					CPFF			
GE FIELD ENGINEERING					FP			
SCOPE, PURPOSE, STATUS & PROGRESS								
This project will provide the primary test facility for determination of the feasibility of using aluminum-clad fuel elements in high temperature water by studying improved alloys and corrosion inhibitors.								
Design work has been stopped. A project proposal, requesting cancellation of this project was submitted to the AEC November 21, 1962.								
* The \$2614 in charges which were incurred for preliminary scoping have been transferred to operating costs.								

SEMI-MONTHLY PROJECT STATUS REPORT						HW-75625	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62	
PROJ. NO.	TITLE					FUNDING	
CAH-958	Plutonium Fuels Testing & Evaluation Laboratory - 308 Bldg					62-k	
AUTHORIZED FUNDS	DESIGN \$ 15,500	AEC \$ 134,500	COST & COMM. TO 11-11-62		\$ 15,500(GE)		
\$ 150,000	CONST. \$ 134,500	GE \$ 15,500	ESTIMATED TOTAL COST		\$ 150,000		
STARTING DATES	DESIGN 11-15-62	DATE AUTHORIZED 6-22-62	EST'D. COMPL. DATES	DESIGN 3-30-63	PERCENT COMPLETE		
	CONST. 2-1-63	DIR. COMP. DATE 5-15-63		CONST. 7-15-63	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	
FEO - OM Lyso					TITLE I		
MANPOWER					GE-TIT. II		2*
AVERAGE					ACCUM MANDAYS		3
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE					CONST.	100	
PLANT FORCES					PF		
ARCHITECT-ENGINEER					CPFF		
DESIGN ENGINEERING OPERATION					FP		
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project provides for the extension of plutonium research laboratories on the second floor of 308 Building by erection of plastered ceilings and walls to provide contamination control barriers. It also includes laboratory service extension and fabrication of a metallography hood.</p> <p>AEC Work Authority CAH-958 (2), dated October 31, 1962 released \$15,500 to the General Electric Company for design work which is in progress.</p> <p>* From Project Planning Schedule.</p>							

PROJ. NO.	TITLE					FUNDING	
CAH-962	Low Level Radiochemistry Building					05-1-63-H-001-23	
AUTHORIZED FUNDS	DESIGN \$ 113,000	AEC \$ 82,000	COST & COMM. TO 11-11-62		\$ 16,500(GE)		
\$ 113,000	CONST. \$	GE \$ 31,000	ESTIMATED TOTAL COST		\$ 1,200,000		
STARTING DATES	DESIGN 7-23-62	DATE AUTHORIZED 6-28-62	EST'D. COMPL. DATES	DESIGN 5-15-63	PERCENT COMPLETE		
	CONST. 8-1-63	DIR. COMP. DATE		CONST. 8-1-64	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	
FEO - DL Ballard					TITLE I		100
MANPOWER					GE-TIT. II		95
AVERAGE					ACCUM MANDAYS		
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE					CONST.	100	
PLANT FORCES					PF		
ARCHITECT-ENGINEER					CPFF		
DESIGN ENGINEERING OPERATION					FP		
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project provides a building in which extremely sensitive radioanalyses and methods development can be performed in an atmosphere protected from the environs. It consists of designing and constructing a building housing approximately 22,000 square feet of floor area including the basement.</p> <p>Comment copies of the design criteria were issued on October 31, 1962. Distribution was made to the Commission as well to interested individuals within the Company. Completion of the criteria is currently underway.</p> <p>By letter dated November 15, 1962, the Commission has requested interested Architect-Engineering firms to submit design proposals by December 3, 1963.</p>							

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 75625		
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62		
PROJ. NO.	TITLE					FUNDING		
CAH-963	Geological & Hydrological Wells - FY 1962					62-k		
AUTHORIZED FUNDS		DESIGN \$ 1,400	AEC \$ 68,500	COST & COMM TO 11-11-62		\$ 10,343 (GE)		
\$ 80,000		CONST. \$ 78,600	GE \$ 11,500	ESTIMATED TOTAL COST		\$ 80,000		
STARTING DATES	DESIGN 5-18-62	DATE AUTHORIZED 5-9-62	EST'D. COMPL. DATES	DESIGN 6-1-62	PERCENT COMPLETE			
	CONST. 7-6-62	DIR. COMP. DATE 4-1-63		CONST. 4-1-63	WT'D.	SCHED.	ACTUAL	
ENGINEER					DESIGN	100	100	100
FEO - HE Ralph					TITLE I			
MANPOWER					GE-TIT. II	100	100	100
FIXED PRICE					AVERAGE	ACCU MANDAYS		
					8	673		
COST PLUS FIXED FEE								
PLANT FORCES								
ARCHITECT-ENGINEER								
DESIGN ENGINEERING OPERATION								
GE FIELD ENGINEERING								
					CONST.	100	94	96
					PF			
					CPFF	2	2	2
					FP	98	92	94
SCOPE, PURPOSE, STATUS & PROGRESS								
<p>This project involves the continued drilling of special hydrological research, test and monitoring wells.</p> <p>Seventeen of the nineteen wells have been completed; one is in process and one remains to be begun. To date 4150 feet of drilling have been completed; this is 94% of the estimated 4350 feet.</p> <p>Contractor will finish his contract ahead of schedule provided equipment does not break down.</p>								

PROJ. NO.	TITLE					FUNDING		
CGH-974	Analog Simulation Facility					62-a-1		
AUTHORIZED FUNDS		DESIGN \$	AEC \$	COST & COMM. TO		\$		
\$		CONST. \$	GE \$	ESTIMATED TOTAL COST		\$ 1,600,000*		
STARTING DATES	DESIGN	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE			
	CONST.	DIR. COMP. DATE		CONST.	WT'D.	SCHED.	ACTUAL	
ENGINEER					DESIGN	100		
					TITLE I			
MANPOWER					GE-TIT. II			
FIXED PRICE					AVERAGE	ACCU MANDAYS		
COST PLUS FIXED FEE								
PLANT FORCES								
ARCHITECT - ENGINEER								
DESIGN ENGINEERING OPERATION								
GE FIELD ENGINEERING								
					CONST.	100		
					PF			
					CPFF			
					FP			
SCOPE, PURPOSE, STATUS & PROGRESS								
<p>This project will provide an appropriately sized and consolidated analog computer simulation facility for the Hanford complex. Initial application will be associated with startup programs for the NPR.</p> <p>The preliminary project proposal which was submitted to the Washington AEC has been returned to AEC-HOO.</p> <p>* Approximate estimate.</p>								

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 75625	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62	
PROJ. NO.	TITLE					FUNDING	
CAH-977	Facilities for Radioactive Inhalation Studies					62-k	
AUTHORIZED FUNDS		DESIGN \$ 13,500	AEC \$ 10,500	COST & COMM TO 11-11-62		\$ 3,000(GE)	
\$ 13,500		CONST. \$	GE \$ 3,000	ESTIMATED TOTAL COST		\$ 140,000	
STARTING DATES	DESIGN 1-1-63	DATE AUTHORIZED 9-24-62	EST'D. COMPL. DATES	DESIGN 4-15-63	PERCENT COMPLETE		
	CONST. 5-1-63	DIR. COMP. DATE		CONST. 3-15-64	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	
FEO - JT Lloyd					TITLE I		
MANPOWER					GE-TIT. II		
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE					CONST.	100	
PLANT FORCES					PF		
ARCHITECT-ENGINEER					CPFF		
DESIGN ENGINEERING OPERATION					FP		
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project will provide additional facilities essential to the conduct of Biology research programs involving the effects of inhaled radioactive particles. It will comprise an addition to the 144-F Building, consisting of approximately 2000 square feet of indoor dog pens and supporting facilities and approximately 2200 square feet of outside dog runs.</p> <p>Scoping is approximately 80% complete.</p> <p>To date the AEC has not selected an A-E.</p>							

PROJ. NO.	TITLE					FUNDING	
CAH-982	Addition to the Radionuclide Facilities - 141-C Building					63-1	
AUTHORIZED FUNDS		DESIGN \$	AEC \$	COST & COMM. TO		\$	
\$		CONST. \$	GE \$	ESTIMATED TOTAL COST		\$	
STARTING DATES	DESIGN 1-15-63*	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN 5-15-63*	PERCENT COMPLETE		
	CONST.	DIR. COMP. DATE		CONST.	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	
FEO - JT Lloyd					TITLE I		
MANPOWER					GE-TIT. II		
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE					CONST.	100	
PLANT FORCES					PF		
ARCHITECT - ENGINEER					CPFF		
DESIGN ENGINEERING OPERATION					FP		
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project will provide an addition to the 141-C Building in 100-F Area to supplement the present radionuclide study facilities. The building addition will comprise approximately 2500 square feet for laboratory facilities and controlled feeding pens for swine.</p> <p>The project proposal requesting \$14,000 for Title I and II design was submitted to the AEC September 14, 1962. To date the AEC has not acted upon this proposal.</p> <p>* Based on AEC approval by December 1, 1962.</p>							

SEMI - MONTHLY PROJECT STATUS REPORT						HW - 75625	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62	
PROJ. NO. <b>CAH-985</b>		TITLE <b>Additions to the 222-U Building</b>				FUNDING <b>63-1</b>	
AUTHORIZED FUNDS		DESIGN \$	AEC \$	COST & COMM. TO		\$	
\$		CONST. \$	GE \$	ESTIMATED TOTAL COST		\$ <b>150,000*</b>	
STARTING DATES	DESIGN <b>1-2-63**</b>	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN <b>5-1-63**</b>	PERCENT COMPLETE		
	CONST. <b>7-1-63**</b>	DIR. COMP. DATE		CONST. <b>3-1-64**</b>	WT'D.	SCHED.	ACTUAL
ENGINEER <b>FEO - DS Jackson</b>					DESIGN	100	
<u>MANPOWER</u>					TITLE I		
FIXED PRICE					GE-TIT. II		
COST PLUS FIXED FEE					AE-TIT. II		
PLANT FORCES					CONST.	100	
ARCHITECT-ENGINEER					PF		
DESIGN ENGINEERING OPERATION					CPFF		
GE FIELD ENGINEERING					FP		
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project provides an addition to the 222-U Building in which to perform</p> <ol style="list-style-type: none"> <li>1) geologic and hydrologic studies related to waste disposal practices and</li> <li>2) studies on release of fission products from reactor fuels heated to high temperatures.</li> </ol> <p>The project proposal, requesting design funds in the amount of \$17,000, was submitted to the AEC-HOO October 8, 1962.</p> <p>* Order of magnitude ** Based on AEC authorization by December 15, 1962.</p>							

SEMI - MONTHLY PROJECT STATUS REPORT						HW - 75625	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 11-30-62	
PROJ. NO. <b>CAH-986</b>		TITLE <b>300 Area Retention Waste System Expansion</b>				FUNDING <b>63-1</b>	
AUTHORIZED FUNDS		DESIGN \$	AEC \$	COST & COMM. TO		\$	
\$		CONST. \$	GE \$	ESTIMATED TOTAL COST		\$ <b>100,000*</b>	
STARTING DATES	DESIGN <b>2-1-63**</b>	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN <b>6-1-63**</b>	PERCENT COMPLETE		
	CONST.	DIR. COMP. DATE		CONST.	WT'D.	SCHED.	ACTUAL
ENGINEER <b>FEO - OM Lyso</b>					DESIGN	100	
<u>MANPOWER</u>					TITLE I		
FIXED PRICE					GE-TIT. II		
COST PLUS FIXED FEE					AE-TIT. II		
PLANT FORCES					CONST.	100	
ARCHITECT - ENGINEER					PF		
DESIGN ENGINEERING OPERATION					CPFF		
GE FIELD ENGINEERING					FP		
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project will provide two additional 50,000 gallon retention basins, automation of the basin influent valving and semi-automation of the effluent valving. It will provide required storage basin capacity and obtains maximum use of existing basins.</p> <p>The project proposal, requested design funds in the amount of \$14,000 was submitted to AEC-HOO October 8, 1962.</p> <p>* Preliminary estimate. ** Based on AEC approval by December 30, 1962.</p>							

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 75625	
GENERAL ELECTRIC CO. — <u>Hanford Laboratories</u>						DATE 11-30-62	
PROJ. NO. CGH-991	TITLE Waste Calcination Demonstration in the Fuels Recycle Pilot Plant					FUNDING 04 60 40 00	
AUTHORIZED FUNDS		DESIGN \$	AEC \$	COST & COMM TO		\$	
\$		CONST. \$	GE \$	ESTIMATED TOTAL COST		\$ 2,200,000*	
STARTING DATES	DESIGN 10-1-62**	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN 1-1-64	PERCENT COMPLETE		
	CONST. 1-1-63	DIR. COMP. DATE		CONST. 11-1-64	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	
FEO - RW Dascenzo					TITLE I		
MANPOWER					GE-TIT. I		
FEE					AE-TIT. II		
COST PLUS FIXED FEE					CONST.	100	
PLANT FORCES					PF		
ARCHITECT-ENGINEER					CPFF		
DESIGN ENGINEERING OPERATION					FP		
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project will provide equipment necessary to demonstrate pilot scale processes for converting high level solvent extraction separations plant wastes to solids. It includes the purchase, fabrication and installation of equipment into equipment racks in the proposed Fuels Recycle Pilot Plant.</p> <p>A preliminary project proposal was submitted to the Commission on November 21, 1962 requesting \$980,000 for FY-63 procured equipment and long-term procured items.</p> <p>The major portion of this equipment will be procured and/or fabricated by J. A. Jones Company.</p> <p>Note: Dates are taken from the Project Planning Schedule.</p> <p>* Order of magnitude estimate.                  ** Design is not part of this project and is being performed by operating forces and funded out of operating expense.</p>							

TEST REACTOR AND AUXILIARIES OPERATIONREACTOR DEVELOPMENT - O4 PROGRAMPLUTONIUM RECYCLE PROGRAMPlutonium Recycle Test ReactorOperation

The reactor remained down throughout the month. Efforts concentrated on inspection and restoration of the primary system following system decontamination. All spiral wound gaskets were replaced and other mechanical joints and valve packings were inspected on a sampling basis to assure against the presence of caustic. The system was hydrostatically tested at 2060 psi at completion of restoration.

Fuel element decontamination was completed and reactor charging was underway at month-end. All fuel elements were inspected for mechanical integrity prior to charging. One  $\text{UO}_2$  element was inspected in the fuel element examination facility marking initial operation of the facility with an irradiated element. Overall the fuel elements were found to be in satisfactory condition with the exception of a few pins which connect the fuel elements to their hangers. Some bending of pins was noted as well as loss of pin retaining clips. All such fuel elements were either repaired prior to charging or were set aside for future repair and charging.

The original primary system  $\text{D}_2\text{O}$ , which had a purity of  $\sim 94\%$ , was replaced with 99.9%  $\text{D}_2\text{O}$ . Final purity after draining of demineralized  $\text{H}_2\text{O}$  was 99.7%. Total  $\text{D}_2\text{O}$  loss for the month was 552 pounds and helium losses were 57,500 scf. The primary system ion exchanger was replaced.

Several tests were conducted on the light water injection system while  $\text{H}_2\text{O}$  was in the primary system. Adjustments were made to the diesel well pump, piping systems, valve controls and procedures as necessary to assure adequate performance of the LWI system.

The reactor charge included 27  $\text{UO}_2\text{-PuO}_2$  fuel elements.

Equipment Experience

Considerable improvement was gained in operability of shim rods by replacing two units and making in-place repairs. Status of shim rods 11-1-62 was:

UNCLASSIFIED

6 units completely operable (both A&B rods)  
5 units with "A" rod only operable  
1 unit with "B" rod only operable  
6 units completely inoperable

Status after repair efforts: (11-27-62)

12 units completely operable (both A&B rods)  
3 units with "A" rod only operable  
2 units with "B" rod only operable  
1 unit completely inoperable

A total of 9 units were repositioned in the reactor to provide the maximum effectiveness.

Repairs were necessary to the fuel transfer carriage when it was damaged during fuel element decontamination. Two re-enforcement web welds had broken loose allowing the carriage frame to warp and bind on the rails.

Repairs were made to E-9, E-10, E-19 and E-20 (light water injection system) valves this month. All were leaking through. New sealing surfaces were machined on the gold trim. Also, gaskets were installed on the seat inserts on E-9, E-19 and E-20 and on the guide plugs on E-10 and E-20 because of leakage through the threads.

Outlet jumper #1453 and the Parker fitting had to be replaced when galling occurred between jumper nut and Parker fitting.

Considerable effort was extended this month to improve the air exhaust and effluent activity instrumentation. An improved power source and better grounding was provided. Noisy signal cables were replaced on air activity channels A, B and C and effluent activity channels A, B, and parts of C. The original cable installation had an excessive number of conduit bends between pull boxes and modifications were necessary to install the new cables.

Preventive maintenance required 615 manhours or 11.8% of total maintenance effort.

Improvement Work Status (Significant Items)

Work Completed:

Safety Circuit Ground and Low Voltage Detectors  
Relocate Pressurizer Level Transmitters  
Thermowell Replacement  
Flanged Installation of Helium System Safety Relief Valves  
Primary Pump Tachometers and Indicators

Work Partially Completed During Month:

Enlarge Chemical Feed System  
 Decontamination Facility  
 Reactor Core Level Indicator  
 Primary Loop Drain and Flush Valve Modifications  
 Installation of Improved Hofer Comp. Oil Pumps and Oil Regulating Valves  
 Keithley Power Plug Modification  
 Monitoring Voltmeters for DC Systems

Design Work Completed:

Pressurizer Vent Valve Relocation to Minimize D<sub>2</sub>O Loss  
 Rupture Detection System Sample Chamber Modification  
 E-7, E-17 Manual Control Interlock with Gas Balance Compressor

Design Work Partially Complete:

Additional Fuel Storage and Examination  
 Boiler Feed Pump Seals  
 Install Vibration Snubbers for Earthquake Protection

Process Engineering and Reactor Physics

A re-examination of the formulation used to generate the PRTR Xenon Tables uncovered an error in the method used to derive the flux level from the tube power and a re-evaluation of the xenon calculation was made. A comparison of the results from the existing xenon tables and from the revised calculation is made in Table I.

Table I

<u>Element</u>	<u>Tube Power (KW)</u>	<u>Calculation</u>	<u>Equilibrium Poisoning (Xe (+ Rh))</u>	<u>Potential Poisoning (Iodine)</u>
UO <sub>2</sub>	880	Old	26.534 mk	113.560 mk
		New	24.602 mk	224.500 mk

The equilibrium poisoning listed as new includes both xenon and rhodium, the rhodium contributing 2.5% of the total. The very large increase in the potential poisoning due to iodine indicates that the peak poisoning of the transient following a scram from equilibrium will be almost a factor of two larger than had been estimated previously. Efforts were initiated to attempt comparison of the new calculation with the experimental results of Power Test 16.

Autoradiographs, obtained from rods of typical mixed-oxide elements, indicated plutonium agglomeration. An evaluation of the severity of heat output from these localized spots was initiated.

### Procedures

Revised Operating Procedures issued		2
Revised Operating Standards issued		2
Temporary Deviations to Operating Standards issued		0
Revised Process Specifications accepted for use		1
Maintenance Manuals issued		0
Drawing As-built Status		
	<u>November</u>	<u>Total</u>
Approved for as-built	15	864
Ready for approval		17
In drafting		24
Voided		<u>78</u>
		983
Scheduled for review		<u>427</u>
		1 410

### Personnel Training

Qualification Subjects	211 manhours
Specifications, Standards, Procedures	95
Fueling Vehicle	0
Maintenance Procedures	64
FREEF	<u>16</u>
	386 manhours

### Status of Qualified Personnel at Month-End

Qualified Reactor Engineers	7
Provisionally Qualified Reactor Engineers	2
Qualified Technicians	6
Qualified Technologists	17
Provisionally Qualified Technologists	2

### Plutonium Recycle Critical Facility

The cell was pressurized for the first time since completion of the architectural contract. After fixing numerous leaks, the leak rate was  $\sim 2000 \text{ ft}^3/\text{day}$  at a cell pressure of  $\sim 1 \text{ psig}$ . The first two drums of  $\text{D}_2\text{O}$  were added to the moderator system. System heel measurements and tank recalibrations were in progress at month-end. The ion exchanger was deuterized and placed in service.

Work was completed on the safety rod housings to permit repair work without cell cover block removal.

Fuel Element Rupture Test Facility

Project Status (Project CAH-862)

Month-end design test status was as follows: electrical and instruments complete; mechanical design testing - 25% complete. During mechanical testing pressure control valve RL-3 was accidentally closed during repair of its controller. The subsequent pressure increase (to about 2400 psig) caused a vent connection on the return pipe to the annex to fail. The pipe was replaced with heavier schedule pipe and additional investigation led to replacement of two other sections of piping. Investigation also detected a faulty pressure relief valve which was corrected.

Construction work on completion items was deferred while design tests were in progress.

Operation

All operating procedures not dependent on additional design were completed. Practice on the loop discharge operation was conducted employing the 314 Building mockup. Training manhours totaled 138.

GAS COOLED POWER REACTOR PROGRAM

Gas Cooled Loop

Project Status (Project CAH-822)

The project was 93% complete.

The replacement heater installation was completed during November except for electrical connections. All new Hastelloy-X weld X-rays were acceptable and the heater and new piping were successfully subjected to a 550 psig pneumatic test.

Preliminary tests (in air) of the new Bristol-Siddeley P.T.F.E. journal bearings were successful and in-loop tests were initiated.

Several punch list items were completed during November.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 21,412 hours. This includes 16,831 hours performed in the Technical Shops, 3,963 hours assigned to Minor Construction, 500 hours assigned to off-site vendors, and 118 hours to other project

shops. Total shop backlog is 19,483 hours, of which 70% is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 6.0% (1,133.3) of the total available hours.

Distribution of time was as follows:

	<u>Manhours</u>	<u>% of Total</u>
Fuels Preparation Department	4,435	20.71%
Irradiation Processing Department	3,395	15.86%
Chemical Processing Department	696	3.25%
Hanford Laboratories Operation	12,877	60.14%
Construction Engineering and Utilities	9	.04%

LABORATORY MAINTENANCE OPERATION

Total productive time realized was 15,300 of a possible 16,700 hours theoretically available. Of the total productive time realized 91% was expended for HLO components with the remaining 9% directed toward providing service for other HAPO organizations. Overtime worked during the month was 2.4% of total available hours.

Manpower utilization for November is summarized as follows:

A. Shop Work (Fabrication Modification)		<u>3 200</u>
B. Maintenance		<u>7 500</u>
1. Preventive Maintenance	1 800	
2. Emergency or Unscheduled Maintenance	1 700	
3. Normal Scheduled Maintenance	4 000	
4. Overtime	<u>400</u>	
C. R&D Assistance		<u>4 600</u>

*WD Richmond*

Manager  
Test Reactor and Auxiliaries

WD Richmond:bk

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.

<u>INVENTOR</u>	<u>TITLE OF INVENTION OR DISCOVERY</u>
J. T. Russell	HWIR-1575, The Field of Nondestructive Isotopic Analysis
J. T. Russell	HWIR-1576, The Field of Linear Displacement Transducers
D. G. Brandt	A Method for Direct Resistance Heating of a Molten Salt Bath with Alternating Current While Conducting a Direct Current Electrolysis
A. M. Platt and G. Jansen, Jr.	A Method for Confining a Molten Salt in a Porous Container and Introducing a Gaseous Reactant Into the Molten Salt by Gas Pressure External to the Wall
L. A. Bray	Solvent Extraction Process for Recovery of Strontium, Cerium, Rare Earths and Cesium from Radioactive Waste Solutions (CSREX Process) (HW-75537)
B. B. Lane	An Improvement in the Spray Calcination Process as Applied to Radioactive Waste Liquors, 9-27-62

  
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Manager, Hanford Laboratories

**END**

**DATE  
FILMED**

3 / 29 / 93

