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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT

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JANUARY, 1960

FEBRUARY 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

GENERAL ELECTRIC

A.E.C. - G.E. - RICHLAND, WASH.

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
JANUARY, 1960

Compiled by
Operation Managers

February 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE January 31, 1960

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	128	101	229	131	102	233	0	0	3	1
Reactor & Fuels Research & Development	197	170	367	197	170	367	2	1	2	1
Physics & Instrument Research & Development	66	33	99	66	33	99	2	0	2	0
Biology Operation	35	46	81	35	45	80	0	1	0	0
Operation Res. & Syn.	17	4	21	16	4	20	1	0	0	0
Radiation Protection	33	100	133	34	100	134	0	1	1	1
Laboratory Auxiliaries	54	193	247	53	193	246	1	1	0	1
Financial	14	13	27	14	13	27	0	0	0	0
Prof. Placmt & R. P.	55	19	74	72	18	90	0	3	17	2
Programming	15	4	19	15	4	19	0	0	0	0
General	1	2	3	1	2	3	0	0	0	0
Totals	615	685	1300	634	684	1318	6	7	25	6
Totals excluding internal Transfers	615	685	1300	634	684	1318	2	7	21	6

Composite Separation Rate ---------- 2.3846

Separation Rate (based on separations leaving G. E.) ---------- .7692

Controllable Separations Rate ---------- .3076

BUDGETS AND COSTS

Costs for January were $1,820,000, a decrease of $31,000 from December. Fiscal year-to-date costs are 56% of the amounts currently authorized to Hanford Laboratories. Hanford Laboratories programs at January 31 have the following cost-budget relationship:

(Dollars in Thousands)	Cost	Budget	% Spent
2000 Program	$ 305	$ 616	50%
4000 Program	3 877	7 052	55
5000 Program	282	541	52
6000 Program	1 238	2 198	56

An increase of $223,000 for research and development on IPD sponsored programs was received during the month. Costs of HLO research and development for Hanford Product Departments are in line with amounts authorized.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

The PRTR Phase III contract is about 55% complete versus a scheduled 76%. Fabrication of the calandria and top and bottom primary shields is completed. The PRTR Final Safeguards Analysis has been discussed with AEC Hazards Evaluation Branch personnel, and a final review by the ACRS was held on January 28. Writing of Critical Test outlines for PRTR startup is complete and review by the Startup Council has begun. An analysis of PRTR primary pump rundown times following simulated total loss of electrical power indicates that present pump flywheel assemblies are adequate to prevent boiling in the hottest channel of the reactor.

Full operational control of the Plutonium Fabrication Pilot Plant was established during the month, and on January 22, the first full-scale "hot" work with plutonium was started. Previous operations in the building had been with fully jacketed plutonium-enriched materials or dummy materials.

Local overheating produced by draining the water was determined to be the cause of the pressure tube failure in the 6x9 loop at the ETR.

A sufficient number of swaged UO_2 fuel rods has been fabricated to fulfill the needs of the first PRTR fuel loading. End closures on swaged rods made by welding have shown an acceptance rate of 99.5 percent in the past three months.

The 46 PRTR Zircaloy process tubes with acid-stained surfaces have been reprocessed, and between 85 and 90 tubes which meet all specifications are expected to be ready for installation in the reactor by mid-February.

Initial heat transfer experiments were performed to determine circumferential temperature variations around Hanford fuel elements and to investigate forced convection boiling by high speed photography. Preliminary results indicate that temperature gradients within the cooling water and local boiling effects can be pronounced.

A study of thermal damage to irradiated masonite when heated in air at temperatures up to 200 C has been completed at the request of IPD. As a result of this study the temperature limit for exposure of the masonite shields to an air atmosphere has been raised from 100 to 150 C.

Tensile properties of specimens cut from the discharged KER loop show effects of thermal recovery and radiation hardening. Yield strengths of the irradiated specimens varied from 50,300 psi to 99,000 psi as compared to the average yield strength of the unirradiated material of 88,300 psi. The irradiated Zircaloy-2 KER tube sections which were burst tested at room temperature (reported last month) elongated 2.7 and 3.0%, somewhat less than the 3.3% elongation for the two unirradiated control samples.

The defected rod from the first ETR intentional rupture test has been sectioned through the defect. Examination disclosed a small packet of oxide 1/8" in diameter within the defect. The rod did

not measurably distort. Hydride concentrations varying from 280 ppm at the outer surface to 50 ppm at the inner surface were found in the Zircaloy-2 cladding of the ruptured rod from the 7-rod cluster element which failed in the KER Loop 2 in October 1959.

Pickling Zircaloy-2 surfaces prior to salt bath heat treatment of NPR size coextruded tubes was found to be the source of 80 ppm of hydrogen in the cladding. Vapor blasting between pickling and heat treatment eliminated this pickup by removing the layer of zirconium hydride.

Hot heading has been successfully employed to produce closures in 1.8" KER size Zircaloy-2 clad coextruded inner tubes.

Laboratory hydriding studies show that the NPR gas atmosphere must be maintained free of hydrogen to avoid risk of hydriding the NPR Zircaloy process tubes from the gas side. A pre-autoclaved film on the Zircaloy tubes gives temporary but not absolute protection.

Twenty-one NPR prototype Zircaloy-2 process tubes were ready for inspection at two vendors' plants at the end of January.

Graphite contractions ranging generally from 0.03% to 1% were measured from the second high temperature graphite experiment removed from the GETR, after a maximum damaging dose equivalent to about 10,000 MWD/AT in a Hanford reactor. The needle-coke graphites generally contracted less than CSF graphite, and all samples showed higher contraction rates at higher temperature.

Analysis of the effect of the Fuel Element Rupture Test Facility on PRP objectives has been completed and has shown the reactivity effect to be small.

Preliminary heat transfer experiments with a PRTR 19-rod cluster fuel element indicate moderately lower heat transfer coefficients within the element from surfaces facing the larger flow areas, from surfaces facing the process tube wall, and from those surfaces behind a wire wrap.

Texture studies of Zircaloy-2 coextruded with uranium have revealed an alignment of the prismatic planes normal to the extrusion direction. The basal planes are predominately at angles of approximately 55° to the tube radius. This structure is quite different from that in extruded Zircaloy tubing.

After irradiation, no visible changes were found in the UO_2 adjacent to an intentionally produced defect in the Zircaloy-2 cladding of a swaged fuel rod. Although hydride was observed in the cladding near the defect, the oxide fuel appeared to have operated in a normal manner.

No measurable creep has been observed in a Zircaloy-2 creep specimen under irradiation at a stress of 25,600 psi up to 550 F (288 C) for the last month of exposure.

The particle size of PuO_2 produced by calcining the oxalate in air at 300 C is 0.9 micron. On further heating particle size increases with temperature up to 2.3 microns at 1000 C, the highest temperature employed.

Ten Zircaloy clad aluminum dummy PRTR elements have been thermally cycled at atmospheric pressure eighty times with no observable change. Samples are being prepared for thermal cycling tests at 1000 psi.

2. Chemical Research and Development

Equipment will be ready on time in the A cell of the High Level Radiochemistry Facility to demonstrate promethium recovery from the forthcoming plant-prepared rare earth concentrate. Intensive laboratory research resulted in firming up important flowsheet details for the strontium recovery process destined for plant tests.

In the development of fission product isolation and prototype equipment, manipulator, hydrolyzer and filter difficulties were encountered and progress was made toward their solution. Cesium volatilization appears not to be a problem at lower temperatures.

Fluid-bed calciner studies in the prototype equipment and batch calcination tests yielded significant findings for simulated ICPP and other high-level wastes.

The use of Mistron (a surface active agent) in pilot plant studies significantly decreased gross crud formation in a Purex-HA-type column without producing obvious adverse effects on column performance.

Development of methods continued in the study of mechanical handling, feed preparation, extraction and materials of construction for non-production fuels reprocessing. Loss of plutonium on precipitated molybdic oxide formed in the dissolution of U-Mo fuels in strong nitric acid may be a problem. An alloy of Hastelloy F composition but stabilized with titanium rather than niobium shows better corrosion resistance than the usual alloy and has good promise for use in decladding and core dissolution equipment.

In research on the Salt Cycle process, plutonium dioxide dissolved from the irradiated mixed oxide and co-deposited with the uranium dioxide in the reduction step; both behaviors are opposite from those found with unirradiated fuel. The anomalous behavior may be of value in the handling of blended fuels for recycle.

3. Physics and Instrument Research and Development

Reactor physics measurements were made with the PCTR on tube-in-tube fuel elements in a graphite lattice similar to that for the N reactor. The PCTR also was used to study the effect of graphite temperature on neutron temperature using a core of solid graphite. Experiments were completed over the temperature range from -180°C to +450°C.

Development tests were completed on the detectors and circuitry for the prototype 105-N Building area radiation monitor. Further development continued on the NPR Fuel Failure Monitor program with completion of new circuits which improve the discrimination between signals from adjacent fuel channels.

The power decay of the NPR for the first minute following a scram has been studied with the analog computer. During this period the temperature feedback from the heat exchangers may be ignored and the coolant flow rate and temperature assumed to remain constant. Various NPR startup situations are currently being studied with the analog computer and a simulation of the NPR Heat Exchanger System is being prepared.

In the Nuclear Safety Program, criticality experiments were begun with Pu-Al alloy (5 w/o Pu) fuel element rods in light water. A near serious contamination incident occurred in this work when a

plutonium compound was squeezed out of one of the rods by corrosive action. Similar criticality experiments also were conducted with 0.175-inch diameter uranium rods of 3.063 percent enrichment. Nuclear safety studies associated with the dissolution of spent power reactor fuels were studied and safe dimensions were determined for a dissolver design.

Evaluation tests were completed on the detectors for the PRTR Fuel Failure Monitor. Radiation damage tests are under way on components for probes for measuring the temperature of irradiated PRTR fuel elements.

In the Nondestructive Testing Research Program, the experimental broadband eddy current equipment has shown sufficient sensitivity under ideal laboratory conditions to measure either clad thickness or air gap thickness for unbonded Pu-Al alloy core, Zircaloy clad, fuel rods. Further refinements are needed to make this a practical fabrication control tool. Infrared methods for determining the heat transfer characteristics of fuel element core-cladding interfaces are under investigation. A photoelectric system was devised for detecting small cracks and flaws on the inside surfaces of tubes. The defects are revealed by the fluorescence of dye penetrant material under ultraviolet illumination.

The Shielded Personnel Monitoring Station was closed for two weeks for changes to the cell door to permit it to be opened from the inside even in the event of power failure. A recalibration of the whole body counter for potassium increases previously reported results by 15% and brings them into good agreement with the results of other laboratories. This also led to a change in the correction in the calculation for Zinc-65 because of the presence of potassium. Average values of Zinc-65 found in people are decreased 20 percent by this change.

In the Atmospheric Physics Program, the determinations of filter loadings of tracer materials collected during last summer's dispersion experiments were temporarily delayed. The filter assay equipment failed to maintain adequate calibration over the wide range of pigment loadings encountered. More adequate equipment is being requisitioned. Plans were completed for the reactivation of the field sampling grid to 3,200 meters distance from the source and including all 20 sampling towers.

Development continued on a number of radiological instruments in support of the Biology and Medicine program. Good test results were obtained with a new high level alpha air monitor and with a transistorized portable beta-gamma dose-rate meter which has either a linear or a logarithmic response.

4. Biology

Biological monitoring revealed no marked trends from the pattern developed in previous years.

Acute lethal dose of inhaled plutonium oxide appears to be less for beagle dogs than earlier estimated. Initial lung burdens for dogs dying within two months after exposure were less than 50 uc.

Fecal excretion of intravenous administered PVP occurs when rats are exposed to single doses of 1,000 r, but does not occur when the dose is given in 250 r increments over a period of two weeks. Nitrogen mustard provoked a response similar to that seen with radiation.

Swine exposed to 900 r total-body x-irradiation were treated with injections of 70-day-old fetal swine hematopoietic tissue. All animals died, suggesting that such young fetal cells afford no protection.

5. Programming

Commission approval was granted for the program to prepare about 40 kg of high exposure plutonium for Plutonium Recycle Program use by the irradiation of Pu-Al fuel elements in SRP reactors.

Work was completed on improving and converting from IBM-650 to IBM-709 format the Meleager, PUCK, and GPR plutonium fuel cycle analysis codes.

Current and potential programs for the AEC Division of Reactor Development were reviewed with senior DRD personnel.

The Plutonium Recycle Program Annual Report for FY-1959 was issued.

A review of all 6000 Program activities was presented to the Advisory Committee to the AEC Division of Biology and Medicine.

TECHNICAL AND OTHER SERVICES

The programming of the GCL estimation procedure for systems of structural equations has been completed and the program is now being tested.

Assistance has been given in designing experimentation procedures to obtain information concerning rupture rates at powers and exposures beyond the range of present experience. In addition to supplying information essential in making long term expansion plans at HAPO, the test as designed will also answer questions concerning certain aspects of the fuel element manufacturing process.

Studies are being made of the behavior of the solutions to the three-parameter differential equation of reactor kinetics. All the approximate solutions thus far obtained have exhibited instability.

A statistical analysis of zirconium corrosion data was completed and the results will be used to calibrate future autoclave experimentation.

Statistical studies in connection with gamma spectroscopy include the determination of the relative magnitude of instrument instability and an empirical study of the possibility that a nominal set of monoenergetic spectra can be used to generate all such spectra in the less than 3 mev. range.

Work on 6 operations analysis programs continued during the month. In addition, statistical and mathematical assistance on 25 problems was given within HLO and to other departments and operations.

Two minor plutonium deposition cases were confirmed during the month. The total number of deposition cases that have occurred at HAPO is 246 of which 178 are currently employed.

Findings in the environs were about as expected for this season of the year. No unusual trends or incidents occurred. Preparation of the annual HAPO environmental report was started.

There were 22 authorized projects at month's end with total authorized funds of $6,735,000. The total estimated cost of these projects is $8,720,000. Two project proposals were submitted to the Commission and three projects are in preparation.

During the month 16 CPFF work orders and two supplemental orders were issued to J. A Jones Company amounting to $211,220. There were 40 existing HL orders at the beginning of the month with a total remaining unexpended balance of $238,450. Total expenditures during the month were $99,800.

SUPPORTING FUNCTIONS

A report of results was issued for the physical inventory of movable cataloged equipment in the custody of Biology Operation. Seven hundred and sixty-nine items valued at $533,000 were physically counted. One item valued at $105 was not located during the inventory.

Expenditure forecast for miscellaneous capital work orders indicates that authorized work will require $149,000 compared with our ceiling for FY 1960 of $150,000. No further work in this category can be authorized this fiscal year.

As of January 31, 1960, the staff of Hanford Laboratories totalled 1300 employees, including 615 exempt and 685 nonexempt. There were 524 employees possessing technical degrees, including 312 B.S., 113 M.S. and 99 Ph.D.

The medical treatment frequency for January was 1.41 as compared with 1.56 for December. There were 2 security violations during January.

The HAPO study of Pressure Systems continued during January with initial steps being taken toward development of recommendations for uniform HAPO procedures.

Recruitment of experienced BS/MS personnel slowed down during the month with 9 offers being extended and 2 acceptances received.

During the month 7 Ph.D. candidates visited Richland. Three offers were extended and one was accepted by a Ph.D. veterinary physiologist

for assignment to the Biology Operation. HAPO participated in the Company's coordinated Ph. D. recruiting at the American Physical Society Meeting.

Nine Technical Graduates accepted permanent assignment, 7 Engineering and Science Program members transferred to other sites and 1 Technical Graduate terminated for other employment. At month end there were 43 Technical Graduates and 7 Technician Trainees on the Program rolls.

Seven nonexempt requisitions were filled during January. With the receipt of 4 requisitions there were 5 openings at month end for which 4 candidates are in process and 1 transfer is pending.

Program VIII of the Information and Orientation Series, "The PRTR and the Plutonium Recycle Program", concluded the presentation of the series.

H M Parker

Manager
Hanford Laboratories

HM Parker:pmg

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Hydriding of Zircaloy in Simulated NPR Gas Atmosphere. Three sets of Zircaloy-2 and Zircaloy-4 samples were exposed in a gas atmosphere made by passing wet helium over graphite at 1100 C. In 21 days the etched but unautoclaved samples of both alloys were severely hydrided and very brittle. The autoclaved samples show some hydrogen pickup, but about 20- to 70-fold less than the etched samples, indicating partial protection by the autoclave film. There were indications the hydriding started around the punched holes in the samples. The large hydrogen concentration gradients indicated for the unautoclaved samples were confirmed by metallography. The other two sets of samples are still under test.

Barrier Films on Zircaloy-2. When Zircaloy is oxidized in air or water, it forms a duplex corrosion product film (similar to the filming behavior of aluminum) consisting of a thin barrier film adjacent to the metal and an outer, thicker bulk film. The barrier layer is of the order of 100 to 200 Å thick, whereas the bulk film may be as much as 20,000 to 30,000 A thick. The barrier film thickness is primarily a function of the temperature of oxidation, and it attains a limiting thickness in relatively short times.

Barrier layers were measured as a function of time on Zircaloy-2 at 500 C and 630 C in air. At 500 C, the barrier film increased to about 260 Å in six hours. At 20 hours there was a sudden increase in barrier voltage corresponding to a thickness of 900 Å. This is believed to be a change in the electrical properties of the film rather than a change in actual thickness. After 42 hours, the barrier voltage was decreased to a very low value corresponding to 16 Å thickness. Since breakaway corrosion of Zircaloy-2 is expected at about 36 hours at 500 C, it is tentatively concluded that this decrease in barrier voltage is associated with the initiation of breakaway corrosion. At 630 C, a similar decrease in barrier voltage was noted associated with the appearance of white breakaway corrosion product at two hours.

Since it appears that barrier film voltage measurements may be employed to detect the initiation of breakaway corrosion on Zircaloy-2, the above tests are being extended to determine whether such measurements will distinguish between breakaway corrosion and "superficial effects," such as acid staining. Barrier voltage measurements appear promising as a non-destructive, positive means of evaluating the corrosion properties

of autoclaved Zircaloy components. Such a test might also be particularly useful for complex shapes which do not permit adequate visual examination.

Autoclaving Studies of Zircaloy-2. Laboratory-scale autoclaving studies of Zircaloy-2 coupons have been conducted to elucidate the effects of operating variables (temperature, pressure, and time) on the rate of autoclave film formation. Although this work is continuing, some preliminary conclusions to date are as follows:

1. At a given temperature, the weight gain is approximately 2 mg/dm^2 higher in 72 hours at 100 psi than it is at 1500 psi. The initial rate is higher at 100 psi, but levels off faster than at 1500 psi. However, the random variations of weight gain for a particular temperature were approximately three times as large at 100 psi than at 1500 psi.

2. The allowable temperature variation from the specified value during autoclaving is somewhere in the range of plus-or-minus 10 to 20 C.

3. Formation of a visually acceptable black film is rarely harmed by two pieces of Zircaloy-2 touching each other during autoclaving. This is of significance in autoclaving hardware assemblies.

Copper and Iron Contamination of Zircaloy-2 and 4. A corrosion test was initiated during the past month to determine the effect of copper and iron contamination on the corrosion rates of Zircaloy-2 and Zircaloy-4. Copper-contaminated coupons were prepared by electroplating copper on the surface of Zircaloy plates and then vacuum annealing the plates at 750 C for one hour. The iron-contaminated coupons were prepared in the same manner except that the iron was deposited on the plates by flame spraying. All the coupons were then etched to varying depths and exposed to 400 C steam. Preliminary results indicate that the above copper contamination approximately doubled the corrosion rate during the first 24 hours of exposure for both Zircaloy-2 and Zircaloy-4, but this acceleration of the corrosion did not continue after the first 24 hours. Furthermore, coupons which were surface-etched two mils or more (the copper penetrated only one to two mils) did not exhibit accelerated corrosion rates even during the first 24 hours. The iron-contaminated samples, which were essentially iron-free after removal of one mil of zirconium, did not exhibit accelerated corrosion after 72 hours of exposure.

Radiometallurgy Laboratory Studies

Thirteen tensile specimens were cut from five sections of KER Loop 2 Zircaloy-2 process tubing which had been removed from the reactor after 27 months. These specimens were tested at room temperature. Examination of the ruptured coextrusion clad fuel rod of a Zircaloy-2, 7-rod cluster showed that the water had progressed along the bonding layer for about one-half the circumference of the element and caused the cladding to fail in tension.

Examination of the three-foot long tube-and-tube coextrusion clad fuel element continued. The outer tube had very little warp but had the same bumping effect as was observed on the inner tube.

A transverse sample was obtained 13 inches downstream from the blow-out type ruptured inner tube of a three-foot long tube-and-tube fuel element. Metallographic examination showed that the inner Zircaloy-2 cladding contained an estimated 300 to 500 ppm of hydrogen, compared with about 150 ppm in the outer cladding. The hydrides at the 13-inch position were not as uniformly dispersed as found 3/4-inch from the rupture but extended completely around the circumference of the sample.

Hardness and metallographic examinations were completed on the sample of stainless steel process tube from the ETR 6x9 loop. Intergranular corrosion was observed at the exterior surfaces, and direct evidence of high temperature operation was observed in the rupture area.

Two PT-3NA uranium tensile samples (representing 0.075 and 0.10 a/o burnup, respectively) were annealed by cycling 10 times between 100 and 625 C at a rate of 50 C per hour. Visual examination, after annealing, showed small cracks on the 0.075 a/o burnup samples but no cracks on the 0.10 a/o burnup (108-A). The results and conclusions from these tests will be reported in connection with the respective programs of Fuel Design and Physical Metallurgy Operations.

Basic Metallurgy Studies

Radiation Effects in Structural Materials. A Zircaloy-2 tube which has been exposed to neutron radiation over a 25-month period and a similar unirradiated tube were removed from the KER facility. These tubes will be mechanically tested and examined metallographically to determine the effects of high neutron exposure at elevated temperatures on Zircaloy-2 and to establish testing methods for monitoring NPR tubing. Strip-type tensile specimens were cut from five irradiated and five unirradiated tube sections and tested at room temperature during the month. The average unirradiated properties were as follows: 0.2 percent yield strength - 88,300 psi, tensile strength - 96,000 psi, and total elongation - 7.0 percent. The irradiated specimens showed both positive and negative deviations in yield stress from these values. Of the four specimens showing negative deviations, two were known to have come from a partially recrystallized tube section. These specimens had yield strengths averaging 50,300 psi and tensile strengths averaging 82,000 psi. Therefore, the four specimens are being investigated metallographically for signs of recovery. For the specimens showing increases in yield stress, the deviation generally increased with neutron exposure. Corresponding decreases in ductility indicate that permanent irradiation damage was sustained at the normal tube operating temperatures (about 230 C maximum). The specimens representing the most highly exposed portion of the tube had the following average properties: 0.2 percent yield strength - 99,000 psi, tensile strength - 106,000 psi, and total elongation - 3.6 percent.

Mechanical and Physical Properties of Materials. The creep properties of Zircaloy-2 are considerably improved by small amounts of residual cold work. The extent to which increasing amounts of cold work influence creep properties and the effects of recovery during testing are being determined on specimens cold worked in the range of 15 to 45 percent. The test conditions, as well as the amount of cold work in the specimens, were selected as limits of conditions that would be encountered in service in reactor process tubing or fuel element cladding.

The tests completed at 440 C show that residual cold work certainly does improve creep strength of Zircaloy-2. A marked reduction in initial deformation and first stage creep are produced by increasing amounts of cold work. However, the higher cold worked specimens(45 percent) have higher second stage creep rates than specimens with 25 percent cold work.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material is a direct way of detecting radiation damage in these materials. Thin films or foils offer advantages, since radioactivity restrictions are reduced. The preparation, irradiation, and subsequent microscopic examination of films and foils are continuing.

Five of the seven capsules containing thin evaporated and sputtered films of UO_2, ThO_2, ZrO_2, Al containing particles of UO_2, ZrO_2-UO_2 sandwich films, amorphous carbon films and cold worked foils of Al have been irradiated and received for examination. These samples were irradiated in an evacuated capsule to confirm observations made on films which were irradiated in an air environment. Preliminary observations of the UO_2 and ThO_2 films have been made on the low exposure sample. After an exposure of less than 10^{16} nvt fission trajectories were observed in the UO_2 thin films but not in the ThO_2 film. The absence of trajectories in the ThO_2 presumably result from insufficient exposure to neutron irradiation to form U-233 which will fission. Examination of the films exposed to higher levels is in progress.

Development of techniques for preparing thin foils of Zircaloy-2 is continuing. Experimentation has established that films of Zircaloy-2 thinned by electrodissolution in 1:4 perchloric acid-alcohol electrolyte results in a residual ZrO_2 layer on the metal and, therefore, is unsatisfactory for electron microscope examination.

X-Ray Diffraction Studies. Texture studies on Zircaloy-2 coextruded with uranium at ratios 20:1, 25:1, and 35:1 have been completed. The $(11\bar{2}0)$ planes are normal to the extrusion direction. The basal planes make angles 55°, 55°, and 51°, respectively, to the tube radius. Microhardness tests are being conducted to determine the effect of crystallite orientation.

The effect of neutron irradiation on the crystal structure of irradiated zirconium is being studied by x-ray diffraction. Preliminary studies of four x-ray reflections on the high angle region from zirconium irradiated to approximately 10^{19} nvt have indicated an anisotropy of line broadening. Evidence was found clearly indicating a stacking fault. The faulting may

have been (1) present in the unirradiated state, (2) introduced during irradiation, or (3) developed during storage, due to point defect rearrangement.

Solid State Reactions. The kinetics of recrystallization and recovery in zirconium, Zircaloy-2, and Zircaloy-3 are being determined to establish optimum conditions of heat treatment during fabrication operations. An analysis of recovery of vacuum heat treated zirconium has been made. It has been found that the fraction of the total work-hardening which recovers prior to recrystallization is strongly dependent upon the initial degree of cold reduction. In ten percent cold worked zirconium almost 90 percent recovery occurs prior to recrystallization while in 50 percent cold worked zirconium less than 40 percent softening occurs prior to recrystallization. This fact together with the fact that the percentage decrease in x-ray line width (measure of lattice strain) is relatively insensitive to prior cold work level indicates that the recovery process is different for the different cold work levels. Evidence is that a sub-structure capable of hardening the material is being formed upon annealing of zirconium with 50 percent prior cold reduction. Conclusions are: (1) the probability of sub-structure formation upon annealing cold worked zirconium is increased with increasing degree of initial deformation, and (2) the material with sub-structure is harder than that with negligible sub-structure, although the residual lattice stresses may in both cases be almost completely recovered.

In-Reactor Measurements. The irradiation of thermocouples to determine in-reactor stability in a variety of gaseous environments has been discontinued due to the failure of the heating element in the test capsule. The capsule will be discharged this month after 7400 hours of irradiation. Prior to charging of a new capsule, refinements will be made in the mechanism to provide intimate contact between the thermocouple thermal beads and the bottom of the thermocouple wells. Spring loading was used in the capsule to be discharged to maintain this contact. During the tests in the reactor it was noted that the contact resistances between the thermal beads of the thermocouples and the thermocouple well had varied. This high contact resistance may have been due to corrosion products at the contact point, possible relaxation of the spring supplying the contact force, or differential expansion of the metals involved. This high contact resistance has produced differences of readings of 12 C to 23 C in the three thermocouples involved. Welding of the thermocouple thermal beads to the thermocouple well will be explored to alleviate the error introduced by this high contact resistance. The modification will also attempt to eliminate the errors introduced in the thermocouple readings due to the thermal gradient that exists in the thermocouple well and the thermocouple conducting leads.

Metallic Fuel Development

Cluster Fuel Elements. The status of the 7-rod hot headed cluster irradiation as of January 25 was: 885 MWD/T, 90 kw/ft, 270 C outlet temperature.

The defected rod from the first ETR rupture test has been sectioned through the defect. A small pocket of oxide, perhaps 1/8-inch in diameter at its largest dimension, had formed under the hole. No distortion of the fuel occurred

The section through the ruptured rod of the 7-rod cluster which failed in KER Loop 2 in October 1959, has been polished and etched for hydrides. At the outer surface of the cladding the hydride concentration was 200-250 ppm and at the inner surface it was 50-80 ppm

Tubular Fuel Elements. Enriched tubular elements in KER size which can reach NPR specific power at the KE Reactor have been fabricated. These elements have passed the following non-destructive tests: ultrasonic clad thickness, bond integrity, grain size, "Zyglo," and x-ray.

Four tube/tube elements of 18-inch length will have reached about 500 MWD/T by February 1. They are generating 133 kw/ft, and have maximum uranium temperature of 400 C. Three 36-inch long elements of the same type were completed but are not charged.

Zircaloy-2 clad, normal uranium, 20 inches long, tube and tube elements are being prepared for an eight-element KER charge. The primary objective of the irradiation is the testing of the hot headed and projection welded end closure. The inner tubes will have this closure and the outer tubes will have TIG welded end caps. Twenty of the inner tubes have been headed and are currently being projection welded at Sciaky Brothers in Los Angeles. The charge is scheduled for completion by February 15.

Six 18-inch long tube and tube fuel elements are being fabricated for irradiation in a KER loop. Three of these are 1.6 percent enriched U - 2 w/o zirconium alloy and the other three are 1.47 percent enriched unalloyed uranium. Ultrasonic tests showed that one of the alloy outer tubes had unbonded areas on its bore. The tube was sectioned through one of these unbonded areas and a fine, hairline crack was seen along the bond layer. Two of the unalloyed outer tubes had defective welds which were detected during autoclaving. These welds have been cut off and the fuel elements are being reworked.

Evaluation of KER tubular Zircaloy-2 clad material has continued this month with the examination of material received from FPD. A total of fifteen-twenty-inch lengths from five different inner extrusions have been examined; eighteen-twenty-inch lengths from five different outer extrusions have been examined. Microscopic examination of the material reveals good uranium quality. In several instances oxide particles were noted at the U-Zr interface and one extrusion was rejected for this defect. Historical information shows this billet to have leaked during billet assembly. Eddy current and ultrasonic testing shows all material to be satisfactory in bond integrity, clad integrity, uranium quality, and clad thickness. However, visual examination shows that the inner surfaces of practically every tube in both sizes contain numerous irregularities. These irregularities appear as galled areas resulting from a

lubrication deficiency. After longitudinally splitting one tube of each size, one could observe the following: (1) depressions resulting from metal having been torn out or metal or lubricant forced into the surface; (2) small shallow tears; (3) humps usually associated with an adjacent depression. Although complete measurements of the depth of these depressions and tears are not complete, information to date indicates that they are up to 0.005-inch deep.

The Zyglo-penetrex method of examining the internal wall surfaces of Zircaloy-2 clad tubes, using ultraviolet light pipes of sapphire or quartz, appears feasible only for detecting certain types of surface defect. Other approaches, which appear to be better tests, include: (a) a surface facsimile technique consisting of painting the surface with a thermosetting plastisol film, baking the latter, mechanically stripping and examining; (b) autoradiographing of the jackets, both internal and external, to detect certain types of defect, as well as variations in the Zircaloy wall thickness; (c) using the Vectorscope to measure the wall thickness and at the same time determine the type and location of different types of cladding defect. The Vectorscope appears to be capable of locating and distinguishing between embedded particles of various sizes and composition; metallic surface films on deposits, such as copper and iron; tears, folds, cracks, and other discontinuities; variations in jacket composition, for example, spots of segregated tin-rich Zircaloy.

Component Fabrication. Fuel element length sections of KER inner and outer tubes have been heat treated prior to assembly as production test elements. Twenty-two inner tubes were salt bath treated after heading with the copper and lubricant left on the surface. These were treated vertically and held seven minutes at 730 C, quenched to 600 C, held for seven minutes and air cooled. The resulting dimensional changes and warp were recorded. The maximum indicator runout varied from 0.008-inch to 0.120-inch in a 20-inch length, with the majority having warp of 0.030-0.050-inch. Ten outer tubes were salt bath treated after copper removal and vapor blasting. These were treated vertically and held five minutes at 730 C, quenched to 600 C, held for five minutes and air cooled. Representative sections of both geometries are being examined for U-Zr-2 bond zone, uranium grain size, and observations of the Zircaloy-2 clad. No blisters or other obvious changes resulting from heat treatment were observed.

An increase in hydrogen content of the Zircaloy-2 clad on NPR size coextruded tubes to approximately 80 ppm was observed after beta heat treating in a Houghton 980 salt bath. Vacuum fusion analysis for hydrogen in the as-received cladding indicated that the level was normal, 15-20 ppm. Strips of one-eighth inch thick Zircaloy-2, one-half inch by two inches were treated in NuSal, Houghton 980 and liquid heat 300 salts at temperatures from 600 to 750 C for one to 30 minutes. All the specimens were vacuum annealed four hours at 750 C prior to salt bath treatment. The hydrogen content was analyzed as 20 ppm for this base condition. Vacuum fusion analysis of the salt bath treated strips showed no hydrogen pickup greater than 10 ppm, and it was concluded that the hydrogen pickup in the fuel

element cladding did not result from the bath. To produce an increase of 60 ppm hydrogen in the Zircaloy-2 by transfer from the uranium core was calculated to require removal of 2 ppm for the NPR inner tube and 3 ppm for the NPR outer tube uranium. This would not appear reasonable since the uranium cores were analyzed and contained 1.0 and 1.9 ppm, respectively, in the as-received condition. The elements showing hydrogen pickup were heat treated in the as-pickled condition following copper removal. Sections of the coextruded stock were vapor blasted after copper removal and then heated ten minutes at 730 C in Houghton 980 salt. The resulting pickup of hydrogen in the clad was reduced to approximately 20 ppm. Micro examination of sections in the as-pickled condition revealed a hydride layer in some areas. It appears that the high pickup of hydrogen resulted from this layer being absorbed by the clad during heating in the bath with a slight amount being added by the salt and by transfer from the uranium. All pickled surfaces should be vapor blasted or etched with $HF-HNO_3$ solution before any heat treatment.

Twenty Zircaloy-2 clad uranium coextruded KER inner tubes, 20 inches long, have been hot headed for use in a production test. Heading was successful on 18 of the tubes with two tubes being rejected because of cladding injury caused from the tubes slipping in the heading grip device. This difficulty resulted from the undersized OD of these two tubes. A swelling of approximately 0.008 to 0.010 inch on the tube OD occurred at the junction of the gripping device and the heading container. The swelling is inherent in this method of hot heading; it was reduced to approximately 0.0015 inch by a subsequent drawing operation.

A facing cut 0.002 to 0.003 inch deep was necessary on the headed tube ends during the removal of the heading extrusion to prepare the surface for the projection welded final closure. The projection weld requires that the surface on the hot headed tube ends be flat within 0.001 inch. The variation in the as-headed tubes is approximately 0.003 inch. This is due to the graphite lubricant applied to the tube ends for the heading operation.

Attempts have been made to hot head short lengths of KER outer tubes. Due to difficulty in loading the tubes in the container, these tubes were cooled below the desired heading temperature resulting in the tubes not heading completely. Also, the press used may not have sufficient capacity for this heading. However, the headed ends examined showed considerable promise, and the next attempt will be with tubes sized to freely fit the container which along with a larger press should produce satisfactory headed ends.

Sizing tests were made on KER size coextruded rods. The rods were reduced from 0.617 inch diameter to 0.520 inch diameter in 0.010 inch steps. One rod was heat treated (730 C for ten minutes, 600 C for five minutes, air cool) and sized, the other was sized in the as-extruded condition. The springback after each reduction increased for four reductions. The fifth reduction showed a marked decrease in the amount of springback in both rods. The following reductions again showed an

increasing amount of springback in both rods. Further tests are planned with strain-gaged dies to determine if the dies yield at the fifth reduction. Metallographic examination shows tensile cracking in both pieces of material, but the heat treated sample begins cracking much sooner than the as-extruded piece.

Closure and Joining. A 95 w/o zirconium-5 w/o beryllium eutectic alloy appears to be a promising braze alloy for closure of Zircaloy-2 clad uranium tubes. Westinghouse reports the corrosion resistance of this alloy in 300 C water equal to that of Zircaloy-2. The melting temperature of this eutectic is approximately 950 C; however, most of the arc-melted braze alloy buttons are slightly off eutectic composition. To obtain eutectic composition, these buttons must be remelted in a Zircaloy-2 crucible and the eutectic allowed to dribble into diffusion pump oil. This eutectic is extremely hard, somewhat brittle and extremely difficult to fabricate. Nuclear Metals has extruded the alloy into wire; however, most success at HAPO has been with finely ground powder. Particles less than 60 mesh give the best braze, melting near 980 C in less than 45 seconds. Particles larger than 10 mesh require temperatures in excess of 1030 C and times of two minutes or longer. At these higher temperatures sporadic melting of the uranium occurs, resulting in small voids in the uranium.

Eutectic brazing has been performed on KER outer tubes which were chemically milled to a depth of one-fourth inch. A Zircaloy-2 end cap is placed into this cavity and the powdered braze alloy is poured over the cap. Dies are being fabricated to fold the excess Zircaloy-2 jacket into a dome shape. A single pass Heli-arc weld will then form the final closure.

Allied Fuel Studies. Reactor swelling experiments of Zircaloy clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposures are being conducted. Three of the four swelling capsules, presently being irradiated in the MTR to extend the coverage of temperature, exposure, and cladding restraint, have uranium center temperatures ranging from 300 to 350 C. Temperatures in the remaining capsule vary from 600 to 750 C. Exposure on all the capsules is approximately 1250 MWD/T. Goal exposure on the high temperature capsule is 3500 MWD/T. The lower temperature capsules will go to the following exposures: 2100, 3500, 5000 MWD/T. Seven swelling capsules in D Reactor were discharged at an exposure of 2100 MWD/T. Six more capsules remaining in the reactor will be discharged early in February at this same exposure. The center uranium temperatures of the fuel rods in these capsules are in the range 400-500 C.

An ex-reactor test simulating the charging of an NPR fuel element prototype in a Zircaloy-2 process tube showed a problem of severe process tube scratching. In addition to the loss of metal and eventual thinning of the process tube after a number of charge-discharge operations, these scratches may lead to localized corrosion or act as regions of stress concentration. A series of tests have been completed in which flat autoclaved Zircaloy-2 samples with contact areas from 0.7 to 3.4 in^2

were placed under a load of thirty pounds and pulled across another larger autoclaved Zircaloy-2 plate, simulating the process tube. Scratching of the Zircaloy-2 plate occurred in less than one foot with all the specimens tested. These tests indicate that charging and discharging fuel elements with sliding autoclaved Zircaloy-2 supports will break through the oxide film and scratch the parent metal of the process tube. Another series of tests were made to see if other surface materials could be used on the fuel element supports. Soft materials such as copper, bronze, and graphite did not damage the process tube, whereas, tantalum, aluminum, and tungsten carbide scratched within a distance of one foot.

A fuel tube support that provides large area of contact with the process tube and small areas of contact with the fuel rod or tube was made. This design which may decrease tube galling and scoring increases support contact area. The support is a thin square or rectangular plate with rounded corners. The plate is attached to the fuel tube along the plate center line. Two of the free edges of the plate contact the process tube. Tests are planned to determine the pressure drop caused by this support.

Coextruded bonds which have been subjected to a uranium beta treatment and tempered by lead bath quenching at temperatures in the range of 350-540 C behave no better during failure than other slowly cooled bonds. For practical purposes there are two types of bond failure behavior -- bad and good. A bad failure behavior results from rapid cooling (oil quench, lead quench, air quench) through this critical temperature range. "Bad behavior" bonds can be made "good behavior" bonds by annealing or aging below the critical 590-600 C temperature. Such an annealing or aging may occur in-reactor during the early service life of the coextruded fuel material. The role of irradiation and burnup or the nature of the bond with regard to its failure behavior is currently being tested.

A 7-rod uranium-zirconium clad fuel element was intentionally ruptured in the 3x3 loop at the ETR on December 12, 1959. The fuel was operating at 128 kw/ft, 300 C cooling, 2000 psi, 60 gpm. After mechanically piercing the cladding, the fuel operated for seven hours at full reactor power. Multi-channel analyzers on the effluent stream indicated that a small amount of fissionable products were released. The test was successful from the standpoint of demonstrating the ability to rupture elements by remote control. It also presented valuable information to IPD on types of instruments that should be used to detect failures in the NPR.

Under cyclic temperature operation, polycrystalline uranium develops microstress distributions due to the anisotropic thermal expansion of the uranium crystals. These microstresses affect the macroscopic creep rates. Creep tests are being run on uranium with large temperature cycles ($\Delta T > 200$ C) to simulate the temperature cycles observed in reactor fuel elements. The first test was cycled between 150 C and 465 C at one cycle a day and at 2000 psi stress. Under a uniform temperature of 465 C, this load gives negligible strain rates. After six

temperature cycles, the total strain is 6.5 percent. The straining occurred during the temperature changes. The strain per cycle was not uniform and varied from three percent on the first cycle to 0.21 percent on the fourth cycle.

Design Analyses and Computations. A rational basis for end closure designs should be established. As a start, a note was circulated describing what operational requirements must be specified to design and test end closures and what thermal, hydraulic, and mechanical problems needed either analytical or experimental methods of evaluation to see if an end closure satisfies operational requirements. Solutions were found for determining maximum surface temperatures in flat and toroidal end caps. Numerical evaluation is started. A mechanical testing method for unbonded end cap for duplicating the effects of expansion incompatibilities between the fuel material and the end cap is under development. The successful development of this technique depends upon forming a bond between a Ni-Mn-Cu alloy and Zircaloy-2. Some bonding has been accomplished by Dynapak coextrusion, but the extrusions were not suitable for end closure testing.

Facilities and Equipment. On November 30, 1959, seventh day of 24th ETR cycle, the pressure tube in the CG 6x9 position of the ETR fractured after 5.35×10^{20} nvt fast neutron exposure. Radiometallurgical examination of appropriate tube samples is completed, and report HW-63556 was issued. It was concluded that the tube failed because of local overheating to a temperature between 1400 to 1700 F. The replacement tube should be installed in the ETR on or about February 22.

The Dynapak was used to form an end closure on one inch OD by one-half inch ID, coextruded Zircaloy-2 clad fuel elements. The object was to bring the inside jacket and outside jacket together so the two could be joined with a single weld pass. Forming was done cold with a shaped die enclosed in a 1-1/2 inch diameter die cavity. Forming pressure was applied by the Dynapak with rubber and wax as a pressure transmitting medium. The outside jacket was turned in with excellent results, but the inside wall cracked because of multi-axial stress conditions. This difficulty should be overcome with further experimentation. Tensile test specimens are large on both ends in order to confine high stress to the gage length. These large ends perturb the heat distribution when the specimen is generating heat as would be the case with uranium during irradiation. In order to design a suitable uranium specimen for irradiation testing, the excess uranium on the ends of specimens are replaced with Dynapak coextrusion bonded Zircaloy-2. A 1/8 inch wall thickness sheath around a 1/4 inch diameter rod broke at the bond because of thermal expansion incompatibilities, but a 0.075 inch thick Zircaloy-2 sheath was successfully Dynapak coextruded. The extrusion ratio was 10:1.

An experimental and theoretical analysis of the kinetics of the Dynapak was undertaken so the Dynapak may be used more effectively with less tool breakage. Movies taken at 2000 frames/second appear to stop the punch action adequately for the study.

2. REACTOR PROGRAM

Coolant Systems Development

Low Temperature Aluminum Corrosion Testing. Out-of-reactor testing of reactor grade nickel-plated fuel elements at 80, 120, and 165 C is continuing. Inspections at four- and six-week exposures showed extremely good corrosion resistance.

X-8001 dummy fuel elements with defected autoclave coatings exposed at 165 C in process water were inspected after five and seven weeks of exposure. One piece was removed at each exposure to examine the accelerated attack. An X-8001 dummy exposed for five weeks showed a groove type of corrosion not particularly oriented with the direction of flow. The grooves were fifty to 100 mils wide and five to ten mils deep. The grooves were not similar to those experienced in-reactor. At seven weeks of exposure a C-64 dummy was removed with similar groove corrosion but to a much lesser extent.

The test to determine the corrosion effects of a silicate film on X-8001 dummies in 120 C process water was completed after seven weeks of exposure. The final results indicated almost no change or a slight reduction in corrosion rates.

Decontamination of Present Reactors. Five tests were completed in the single-pass flow facility during the past month. The test pieces were contaminated D Reactor pigtails. A 10% solution of Wyandotte-1112 (inhibited bisulfate) at eight gpm and 50 C for 24 minutes gave a decontamination factor of 43. Two tests at four gpm and eight gpm with 2.5% Wyandotte-1112 gave no appreciable decontamination. Another test of 2.5% Wyandotte-1112 with 2.5% diatomaceous earth added showed an insignificant increase in the decontamination factor.

A test of a three oz/gal solution of Turco 4306 B at eight gpm and 50 C for 25 minutes reduced the activity to essentially background. However, Zircaloy-2 coupons in the test section showed a corrosion penetration of one mil.

Evaluation of Hydrazine for Removal of Oxygen. A static test was run to determine the effectiveness of hydrazine as a corrosion inhibitor for carbon steel in oxygen-saturated water at low temperature. Polished carbon steel samples were exposed in water at room temperature and at 60 C. Three different water quality systems were studied: (1) deionized and deoxygenated samples as controls, (2) deionized and oxygen saturated samples to study the oxygen effect, and (3) filtered and oxygen-saturated samples to study the combined effect of oxygen and impurities. Duplicate samples were also prepared at pH levels of seven and ten. The samples were arranged in groups of three with the following hydrazine concentrations: (1) no hydrazine, (2) hydrazine concentration equal to oxygen concentration, and (3) hydrazine concentration equal to five times the

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oxygen concentration. The following observations were made during a five-day exposure period:

1. Corrosion in the pH 10 samples was less than in the pH 7 samples under all conditions.

2. Corrosion increased at the higher temperature under all conditions.

3. Corrosion was worse in the filtered water samples than in the deionized and oxygen-saturated samples. No appreciable corrosion was observed in the deionized and deoxygenated samples, as expected.

4. Corrosion rate in deionized and oxygen-saturated water was decreased by higher hydrazine concentrations. The rate appeared to increase, however, in the filtered water under the same conditions.

A sample of 12-30 mesh activated carbon was received for some catalyst studies of the hydrazine-dissolved oxygen systems.

Decontamination of Stainless and Carbon Steels with Ammonium Citrate. A test has been made using the APACE process preceded with peroxide-bicarbonate. Enthone-11 (0.2%) was added to the ammonium citrate to inhibit carbon steel corrosion. Total corrosion for carbon steel was in the range of 0.10 to 0.20 mil, while stainless steel coupons corroded about 0.01-0.02 mil. The final carbon steel coupon activity was generally high, 50,000 to 70,000 c/m, and D.F.'s were low, 30 to 50. By comparison, the stainless steel coupons cleaned up better, with D.F.'s of about 100 and final activities of about 20,000 c/m.

Effect of Cycling on Decontamination. Laboratory tests were made using a technique of repeated short interval exposure of coupons to NaOH-$KMnO_4$ and an acid step. Both two-minute and one-minute exposures were tried. There was good defilming after three complete cycles; defilming was not as good on other coupons exposed for the same length of time without cycling. The acid rinses, in the order of the best defilming in the least time with the cycling process, are: Turco-4512, Turco-4518, Wyandotte-1112, and $(NH_4)_2$ citrate. Corrosion losses by the carbon steel for all of these processes were about 0.03 mil, which is essentially the thickness of the magnetite film.

Effect of Irradiation on Corrosion in High-Temperature High-Purity Water. Corrosion data from three in-reactor corrosion tests in the KER loops indicate there is very little effect of irradiation on corrosion of several alloys of aluminum, 304 stainless steel, Zircaloy-2 and Zircaloy-3. Two of the tests were in neutral pH deionized water and the other test was in pH 4.5 (H_3PO_4) deionized water. Although the temperatures varied considably with time, the nominal temperatures were about 200 C.

Heat Exchanger Scaling Tests. The ELMO-1 heat exchangers were examined after two months of operation with raw cooling water following the descaling runs. There was no difference in scale build-up between the top heat exchanger, which had been descaled with inhibited H_3PO_4, and the bottom heat exchanger, which had been descaled with inhibited H_2SO_4. Rust barnacles about 1/8" high were found in stagnant areas on the carbon steel shell baffles. Additional descaling tests using cold inhibited H_2SO_4 and cold inhibited HCl are being planned.

Structural Materials Development

NPR Zircaloy Process Tubes. Chase Brass and Copper Company has completed the fabrication of 13 NPR process tubes. The final drawing operation proceeded smoothly, and the tubes emerged with no apparent scratches but with varying amounts of bow. The bow was removed by a press straightening operation. Three of the tubes had been stripped of drawing lubricant, and one had been inspected as of January 22. This one tube had two small galled areas inside, which were successfully removed by localized grinding. Clean-up and inspection is proceeding on the remainder of the tubes.

The first tube produced by Allegheny Ludlum Steel Corporation went through the rocking process at Tube Reducing Corporation on January 19. This tube passed through the tube reducer uneventfully, emerging with less than the usual bow or spiral and a better than normal outside surface. Seven more tubes were processed during the next two days, and four more are nearly ready for tube reducing. Inspection is proceeding during the week of January 25.

Stress-Rupture Facilities. No information on the stress-rupture properties of Zircaloy tubing at anticipated reactor operating conditions is presently available, although tests to determine the ultimate bursting strength at operating conditions have been made. Scoping is in progress for facilities which can be employed for making stress-rupture studies on both unirradiated and irradiated tubing.

Burst Tests on Irradiated KER Tube. Evaluation of the results of the room temperature burst tests on the Zircaloy-2 irradiated KER tubes has been completed, and a report is being written. The data indicate that irradiation lowered the ductility only slightly. A close examination of the fracture surfaces of the two irradiated specimens revealed a failure in the radial plane. After the crack propagated for an inch or two, the fracture surfaces rotated to form angles of 45° or less with the radial plane. This is interpreted to mean that the cracks were initiated as tensile failures but reverted to shear type failures after propagating for a short distance.

Nonmetallic Materials Development

GETR Graphite Irradiation Experiments. The H-1 experiment in the GETR was discharged January 6, after a four-cycle exposure. In general, the experiment was found to be in better condition than the previously-discharged

experiment, although the predicted flux level was higher in H-1 than in H-2. All of the graphite samples measured to date had undergone small amounts of contraction. Nickel-activation foils indicate significantly lower fast flux values than previous data available. If confirmed, this means that the H-1 graphite samples were exposed to a maximum of about 4×10^{20} nvt fast flux (E greater than 1 mev), or on the order of 10,000 MWD/AT equivalent damaging exposure when converted to a C Reactor hot test hole basis. If confirmed, this substantially lower exposure than previously believed improves the correlation of the contraction data with previous measurements and indicates no decrease in the rate of contraction to this exposure. The data also indicate higher contraction rates at the higher temperatures and generally confirm the lower contraction rates for needle-coke graphites than for CSF.

A series of experiments designed to explain some of the damage observed in the H-2 capsule were performed in a laboratory induction furnace at 1500 C. The loss of the molybdenum parts in the H-2 experiment now appears to have been caused by the dissolving action of aluminum vapor. Aluminum and graphite systems when heated to the vicinity of 1400 C rapidly form Al_4C_3. The Al_4C_3 in or on graphite is very detrimental to the graphite body if moist air is present. The carbide in the presence of water forms aluminum oxide and methane, and some graphite samples thus treated have completely disintegrated in a few weeks in contact with room temperature air and moisture.

Flux Values for Y Test Hole at C Reactor. The Y Test Hole at C Reactor has been the chief source of Hanford data on high temperature graphite irradiations. Initial nickel foil activation flux determinations, coupled with a 32-group calculation (by ORNL) for the fast flux spectrum, indicate that 1 MWD/AT (YTH-C) = 3.9×10^{16} nvt (> 1 mev), as an average from 10 foils. A 10% variation with respect to position in the test hole was indicated. The irradiation was performed 5'7" from the center line of the reactor toward the inner rod room and between process tube rows 35 and 36, where the position factor was 0.987. The calculation of accurate integrated fast flux dose values from the tube power is expected to require a slightly different conversion constant for each test hole, and perhaps each position in the test hole.

Graphite Burnout Monitoring. Samples were discharged from 1960-C after 22 months of exposure. Weight changes will be measured after the samples have been dessicated. Oxidation rates are expected to be high because the center graphite sample carrier crumbled easily during the discharge operation. In order to correlate power and burnout rates, nickel and aluminum-cobalt alloy flux monitors were included with the graphite samples when the channel was recharged.

IP-22A-Intermediate Temperature Irradiation of Graphite. The heaters in the controlled temperature irradiation assembly that was charged into 1573-DR in December 1959, have failed. Failure of all four heaters occurred in the same manner, viz., the circuit resistance gradually increased over several days from about 20 to 400 ohms, and the cause is at

present unknown. The assembly is to be discharged during the next shutdown period.

Thermal Hydraulic Studies

Hydraulic Studies. Experimental isothermal hydraulic demand characteristics were determined for full length charges of self-supported I & E fuel elements in a ribless zirconium tube of C Reactor geometry. The data show an annulus to hole flow split ratio of 1.97. The pressure drop is about 9% greater than that of current C Reactor geometry with C-II I & E fuel elements. This increased pressure drop will result in a normal tube flow rate about 4% less than that for C-II I & E fuel elements.

Glass Heat Transfer Test Section. A heat transfer test section using an electrically heated rod in a glass tube with annular water flow was built. The tube is 1.5-inch ID precision bore glass pipe, 30 inches long. The test section is provided with a thermocouple plate at the water outlet end of the tube to measure local water temperatures around the annulus. The glass is so supported that its position can be fixed either concentric or with known eccentricity with respect to the heater rod.

The test section was designed primarily to investigate circumferential temperature variations due to eccentricity. It will also be used, within its pressure limitations, to investigate forced convection boiling phenomena. Initial experiments were performed to determine its capabilities in investigating these problems. Experiments using a 24-inch long heated section with a 100-mil annulus were performed to determine circumferential temperature variations and to provide local boiling to be photographed with a high speed motion picture camera.

The initial circumferential water temperature measurements gave erratic results. This was determined to be the result of a rather severe radial temperature gradient across the annulus. A gradient of about 8 F was measured in a case where the bulk inlet to outlet temperature increase was about 35 F. This is interesting in itself; but also, since the thermocouples of the thermocouple plate were not inserted equal distances into the water stream, the radial temperature variations masked circumferential variations. Plans were made for further experimentation with an improved thermocouple installation.

Motion pictures of local boiling were made at speeds up to 3600 frames per second of local boiling under conditions of 30 to 60 F subcooling. While these first pictures were not entirely satisfactory as far as lighting, camera focus, and operating procedures are concerned, they did provide interesting qualitative information and gave promise of obtaining further improved information.

The pictures showed that even under the degree of subcooling used, local boiling was vigorous. Furthermore, the bubbles formed did not condense upon leaving the heated surface but actually continued to grow or coalesce. There was a slight but pronounced upward movement of the bubbles. Linear

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velocities of the bubbles were calculated to be as great as 60 feet per second which may be compared with the single phase water velocity of seven feet per second. The qualitative observations seem to indicate that there exist temperature gradients within the water and that local boiling effects can be quite pronounced.

Laboratory Equipment. The high pressure apparatus was shut down for installation of the steady-state equipment of Project CH-834. It is anticipated that the shutdown will last for about two months. Installation progress to date has been on schedule.

Heat Transfer Characteristics of 7-Rod Cluster Fuel Elements. Further experimental heat transfer data were obtained from an electrically heated mockup of a 7-rod cluster fuel element. The mockup consisted of seven rods, 0.704 inch in diameter and 35 inches long, equally spaced in a 2.70 inch horizontal flow tube. The electrical resistance of the center rod in the cluster was greater than that of the six outer rods so that each of the outer rods had a 42% greater heat generation rate than had the center rod. Thermocouples were installed to measure rod surface temperatures and water temperatures in the various flow channels. Data were obtained at heat generation rates of 114,000 to 410,000 BTU/hr-ft^2, flow rates of 57 to 135 gpm, an outlet pressure of 535 psig and an inlet temperature of 425 F, that is 20 F subcooling.

The data show that inter-channel mixing was negligible. The water temperatures of the various flow channels were those which would be calculated assuming no inter-channel mixing. This is further substantiated by the fact that the center rod surface temperatures were approximately those of the outer rods despite the lower heat generation rate of the center rod. This shows the effect of the higher water temperature in the inner channels.

The data also show that phase separation was significant even though bulk boiling did not occur. The phase separation was, as would be expected, greater at low flow rates. This was evidenced by a 40 F difference in temperatures between top and bottom rods in one run at a flow rate of 57.7 gpm and a 15 F difference in another run at 135 gpm.

Shielding Studies

Neutron and Gamma Attenuation. The perforated ferrophosphorus concrete test slabs have been baked at 320 C and placed in the shield facility for irradiation. The iron-serpentine concrete (265 lb/cu ft) test slabs, previously baked at 100 C, were removed from the shield facility and placed in an oven where they will be baked at 320 C. After the foils have been counted and analyzed, this will complete the testing at 100 C.

The second irradiation of as-cured iron-serpentine concrete (210 lb/ft^3) was made and the foils from the first irradiation are being counted. This concrete has been recommended for use in the front and rear biological shields of the NPR.

Foils from the second loading of the NPR boron steel thermal shield test were counted again because of discrepancies in the results from the first counting. These data are now being analyzed. Counting of sulfur foils from the third loading was completed.

The delivery date for the parts of the Perlow Recoil Neutron Counter from the Argonne Laboratories has been extended for two weeks. Negotiations are under way to complete the assembly there. Modifications on the subtraction unit for the 100-channel analyzer are in progress. Initial installation showed that the unit would only subtract on the first 20% of the spectrum.

Masonite Thermal Damage. The study of thermal damage to irradiated masonite, requested by IPD personnel, has been completed. Small samples were taken from the shield step plug used originally in the shielding facility atop the DR Reactor. The samples were heated in air at various temperatures from 120 to 200 C, and the weight loss (due to loss of hydrogen and oxygen) was measured as a function of temperature. The results are indicated in the following table:

Temp., C	Heating Time, hrs.	Weight Loss, %
120	342	3.4
160	169	7.1
190	72	11.5
190	119	22.3
200	114	48.8

All of the samples darkened in color on heating, though no ignition was observed. The results of this investigation have been transmitted to IPD personnel and were used to raise the temperature limit for exposure of the masonite shields to an air atmosphere from 100 to 150 C.

B. WEAPONS - 3000 PROGRAM

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

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

Basic Studies. Investigations have continued on the thermal expansion of plutonium dioxide. A slight discontinuity has been observed between approximately 600 and 700 C on plots of $\Delta L/L$ versus temperature. The same data were obtained from three different samples, each approximately 1/2" diameter x 1/2" long, which had been run in a vacuum dilatometer at a heating rate of 25 C/hr. Expansion curves determined for UO_2, copper, and aluminum were continuous through this region indicating the cause is not due to the apparatus. A relatively high vacuum, 10^{-4} mm Hg, was employed; however, in view of the low temperature of the discontinuity, vaporization to a sub-oxide seems unlikely. When a sample was run in helium, there was no evidence of a discontinuity which indicates the cause is not due to an allotropic transformation. Investigations into this effect will continue using both dilatometric and high temperature x-ray diffraction techniques.

The effect on particle size of heating 300 C oxalate calcined PuO_2 in air has been found. Average particle diameters, as determined by a Sub Sieve Analyzer, were found to vary from 0.9 micron for the as-calcined material, to 2.30 microns after heating to temperatures near 1000 C. The effect of calcination temperature on the stability of PuO_2 in hydrogen will be determined as soon as the various batches of oxide are available.

Studies on the formation of plutonium uranium carbides have been resumed. The induction furnace was used to make a heat of PuO_2 mixed with graphite and UO_2 mixed with graphite. In each case stoichiometric, less than stoichiometric, and greater than stoichiometric amounts of graphite for monocarbide formation was added along with a binder and pressed into pellets. As indicated by the bell jar pressure, a reaction took place near 1800 C. After holding for two hours at this temperature, the pellets were cooled in vacuum and then examined in the hood atmosphere, which was nominally argon. The pellets showed a considerable amount of shrinkage and porosity, due to gas evolution during reaction. The hand press in the hood proved incapable of enough pressure to recompact the porous pellets and two of them were lost in this operation. The other four were re-sintered for four hours at 1900 C. Preliminary x-ray data show clearly the formation of UC. The lines of the Pu samples are not very strong, but look more like Pu_2C_3 than the monocarbide. The experiment is presently being repeated with a higher capacity press in the hood; this should mean that higher density, more homogeneous pellets will be produced.

Fuel Fabrication. Ultrasonic testing techniques are being developed for inspecting the cladding quality of the PRTR fuel rods. The equipment is in operation and the standards are being evaluated. Preliminary inspection of some of the tubing indicates the presence of defects in excess of 10 mils.

The canning hood, hooded drawbench, and welding box are being activated in the Pilot Plant. As soon as they become available, the entire fabrication, with the exception of extrusion, straightening, and cut-off, will be performed in the 308 Bldg.

The Zircaloy tubes are being swage sized on a stainless steel mandrel to give as uniform an inside diameter as possible. This swaging operation sometimes causes a slight bending of the tubes, and it is necessary to straighten them after swaging. Also, the gauging head has caused small scratches on the inside surface of the tubes creating burrs which make loading of the cores difficult. The inside diameter of the tubes is treated with emery to remove any burrs. Eight hundred and thirty tubes are currently in the process. They have all been preliminary gauged and 406 have been completed and are ready to have the first end caps welded in place.

Enough billets for 666 cores of the corrosion resistant alloy have been cast, 180 during the past month. In order to reduce the reject rate for blisters on extruded rods, the pouring rate was increased to fill the mold as rapidly as possible, thus reducing the possibility of entrapping air in suddenly chilled metal. The reject rate has been cut in half, but since the pouring operation is manually regulated, consistent control is difficult. There have been no corrosion test rejects since the solidification rate was increased through the use of unheated molds. Four hundred and four cores have been extruded and of these, 228 have been completely finished and are ready for loading. A graphite lubricant in the form of dag is being applied to the outside surface of the cores to assist in loading and to help the thermal cycling problem. Forty-three rods have been completed and are ready for etching and autoclaving.

Zircaloy end brackets of the Mark I-G design are being fabricated on an accelerated basis to meet the April delivery date. At the present, plans are under way to projection resistance weld the 3/8" diameter sleeves to the 6-rod ring and 12-rod ring. These subassemblies will then be assembled with the other parts and fusion welded in an inert gas welding box. All parts have been machined from the Zircaloy stock found on site. The large and small rings were machined from scrap tubing remaining from other jobs. Other parts were made from 5/8" rod and 1/16" sheet, both of which were available from stock. The 3/8" diameter tubing has been purchased off-site and is to be shipped by the 8th of February. All fixtures have been completed including the necessary tool and die work for forming the projections in the rings. All projection resistance welding is being done with the cooperation of Ceramic Fuels Development Operation.

Fuel Evaluation. The 11-inch long Zircaloy clad 3.1 w/o Pu alloy 3-rod cluster (GEH4-46) has successfully completed its irradiation in the MTR. This element was fabricated by swage sizing the Zircaloy tubes onto cores which had been lubricated with graphite. It was irradiated 32.8 days for a calculated maximum burn-up of 33 percent of the Pu atoms. The thermocouples, however, indicated an average power generation of only 38 kw/ft of element instead of the calculated value of 75 kw/ft. The reason for this discrepancy is not apparent at the present time.

The fabrication of a three-foot long Zircaloy clad 7-rod cluster (GEH-11-3) containing UO_2-PuO_2 sintered pellets in as-received tubing has been completed. This element will be irradiated in the high-temperature high-pressure loop in the ETR. Six-tenths w/o PuO_2 was mixed with depleted UO_2 and then sintered to densities of the order of 95 percent of theoretical. The pellets were ground to 0.502 $\pm$ 0.001 inch diameter and loaded into Zr tubes with a 0.506 inch inside diameter. These rods will generate a maximum of 13 kw/ft in a thermal flux of 1.28×10^{14} nv.

The high density UO_2-0.026 a/o PuO_2 (GEH-14-19) which had been irradiated in the MTR to a 0.18 a/o burnout has been through radiometallurgical examination. The structure contained no central void but had extremely large central grains which transformed to radially oriented columnar grains. Large isolated spherical voids were noted in the grain centers while the voids along grain boundaries were tubular in shape. The fission gas released totaled 23.3 percent of that generated. The gas sample contained 14.5% Xe and 2.8% Kr.

All ten high density UO_2-PuO_2 capsules (GEH-14-82 thru 91) have been irradiated in the MTR. The specimens contain mechanical mixtures of UO_2-PuO_2 with 0.0259 to 5.67 a/o PuO_2. Eight were recently discharged. Two are currently being examined in the Radiometallurgy Laboratory. No significant changes in external capsule dimensions were noted.

All ten low density UO_2-PuO_2 capsules (GEH-14-65 thru 74) have been irradiated. The specimens contain mechanical mixtures of UO_2-PuO_2 with 0.187 to 7.45 a/o PuO_2. Two additional low density UO_2-0.0259 a/o PuO_2 capsules have also been irradiated. The specimens contain nonsintered, mixed crystal oxide compacts. One sample is presently being examined in the Radiometallurgy Laboratory. The capsule cladding (9/16" diameter by 2.5" long) decreased 0.0015-0.002" in diameter and increased 0.009" in length.

The Al-Pu and Al-12 w/o Si-Pu alloy capsules (GEH-14-5 thru 12) with 5, 10, 15, and 20 w/o Pu are now being evaluated. All specimens were to have been subjected to about 0.1 a/o burnout. Dimensional changes in the cladding (9/16" diameter by 2.5" long) were as follows: diameters decreases ranged from 1.2 to 3.5 mils whereas the length increases ranged from zero to 33 mils.

Fabrication Development. Thermal cycling experiments on dummy Zircaloy clad wire wrapped rods is continuing. Some previous cycling experiments indicated that the testing pressure in the autoclave was affecting the results to a greater extent than expected from thermal stress calculations. Ten Zircaloy clad rods, 33 inches long were fabricated with a minimum diametral gap of 0.004 inch with no graphite lubricant. They were helically wrapped with a Zircaloy wire and thermally cycled between 100 and 350 C in the normal manner with the exception that the vessel was operated at zero pressure. After 80 cycles, no dimensional changes, distortion, or loosening of the wires was observed in any of the ten rods. This demonstrates that the testing pressure was definitely affecting the thermal cycling results. Additional rods have been fabricated by various techniques and will be cycled between 150 and 350 C at a pressure of 1000 psi. It appears that a thicker wall on the Zircaloy cladding would help the thermal cycling problem.

Two Pu-Al capsules which were injection cast for irradiation testing in the MTR were found to be unbonded and not representative of pneumatic injection castings so it was decided to refabricate the 2-1/2 inch long capsules after determining a method for making bonded elements. A nine-inch long split tube furnace was used to prevent the castings from freezing before a reaction layer was obtained between the aluminum and Zr tubing. The tube furnace was placed above a crucible furnace containing molten aluminum and various combinations of heating cycles and melt temperatures were explored by injection casting into Zr tubing. It was found that a uniformly bonded, 10-inch long Zr-clad aluminum casting could be made by forcing aluminum at 730 C into Zr tubing with atmospheric pressure. The tube furnace was heated to 800 to 900 C before the casting was made, and the evacuated Zr tube was then lowered through this furnace until the end containing a tapered aluminum plug was immersed in the molten aluminum. When the aluminum end plug melted, atmospheric pressure forced molten aluminum into the tube until it contacted a vented aluminum freeze plug. The casting was left in the furnace for 30 seconds and then removed and inverted during solidification. Two 1.9 w/o Pu-Al castings were made by this method. Four capsules will be made by this technique and shipped to the MTR for irradiation testing.

The heating pattern in the 308 Building autoclaves has been adjusted to a maximum gradient of 15 C in the fuel element load zone. Currently, the process is plagued by small steam leaks at various flanged seals and/or valves. The leaks will be found by helium pressurizing of the vessel and sniffing with a mobile mass spectrometer. A Zircaloy-2 clad, aluminum cored, PRTR type dummy load was autoclaved at 100 psig for 24 hours. The low steam pressure resulted in an increased temperature gradient in the fuel element load zone. The maximum temperature was 565 C with a 100 C gradient. Visual examination of the elements after autoclaving revealed cladding cracks on one element. The oxide coating appeared uniformly black.

UO_2 Fuel Development

PRTR Fuel Elements. Rods swaged this month will fulfill the requirements of the first load of the PRTR. These rods will be completed, tested, and assembled into fuel elements by the goal date of April 1, 1960. The process yield for this month is about 85 percent. Density of these rods was between 88.0 and 89.0 percent of theoretical.

The total number of rods swaged during the campaign was 2180. Of this number, 632 contain fused oxide and 1548 contain PWR grade or micronized UO_2 which was sintered and crushed in the laboratory. Tubing used for these rods came from two orders; 496 tubes were from the recently delivered (November and December 1959) 1100 tube order and the rest from an order delivered before July 1959.

A total of 63 PRTR fuel rods fabricated by vibrational compaction are in process. Process improvements include facilities for filling and vibrating seven 8-foot long tubes simultaneously. Fuel rods compacted during tube loading have higher density and more uniform fuel distribution and can be fabricated more quickly than those compacted after a separate tube-filling operation. Densities of single rods continuously compacted during loading, with fused UO_2, approach 90 percent of the theoretical UO_2 density. Preliminary results show that similar densities can be achieved in compacting seven rods at a time, with a suitable feeding mechanism to add fuel uniformly to all tubes.

Radiographs of 784 closure welds on PRTR fuel rods revealed two welds with defects. These welds have been repaired by rewelding. The yield for the welding operation during the last three months has been in excess of 99.5 percent.

Sixty-two sets of 19-rod fuel element end fittings have been fabricated to date from Zircaloy-2 material. Fifty-one sets are of high quality and will be used on Class I fuel elements for the first PRTR loading. The remainder is being used on Class II and Class III fuel elements and short length fuel element irradiation clusters. Parts and sub-assemblies are in process for fabricating the next twenty sets of end fittings.

The tanks used to etch PRTR fuel rods before autoclaving were found to be slightly contaminated. To determine whether any of the PRTR fuel rods may be contaminated, several autoclaved rods selected at random will be exposed to nuclear track film to determine the amount of contamination present. With this film, it is possible to detect uranium concentrations as low as one microgram of uranium per cm^2 of fuel rod surface. An exposure time of about five days will be required. A scintillation counter is being designed to routinely check all finished fuel rods. Using a counting time of about ten minutes, this instrument will detect uranium contamination concentrations as low as four micrograms/cm^2.

An analysis of the major cost areas associated with the development and fabrication of PRTR swaged UO_2 fuel elements was completed. Cost trends

started to decrease sharply in June and July of 1959, and leveled out during the last calendar quarter of 1959.

Fabrication Development. Experimentation to determine the feasibility of fabricating nested tubular fuel elements by vibration compaction is under way. Initial results are very encouraging. Fused UO_2 was vibrationally compacted to 83 percent of theoretical in a three-foot section of the outer Zircaloy-2 fuel tube. In this preliminary test, the cladding tubes were welded to the end cap, the fuel space was filled with UO_2 and the assembly was vibrated. Coupling to the vibrator was accomplished by welding a threaded screw to the end cap. The coarse fraction of the UO_2 mixture was composed of relatively small particles which do not produce the highest compacted densities. Correct particle size distribution should produce higher vibrated densities.

[redacted]

however, that the opposite actually occurs. The cobalt-60 source was shielded with lead ranging in thickness from 1/2 to 2". As the lead thickness increases, the sensitivity of the gamma absorptometer decreased. The reason for this may be that the sodium iodide crystal used as a scintillation detector is insensitive to small changes in flux when the incident flux is very low. The gamma beam is now being used unshielded.

Fuel Evaluation. The post-irradiation examination of an irradiated, purposely defected, swaged UO_2 fuel rod revealed:

a. No washout of the UO_2 occurred adjacent to the defect hole.
b. No visible changes were observed in the UO_2 adjacent to the hole.
c. An estimated 150-200 ppm hydrogen was observed metallographically in the Zircaloy-2 near the defect. The hydride is uniformly distributed throughout the cladding at that point. The source of the hydrogen has not been verified.
d. A central void was observed in the fuel. Its appearance was identical to that observed in swaged, non-defected UO_2 rods irradiated to exposures in excess of several hundred MWD/T at the same heat generation rate.

Examination of the element will continue.

No fretting corrosion of wire wrapped, Zircaloy-2 clad, swaged UO_2 fuel elements was detected in Radiometallurgy, after their irradiation in KER loops to an estimated exposure of 800 MWD/T.

Swaged UO_2 capsules attained estimated exposures in excess of 13,000 MWD/T in MTR-ETR. No failures of swaged UO_2 have occurred.

Basic Studies. Thermal conductivity measurements of 100 percent dense, arc-fused UO_2 were temporarily suspended because of erratic equipment performance. Measurements will be resumed after the specimens have been buffed and cleaned in a vapor degreaser and new, calibrated thermocouples have been installed.

Various UO_2 specimens, including arc-fused single crystals, sintered pellets, and sintered pellets containing a variety of additives known to increase sintered density, were fractured and are currently being examined microscopically. An attempt will be made to correlate the nature of the fracture surface with physical properties. Additional sintered specimens containing TiO_2, Nb_2O_5 or CaF_2 and UO_2 pellets having a variety of densities were fabricated for fractographic studies.

An attempt was made to remove mechanical surface defects from Zircaloy-2 tubing by induction annealing. A glass shroud housing a six-inch copper induction coil was used to position a 9/16" OD x 0.030" wall tube in a helium atmosphere. Temperatures above 1400 C were attained in the tube. The heat zone, however, was so wide that considerable sagging of the

tubing occurred. After five minutes at temperature, an oxide film approximately 0.001" thick was observed on the tubing. Visual examination showed no change in size or shape of defects.

Stainless steel clad, sintered UO_2 pellets were fabricated for dissolution studies by Chemical Development Operation. Three hundred feet of 1/2 inch OD elements containing sintered, unground UO_2 pellets were delivered during January.

Corrosion Studies

Zircaloy-4 Corrosion Test. Initial corrosion rates of Zircaloy-4 received from KAPL have been determined in 360 C deionized water, 300 C pH 10 water, and 400 C steam. Two 60-mil strips were received. One strip was vacuum annealed at 750 C, furnace cooled and then rolled to 30-mil thickness. Coupons were then prepared from both 30-mil and 60-mil strips and exposed to the different test conditions along with reference Zircaloy-2 coupons. The Zircaloy-4 showed corrosion rates very similar to the Zircaloy-2 reference coupons in both 400 C steam for 187 hours and 300 C, pH-10 water for 242 hours. In 360 C deionized water, the Zircaloy-4 weight gain was approximately 2 mg/dm^2 greater than the Zircaloy-2, after 240 hours. In all the test conditions, the Zircaloy-4 coupons prepared from the strip which had been heat-treated and rolled exhibited lower weight gains than the Zircaloy-4 coupons prepared from the 60-mil strip.

Aluminum Corrosion. High purity base aluminum alloys have exhibited larger corrosion penetrations in 290 C than 360 C water. Perhaps related to this fact, x-ray analyses of 360 C and 290 C stripped aluminum corrosion-product films indicate a difference in film composition: the 360° films appear to be basically alpha Al_2O_3 while the 290 C films are alpha $Al_2O_3 \cdot H_2O$.

Ten-day exposures in 320 C water show penetrations comparable to those for 290 C. Since, according to Ervin and Osborn J. Geol. 59 381-94 (1951), there is a transition in the stable oxide phase from alpha to beta-aluminum oxide monohydrate as the pressure is increased past about 2000 psi, the 320 C tests were run at two different pressures, above and below 2000 psi, to determine whether the corrosion rate was pressure sensitive. However, the ten-day results showed no pressure dependence.

One month results of pretreated high purity base alloys in 340 C, 32 fps water have been analyzed. The samples were pretreated for two weeks in 300 C water. The total penetration of the high purity alloys is only slightly less than for X-8001, but if the calculated penetrations during pretreatment are subtracted from the total penetrations, most of the high purity base alloys appear better by a factor of about two.

Corrosion of Aluminum in High Temperature Water. The test studying the use of HNO_3 as a corrosion inhibitor for X-8001 aluminum at high temperatures has been evaluated. At 300 C and 64 fps, a rate of 0.50 mil/

month was obtained in pH 4.5 HNO_3 after 1500 hours. The corrosion rates for 32, 26, and 21 fps were 0.35, 0.27, and 0.24 mil/month under the same conditions. These data contrast with the rate of 0.06 mil/month obtained from pH 4.5 H_3PO_4 testing at velocities from 20 to 35 fps. On the other hand, in high purity neutral pH water at these conditions, the corrosion rate of X-8001 may be as high as 10 mils/month. In the HNO_3 test a higher corrosion penetration was noted on replacement coupons, indicating a greater effect (than in the H_3PO_4 system) of a lower ratio of fresh aluminum surface to loop volume.

The test in KER Loop 4 of the radiation stability of nitric acid was completed. Average concentrations encountered in the loop water during operation at pH 4.5 were: 1.7 ppm NO_3^-, 0.04 ppm O_2, 0.3 ppm H_2O_2, 1.0 ppm $Cr_2O_7^=$, and 0.1 ppm $PO_4^=$. The loop temperature was 170 to 190 C. The loop was charged with dummies during the test. Water clean-up was one gpm through IR-120 cation exchange resin. Only occasional addition of acid bombs was required to maintain the acid concentration.

Aluminum coupons exposed in the mock-up tube appeared still bright on visual examination, indicating very little attack. Interference with the oxygen analyses developed from the unforeseen formation of dichromate, but this was successfully overcome by passing the sample through an ion exchange resin.

A new test has been started in ELMC-6 using CO_2 as an additive to reduce the loop pH to 4.5. During the conditioning run large amounts of iron and calcium were found in the loop water samples. The most likely source for this material is crud deposited on the internal pipe surfaces over the last few years. This probably would react with any H_2CO_3 to form carbonates and bicarbonates which would be soluble in the loop water. During this same period, loop water samples would precipitate Fe_2O_3 on aging. It might be expected that $FeCO_3$ would air-oxidize to Fe_2O_3 and CO_2 on standing. After one to two weeks of conditioning, however, no water quality problems existed and corrosion testing of X-8001 and 304 stainless steel was started at 300 C and pH 4.5.

Structural Materials Development

PRTR Process Tube Monitoring. Several nondestructive test equipment manufacturers were contacted during the month regarding equipment and testing methods for in-reactor inspection of PRTR pressure tubes. To date none of the test instruments considered have been subjected to gamma dose rates of more than about 10^6 R, whereas gamma dose rates expected in the PRTR are about 5×10^7 R/hr. Therefore, special consideration of possible deterioration of the optical lenses, electronics circuitry, and possibly peizoelectric materials, will be required. Efforts are being made to determine whether substantial amounts of H_2 pickup can be detected by ultrasonics.

PRTR Jacket Tubing. Wolverine Tube Company is about to start fabrication on a new large order of PRTR Zircaloy-4 jacket tubing. The first ingot, 16 inches in diameter and weighing 1900 pounds, is enroute from the

melter to the forger. The first extrusions should be produced early in February, with delivery of the first tubes about the end of February.

PRTR Zircaloy Process Tubes. In the reprocessing of the 46 tubes which had unsatisfactory autoclave films, all vapor blasting, pickling, autoclaving, and testing is scheduled to be completed by the end of January. Based upon results to date, it is expected that between 85 and 90 tubes will meet all requirements for structural integrity, autoclave film, and the 0.146 inch minimum wall thickness. With final straightening scheduled for early February, 85 tubes will be ready for installation in the PRTR by mid-February.

Radiometallurgy Laboratory Studies

The visual and macro examination of a potentially ruptured UO_2 fuel element from GEH-4-40 showed no visible defects or suspect areas. Metallographic examination of the Zircaloy-2 cladding around the defected UO_2 fuel rod near the defect showed a uniform concentration of hydriding around the entire circumference.

Length and diameter measurements were obtained on eight capsules of five to 20 w/o Pu, Al-Pu and Al-Si-Pu alloys, and also on one of the low density UO_2-PuO_2 capsules. The results and conclusions from these tests will be reported in connection with the respective programs of Ceramic Fuels and Physical Metallurgy Operations.

Thermal Hydraulic Studies

Local Heat Transfer Coefficients in 19-Rod Cluster. A test section was built which can be used to measure point heat transfer coefficients on the surfaces of the rods of a 19-rod cluster. Experimentation with this test section is in progress. Preliminary conclusions from the data obtained so far indicate that a moderate variation in heat transfer coefficients will occur. The experimental heat transfer coefficients ranged from about 900 to 1400 $B/hr\text{-}ft^2\text{-}^oF$. In general, the lower heat transfer coefficients are associated with those surfaces facing the large flow areas, with those surfaces facing the process tube wall, and with those surfaces behind a wire wrap.

PRTR Project Management and Design

Phase III PRTR Contract. The Phase III contract portion of the PRTR is 55% completed versus a scheduled 76%. Over-all PRTR project is estimated to be 67% complete versus a scheduled 80%. Leak testing of the biological shield liner and cooling coils is essentially complete, and heavy aggregate concrete placing is expected to start the first week in February.

Leak testing of the biological shield inner liner has been completed except for the blowout membranes in the moat openings and the tubing fitting seals on the rupture detection sample lines. These items will not delay placement of the biological shield. Repairs to the B Cell

liner cooling lines have been completed, and the coils are undergoing the hydrostatic test. Hydrostatic testing of other penetrations in the B Cell is in progress. Spot radiography of the few inner welds indicated that these welds did not completely meet our specifications. No action has been taken other than to make the welds leak tight.

The revised drawings for the electrical connections and piping connections on the helium compressors have been given to the Phase III contractor to prepare a bid price prior to issuing these changes as a contract change. Should the contractor's price be excessive, the work will probably be deleted from the Phase III contract.

The design of the mechanical portion of the rupture monitor system was completed and submitted for approval. A number of items on this system are to be procured by General Electric and furnished to the fabricator to alleviate expected delivery problems. These include the sample flow regulating valves, shutoff valves, and rotameters.

PRTR Stack Addition. Contract work on the PRTR stack is estimated to be 97% complete. The contractor was given a stop order to withhold work pending better weather conditions. This stop order was essentially agreed to with no additional cost to the project. Essentially, all contract work has been completed except installation of obstruction lights and back filling.

Procurement. The fuel transfer system has been fabricated. Some tolerance discrepancies exist; however, operability of the system will be determined during installation in the building because of the necessity for trimming to fit the as-built building dimensions.

The Mosler Safe Company is completing the final cleanup on wall blocks 1, 2, and 4 for the Fuel Element Examination Facility. Blocks 1 and 2 are scheduled to be shipped by the end of January. Shipment of wall block 4 will await the completion of wall block 3, which is being clad. Blocks 3 and 4 are scheduled for shipment the first week in February.

Fabrication of the two sections of the FEEF control console being made by Panellit has been completed. The sections are enroute.

Delivery of the lens required for the FEEF wide angle viewer has now been scheduled for February 15, 1960. Receipt of the lens will permit the assembly and testing of the viewer.

The lighting fixtures for the Fuel Element Examination Facility have been received from the vendor.

The supports for the shield portion of the FEEF were incorrectly located when the heavy aggregate shielding wall was poured. The contractor has submitted a proposed method, now under review, for relocating the supports.

The calandria and top and bottom primary shields are completed. Delivery to the Phase III contractor is awaiting the contractor's request for these items.

Fabrication of the standpipe modification to the pressurizer was completed during the month and delivered to the Phase III contractor. This device permits the attachment of liquid level control and alarm systems at a lower level than would be possible by use of existing nozzles on the pressurizer vessel.

All the parts for the outlet nozzles have been received from Cherry-Burrell. Fabrication and inspection jigs have been completed. Six nozzles have been completed by J. A. Jones. These nozzles have been inspected and contain only minor deviations from the drawings. Some tolerance relaxation will be required because of the condition of the nozzle parts as received.

Fuel Element Rupture Test Facility (Project CAH-867). To date, rough draft design criteria have been prepared on approximately 60% of the systems comprising the "rupture Loop" including the test section, the main coolant system, cleanup system, makeup system, and miscellaneous systems. Layout of equipment in B Cell and in the underground annex is being developed.

High Pressure Loop (Project CAH-841). Work on this project has been temporarily suspended pending approval of the project proposal.

PRP Critical Facility (Project CAH-842). Total funds requested for Project CAH-842 have been revised from $310,000 to $360,000 in order to incorporate additional safety rods and possibly a moderator storage vessel. These changes may require deepening the reactor cell from 26 to 32 feet below grade plus provision of reactor support dunnage in addition to the vessel and rods.

Analysis of the proposed light water assembly has shown that the design case requires a large quantity of enrichment to drive it to critical. Reactor Lattice Physics Operation will re-define the light water requirements so that a new assembly may be scoped for inclusion in the design criteria.

Detailed design drawings of the critical facility building and services have been transmitted from CE&U to HLO for comment. The package includes a detailed design for the fuel transfer lock.

Design and Component Testing

PR-1 - Discharge Operation Mockup. Installation of the fueling vehicle in the 314 Building is complete and development work and testing started.

Both the bridge and carriage position indicating system failed during initial testing and are being revised.

Pressure drop in the lower cask section was reduced from 11.25" Hg to 4.25" Hg by the addition of the second air exhaust pipe.

PR-10 - Primary Loop Mockup. The spare PRTR pump operated continuously throughout the month for a total of 1250 hours. The high pressure seal leak rate remained constant at < 0.01 gph until after approximately 1050 hours of operation, when the rate increased to a maximum of 2.6 gph and the graphite seal temperature increased from a normal temperature of 100 F to 200 F. A maximum seal temperature of 320 F during a short period has been recorded. The minimum flywheel down time recorded was 55 seconds at which time the seal temperature was 240 F.

The contribution of helium evolution to the rapid high pressure seal wear during the former 2000-hour seal test is not substantiated by recent experience. Helium was not present at the PRTR spare pump seal face during the present test. The high pressure seal of the prototype pump, which has had helium in the seal leakage water for most of the 2200 hours of operation, continues to operate with leakage generally less than 0.01 gph, and no outward evidence of serious seal wear.

Pump vibration readings in the seal area are approximately 0.4 mil on the prototype pump and 1.2 mils on the PRTR spare pump.

A lower balanced seal of 65 percent will be tested in the spare pump upon arrival from the manufacturer. This seal will allow a higher leak rate, as noted during a former 750-hour test, but should not be as susceptible to damage from vibration or shaft deflection as the 70 percent balanced seal.

The secondary seal operation has improved following the boring cut of the seal chamber vent and circulation port. The leakage rate has been three ml per day without any evidence of graphite wear.

PR-13 - Injection Pump Test. R/M #1204, Vee-Flex packing of molded rings has been ordered for future testing. Universal Style #835 packing, the style presently recommended for PRTR service, has been tested at 1300 psig for 350 hours with the present leakage of 5 ml/min. PR-13 will be reported under PR-10, Primary Loop Mockup on future reports.

PR-40 - Shim Control Mockup. Operation of the mockup is complete, and a final report is being prepared.

PR-52 - Process Tube Thermal Cycling and Pressure Testing. The operation of the process tube has been curtailed during the testing of the fueling vehicle.

Stainless steel shims have been ordered for use in preventing possible seizure of the Zircaloy process tube and the stainless steel outlet nozzle. Shims are being installed in the Single Tube Prototype, and a test assembly is being fabricated for further seizure studies. PR-52 will be reported under PR-10, Primary Loop Mockup, on future reports.

PR-64 - Gas Sampling Technique. Tests with the prototype sampling system have shown that a small excess temperature is required for the gas rotameter in order to prevent condensate plugging of the float. Condensate formed when the rotameter temperature was kept the same as the sample water temperature. The gases at 120 F are 12 percent water vapor by [illegible].

Test gas sample flows were compared with data by Wiebe and Gaddy and are in agreement within 10 percent at PRTR conditions of helium saturation.

PR-70 - Helium Compressor Test. The Vickers' pump has not operated successfully at the Hofer compressor conditions. An original Hofer oil pump with hardened steel sleeve and chromed piston rings has operated satisfactorily for 300 hours.

PR-80 - Air Cooling Duct Test. Fabrication of the second duct is now 60 percent complete. Plans for installation and testing of this duct are now complete.

Special Tools. Drawings of the final reactor jumper wrenches are being prepared for modified prototype models.

The outlet nozzle core saw is complete and will be tested on the fueling vehicle following the present development tests.

Silicone Foam Testing. The initial prototype structural opening filled with silicone foam leaked excessively following an extended test at 18 psi. An interim report was issued with typical wire leak rates included. A new pour with silicone foam is scheduled.

Temperature Probe for Fuel Exam Facility. An arsenic trisulfide window has been installed in the 100-K thermistor probe to replace the radiation resistant glass window. A modification in the thermistor holder has been made to improve the thermal resistance between the thermistor and the probe body. An investigation of the transmission efficiency of the arsenic trisulfide windows after gamma irradiations of 10^6, 10^7, and 10^9 R is under way.

Moderator Level Measurements. Preliminary study indicates that moderator levels in the PRTR calandria (assuming a quiescent liquid surface) may be measured to the nearest 0.01 inch and read out in the control room during the physics startup tests. Availability and cost of commercial liquid level indicators for this type of service are currently being investigated.

PRTR Primary Pump Flywheel Analysis. In the event of failure of both BPA and emergency generator electrical power, the flywheels and the moving components of the pump-motor sets must sustain adequate flow until natural convective flow becomes adequate. Arbitrarily, adequate flow is defined as the primary coolant flow rate which is necessary to prevent bulk boiling in the hottest channel of the reactor. Based on the reactor power decay curve of Untermyer and Weills, free convection becomes adequate about 24 seconds following a scram.

Test runs simulating total electrical power loss were performed on a PRTR primary pump in the 314 Building Laboratory. These tests showed that the duration of adequate flow as sustained by the present flywheel varied with the total time of pump operation. Over a 2000-hour operating period the time duration of adequate flow varied from about 115 to 50 seconds. The corresponding decay times, i.e., the time from loss of electrical power to the time when the flywheel comes to rest, were about three minutes and one minute, respectively.

A visual examination of the primary seal after 2000 hours of operation revealed wear on the graphite and stellite portions of the seal. The stellite member had numerous radial cracks over its sealing surface. The cracks are believed to be due to thermal stresses induced by high frictional energy release. An analytical expression which includes mechanical friction has been derived and found to fit the experimental data to about 10 percent. The calculations indicate that a 7.5-fold increase in friction is involved in reducing decay time from three minutes to one minute. A thermocouple placed in the graphite member of the seal appears to provide an indication of seal wear (and reduced decay times) in the form of increased seal temperature.

Assuming the validity of the Untermyer-Weills power decay curve, the present flywheel assembly appears adequate. A greater margin of safety could be obtained, however, if the moment of inertia of the present flywheel was substantially increased. The feasibility of doubling the present flywheel moment is currently being investigated.

Design Analysis

PRTR Physics Analysis. Calculations of heat generation in a self-shielded PuO_2 fuel rod capsule were completed. The neutron flux was assumed to decrease exponentially into the rod. Although the validity of this assumption has been borne out by previous P-3 calculations for solid Pu rods, a more accurate transport analysis of this problem will be carried out. Further efforts are being made to utilize the SNG code for problems of this type.

Preliminary descriptions of critical reactor experiments for the Critical Test phase of PRTR startup are essentially complete. These are being prepared for presentation to the Startup Council.

An evaluation of the Fuel Element Rupture Test Facility with regard to Plutonium Recycle Program objectives has been completed. Results of the study indicate that the reactivity effect associated with this loop will range from -0.5 to +0.5 milli-k under normal conditions. Insertion of a high temperature alloy liner for certain special tests is estimated to result in a reactivity loss of about 3.3 milli-k. The results of this study are presented in HW-63328, "Effect of the PRTR Rupture Test Facility on PRP Objectives."

PRP Critical Facility Calculations. Physics analysis of several proposed dispositions of fuel in the core of the Plutonium Recycle Critical Facility has been completed. These calculations are concerned with the critical fueling, in experimentally desirable arrays, of both the D_2O and H_2O moderated cores. A general loading pattern for either moderator consists of a central test region, an annular buffer region which serves to insure the desired neutron spectrum in the test region, and an outer ring of enriched fuel which drives the whole core critical because of its neutron-supplying properties.

It has been found that the desired conditions may be met in the D_2O moderated core with minimal enrichment needs in the driver ring, using an eight-inch lattice spacing throughout the core as planned for initial operation. However, the H_2O moderated assembly (four-inch lattice spacing) was found to require a very large amount of enrichment to achieve criticality. A positive result is the discovery that the driver ring must consist of fuel of smaller radius and cells with a smaller H/U-235 ratio.

Preliminary calculations for the shielding covers to be placed over the Critical Facility indicate that a four-foot thickness of iron aggregate concrete (specific gravity greater than 5.0) should be used to obtain acceptable dose rates during tests with irradiated PRTR fuel elements.

PRTR Safeguards Analysis. A discussion of the PRTR Final Safeguards Analysis was held with Hazards Evaluation Branch personnel in Washington on January 5, 1960. As a result of this meeting, the final review of the PRTR by the ACRS has been scheduled for January 28.

Process Specifications. The preparation of the PRTR Process Specifications is continuing. About ten percent of the specifications has been issued in rough draft form for review by the Startup Council.

PRTR Process Piping. Electric Boat Division of General Dynamics Corporation was requested to investigate expansion stresses in inlet and outlet jumpers as a complement to the current study of stresses in piping external to the ring headers.

Plutonium Fabrication Pilot Plant

Full operational control of the 308 Building was established during the month, and on January 29, the first full-scale "hot" work with plutonium-enriched fuels was started. The canning and welding operations were activated. Previous operations in the building had been with fully jacketed plutonium-enriched materials or dummy materials.

Work continued on installation of the sintering furnaces and completion of the oxide fuel finishing line until January 22, when work was temporarily suspended for a review of the expenditure of funds on this work. The suspension of work at this time will have little effect on the over-all schedule, since the cross-push mechanisms and atmosphere control panel have still not been received from Salem Fabrication and Machine Company. Plastering of the concrete block panels is in progress.

Installation of the Group 5 equipment was started January 18. Installation of the hood exhaust line for the second floor is being completed as rapidly as possible before contamination of the hood exhaust system under full process operation of the building. Electrical changes preparatory to erection of the plaster partitions are in progress. Installation of the zirconium etching facility is in progress.

Salem Fabricating and Machine Company plant remained on strike throughout the month. They shipped several items of electrical components for the sintering furnaces during the month, but no progress was made on the cross-push mechanisms and the atmosphere control panel. On January 25, they were requested to immediately ship all components of the furnaces unless they could promise shipment not later than February 10 in a completed condition.

The Atomic Energy Commission discussed a settlement of the Phase III contract with George A. Grant, and reached preliminary agreement on most items. They have rejected his claim for $4000 for 13 spare hood control panels on the ground that these were required under the specifications. The contractor will appeal this item.

The Phase II contractor, Hoffman Construction Company, reduced his claim for extra work in finishing the interior ceilings, walls and floors from $125,000 to $35,000 in presenting his appeal. The appeal is still under consideration by the Contracting Officer.

PRTR Operations

Forty-five of the 53 design tests have been submitted for final design and operational review prior to presentation for approval by the Startup Council. Procurement of special equipment needed for the tests continued. Nine critical tests and the introduction to eight other critical tests were prepared for review of the Startup Council. Additional test descriptions will be presented to the Council each week until all 35 tests are reviewed.

As part of the second phase of their training, 12 Engineering Assistants are performing equipment inspection, procedure reviews and system trace-outs on a two-shift basis. Six Engineering Assistants are assigned to Mechanical Equipment Development for training in the 314 Building. The remaining two Engineering Assistants were assigned to Radiographic Testing Operation at White Bluffs to assist in testing PRTR process tubes.

The Plutonium Recycle Critical Facility scope drawings and design criteria were reviewed and approved. The detail design of the PRCF transfer lock was reviewed and comments issued. Rough drafts of four sections of the Rupture Loop Design Criteria were reviewed.

2. BASIC SWELLING STUDIES

Irradiation Program

Two types of capsules for irradiating uranium at a constant temperature are currently under construction: a metallographic specimen capsule for insertion into either the MTR or the ETR, and a swelling capsule for insertion into a HAPO reactor. The first attempt to assemble a metallographic specimen swelling capsule is now in progress. Assembly of the fourth general swelling capsule (containing four natural uranium spheres) is in the final stages. Capsules one and three failed during bench testing, while capsule number two was ruined by a faulty weld in the final stages of assembly. Capsule number three operated satisfactorily for approximately 50 temperature cycles between room temperature and 500-600 C. An internal temperature of 700 C was obtained with a 4500 watt heater input before the last of the four thermocouples shorted out at the Swagelok fittings used to seal the thermocouples on the inner NaK and uranium specimen chamber.

The Swagelok fittings were eliminated in the fourth capsule and the end cap redesigned to permit welding to the sheaths of the four 1/16" OD thermocouples. Repeated attempts to weld to the sheaths of one available lot of Al_2O_3 insulated thermocouples were unsuccessful, but five out of six MgO insulated thermocouples were welded successfully. X-ray diffraction and qualitative analysis of the insulation were used to positively establish the type of insulation used in any particular thermocouple. The Al_2O_3 was in the anhydrous, hexagonal, stable alpha form, and the MgO was pure in four of the six lots. The MgO insulated thermocouple that did not weld was one of those that contained impure MgO. The reasons for the difference in weldability with the heliarc process of the two types of thermocouples are not understood, but a comparison of the physical properties of MgO and Al_2O_3 reveals that the former has a melting point of 800 C, while the Al_2O_3 melts at 2000 C, and that Al_2O_3 tends to become conductive at approximately 550 C, whereas the MgO remains a good insulator to very high temperatures. Weldability tests on additional samples of both Al_2O_3 and MgO insulated thermocouples will be conducted when samples are available from various vendors. Equipment for the in-reactor tests of the capsule is being assembled, and upon completion of the bench tests on the modified version of the capsule incorporating the welded thermocouple seals, this capsule will be shipped for charging into a HAPO reactor.

Uranium tensile specimens irradiated to high burnups and tested under PT-3NA (a HAPO program to study irradiation effects on uranium properties) were selected for density measurements. Specimens irradiated to 0.1 a/o burnup decreased significantly in density from 18.92 to 18.74 gms/cc after ten-hour, single pulse anneals at 700 C and 800 C. However, these treatments did not significantly lower the density of specimens irradiated to burnups of 0.065 a/o and lower. The effect of thermal cycling on density was studied for specimens given three cycles through phase transformation temperatures. The resulting densities for different burnups and terminal

cycling temperatures are as follows: 18.92 gms/cc, 0.028 a/o burnup, 400-700 C; 18.78 gms/cc, 0.065 a/o burnup, 400-700 C; 18.60 gms/cc, 0.065 a/o burnup, 400-800 C; 18.38 gms/cc, 0.11 a/o burnup, 400-700 C. These specimens had extensive microcrack networks at the surface, therefore microsections are being replicated to observe if noticeable swelling has also occurred.

Fission Product Mobility

Diffusion of rare gases in uranium is being studied to aid in the development of an understanding of pore formation. Rare gases are introduced into the uranium surface by electrical glow discharge (sputtering) and by ion bombardment. The amount deposited under various experimental conditions, as well as the mode of deposition and the depth of penetration is presently being determined.

There are some additional indications that the xenon analyses reported for various segments of the disk sputtered for four days at 620 C may be reflecting porosity and/or stringer inclusion that were present in the original material. In the process of preparing the surface of a disk for glow discharge in the new system, several large oxide inclusions were observed that appeared to be stringers running perpendicular to the polished surface. This disk will be subjected to glow discharge at 620 C in two mm of xenon and a comparison of xenon content will be made between segments having stringer inclusions and those not having them.

Pore Size and Distribution

Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. Swelling in two types of specimens, one with a burnup of 0.41 and the other with a burnup of 0.29 a/o, irradiated at temperatures below 550 C, are being studied as a function of post-irradiation annealing treatments.

Replicas of the specimen with 0.41 a/o burnup after annealing 100 hours at 880 C have disclosed extensive banding or segregation of porosity. Impurity inclusions have disappeared, and very large pores with relatively large interpore distances are observed. The number of small pores discernible is much smaller than the number observed in a similar specimen after annealing 100 hours at 700 C. In order to establish the effect of time at temperature on the disappearance of inclusions and the limited number of small pores present, a specimen with 0.41 a/o burnup will be annealed for only one hour at 880 C.

Shadowed negative replicas of synthetic plastic specimens containing spherical pores with diameters of 1.17 microns have been photographed in the electron microscope, and the observed diameters and shadow lengths of 400 pores have been measured by two individuals. The data are now being analyzed statistically and will furnish a basis for establishing the degree and type of distortion associated with replicating pores.

Solid Surface Tension Measurements

Investigation of the formation of fission gas pores in irradiated uranium has brought about a need for solid surface tension values of uranium in the presence of inert gas at swelling temperatures. The solid surface tension data are to be obtained experimentally by balancing the forces pulling down on a series of five wires of uranium with the forces of surface tension pulling upward. High purity three percent enriched uranium was drawn to 0.00105 inch diameter wire. Short lengths of the wire (approximately one inch) were suspended, with weights attached, in a furnace at 600 C in a purified krypton atmosphere. The weights were selected to bracket the point at which there will be no extension or contraction of the wires. The initial experiment was terminated after approximately 160 hours. The uranium reacted with residual oxygen in the suspension system forming uranium dioxide. The oxide is quite brittle, and the wires shattered between readings. No extension or contraction was observed prior to failure of the wires. The system is being revised to permit direct observation of the sample (formerly observed through a prism), and to permit continuous gettering of the krypton atmosphere with either hot calcium chips or hot uranium chips.

Mechanisms and Theory

Mechanisms of inert gas pore nucleation in uranium are being evaluated. Since most investigators consider this problem in terms of inert gas diffusion, calculations are being made to evaluate the role of diffusion in the nucleation of gas pores. It was previously pointed out (HW-63070) that the nucleation of Xe and Kr pores in uranium by parent atom (e.g., Te and I) diffusion, precipitation and decay is a realistic possibility.

An alternate scheme for inert gas pore nucleation is presented below where it is shown that nucleation may occur with no diffusion of either Xe and Kr or Te and I. This is based on the popular belief that the critical size nucleus of inert gas pores is quite small (< 5 atoms) due to the limited solubility of inert gases in uranium.

It is known that when burnup, B, increases the concentration of fission products increases, and the mean linear distance between fission gas atoms will decrease.

The spacing decreases rapidly in the initial stages of burnup, but after about 0.1 percent, a fairly constant condition begins to prevail. When gas atoms are at average separations of 10 to 15 atomic distances, normal statistical fluctuations could conceivably bring sufficient gas atoms together to form a stable pore nucleus. Thus, volume diffusion would not be required for nucleation. The above figures predict a temperature independent nucleation mechanism. To date, insufficient data exist for a precise evaluation of this postulate, but it is noteworthy that a break in the ΔV (change in volume) versus B (percent burnup) curves obtained by the British occurs between 0.15 and 0.25 percent burnup.

It should be emphasized that these concepts apply only to the nucleation of pores and not to the agglomeration of large numbers of gas atoms into microscopically observable pores. These postulates concerning mechanisms are being used as guides for determining the conditions for future irradiation.

3. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

This program has been initiated to establish the nature of changes caused in the properties of structural materials by reactor environment. Currently, the study of the in-reactor creep properties of Zircaloy-2 is in progress. The problem of Zircaloy-2 creep is of importance due to the ever increasing severity of conditions within operating and future reactors where it is to be used for pressure containment tubing for the reactor coolant and as fuel element cladding. It is not at all certain that mechanical property changes measured after irradiation will be indicative of the changes induced during the period of irradiation. The retained defects associated with residual damage may have entirely different effects on the creep properties than will the instantaneous effect of a high neutron flux. The only appropriate method of testing to determine the property of interest, those of the structural material while under irradiation, is to make the measurements in the reactor.

The irradiation of an in-reactor creep capsule is in progress to determine the effects of neutron flux on the creep rates of an annealed Zircaloy-2 specimen. A duplicate specimen is being tested in the laboratory to provide a direct comparison with the in-reactor test. No creep was measured on either specimen at stress levels of 22,000 psi and at 25,600 psi at temperatures up to 525 F (274 C).

During the month a first stage creep rate of 1×10^{-7} in./in/hr was observed for the ex-reactor specimen; however, there was no measurable creep on the in-reactor specimen nor second stage creep on the ex-reactor specimen at 550 F (288 C) and 25,600 psi stress. The test conditions were altered to 30,000 psi stress and 500 F (260 C). Extension in both samples is now apparent, but insufficient time has elapsed to establish creep rates. The in-reactor specimen has now accumulated approximately 1.2×10^{18} nvt (fast), and all features of the capsule and associated instrumentation are operating satisfactorily.

A second creep capsule has been ordered with certain changes made in specifications to eliminate the shortcomings of the prototype capsule and increase the precision of the creep measurements. Two additional extensometers have been called for in the second creep capsule. There is an additional electrical variable reluctance extensometer with higher sensitivity but shorter range to augment the variable reluctance extensometer of longer range and low sensitivity. A direct reading, mechanical extensometer that has both range and sensitivity will also be used in the capsule. A prototype model of the mechanical extensometer suitable for evaluation tests has been designed and is being built on-site.

One of the problems in the first generation creep capsule has been the upsetting of the thermal balance as the helium pressure was increased to provide the strain on the specimen. A literature search on heat transport by helium revealed that the thermal conductivity of helium increases slowly with temperature and is independent of pressure (one atm to 45 atm), while transport by convection is a function of temperature and the square of the pressure. A test model of the creep capsule has been designed and is being constructed to more accurately measure the thermal transport properties of the helium gas. The model has been designed to provide a flexible arrangement of geometries so the most effective means of baffling can be achieved to reduce the transport by convection.

4. GAS COOLED POWER REACTOR PROGRAM

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

The Struthers-Wells Corporation has submitted a request for extension of the April 15 completion date of the "Phase A" package. A revised completion date is currently being negotiated. The newly established date will be set to assure completion before the end of the present fiscal year.

A purchase alteration was prepared to officially accomplish Addendum No. 3 to the "Phase A" package. Approximate cost is $5000. Main provisions of this addendum are to provide emergency water to the blower jackets, to provide a transformer in place of the emergency motor generator set, and to provide rupture discs downstream of relief valves.

Hastelloy-X, on the basis of preliminary data, appears to be superior for the gas loop service to any of the high temperature alloys currently under test. It is now planned to provide a pressure tube and shroud tube of Hastelloy-X in addition to the Inconel pressure tube and Inconel 702 shroud tube previously planned.

Approximately 30% of the in-reactor section material has been received.

Design and Component Testing

The nozzle closure assembly incorporating the dome seal was tested at 425 to 500 psig and temperatures ranging from 930 to 1050 F. Temperatures were held this low because the assembly is made of stainless steel. Leakage rates were from 0.06 to 0.10 standard cubic feet per day. The gas used in these tests was nitrogen.

Two flexible connectors were received from Parts Engineering. A mechanical device to flex the flexible connectors while they are under pressure and temperature conditions has been designed and is 50 percent complete. A device to synchronize the temperature and mechanical flexure cycles during testing of components has been designed and is 30 percent complete.

Two flexible hoses were received from Avica. These were furnished at no charge to replace previous ones that failed under high temperature tests. Testing has started on one of these connectors.

Irradiation Effects on Nickel-Base Alloys for Gas Looped Facility

Nickel-base alloys are being considered for use as in-reactor structural materials for the gas-cooled loop. Samples of the candidate materials will be irradiated in a side test hole at the C Reactor. Comparison of mechanical properties of the irradiated specimens with those of unirradiated control pieces will yield valuable data on the behavior of these alloys under anticipated loop operating conditions. A graphite capsule containing thin washer samples of candidate alloys was sent to the reactor for insertion during the next shutdown. This capsule will be irradiated approximately one month, exposed to the reactor gaseous atmosphere to determine the chemical stability of the alloys in this environment. Tensile specimens for evaluating irradiation and environmental effects on mechanical properties of Inconel, Inconel 702, Hastelloy-X, and Hastelloy R-235 were fabricated. Graphite capsules for these specimens were also fabricated, and final assembly awaits the preparation of thermocouples for monitoring specimen irradiation temperatures. The production test request authorizing the irradiation of these capsules was approved during the month.

Gas-Graphite Studies

Graphite Oxidation Studies. Graphites of lower purity than F-purified grades might be considered for possible use in the cooler, low-flux regions of some moderator structures. Consequently, the effects of impurities on the graphite oxidation rate are currently being investigated in thermal oxidation studies, using flowing CO_2 at 750 C.

Thermal oxidation of needle-coke CO graphite (no F purification) continued to show rates about four times greater than those of CSF graphite at 750 C. The average specific weight-loss rate observed was 5.38×10^{-4} gm/gm/hr.

Samples were prepared from graphite made with fine grain continental coke (no F purification). This graphite is an all-flour version of CO. There appears to be little difference in the oxidation rates of the pitch-impregnated samples. Lower density samples with no impregnation (RX-1) are being oxidized for comparison. Samples of RX-3 with a different density are also being run. The all-flour coke appears to oxidize about two to three times as fast as CSF. The effects of coke-size and impurities can be inferred from the oxidation rates for these graphites.

Another needle-coke graphite with no F purification is being oxidized. This is pitch-impregnated, 50 flour SP-22 graphite. The weight loss rate observed in flowing CO_2 at 750 C was 1.30×10^{-4} gm/gm/hr. This material has a density of 1.67 and a dib purity of +0.349. F-purified samples of this material will be oxidized for comparison.

Hot Capsule Experiments. Eleven capsule experiments have been prepared to evaluate dimensional stability of graphite similar to that planned for the EGCR. Samples were taken across a 16" x 16" bar in both parallel and transverse directions to give a stability profile. CSF graphite will be used as a reference. Sample temperatures will range from 450 to 600 C, depending upon position within the reactor. The hot capsule experiments will be charged into the MTR on January 25.

Air Oxidation Studies. Experiments are in progress to evaluate the effect of variables of manufacture on the oxidation rate of the graphite. The rate of oxidation of various types of graphite could be very important in determining the life of a reactor. One variable which appears to have great influence on the rate of oxidation is the amount of graphite impurities. An index of graphite purity is the dih value. Seven samples varying in density, dih purity, particle size and type of coke were oxidized at 600 C with an air flow of 2.0 cfh.

The dependence of oxidation rate upon dih purity is best illustrated by comparing SP-7 and SP-10 graphites. Both graphites have the same coke source, particle size and density. Both were processed identically except that a trace Fe_2O_3 was added to SP-10. This caused the dih purity to drop from 1.1 to 0.671 and the oxidation rate to rise by a factor of 3.4.

Oxidation Studies in Co-60 Irradiation Facility. The influence of cobalt-60 gamma radiation on the reaction rate of CO_2 and graphite was observed at 700 C in a glass gas loop. A graphite sample was suspended in the 10^6 R/hr gamma flux and the weight loss was continuously recorded. The oxidation rate was 1.0×10^{-4} g/g hr with a CO_2 gas flow rate of 280 cc/min. When the flow rate was reduced to 140 cc/min, the oxidation rate increased by a factor of 7.6. In the absence of radiation, oxidation rates were observed to be independent of gas flow rate from 150 to 1500 cc/min. Additional oxidation experiments at higher flow rates are planned.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals; namely, copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. Tensile properties, microhardness, electrical resistance, and x-ray diffraction spectra are being studied to determine the characteristics of recovery mechanisms.

One hour isochronal annealing treatments at 25 C increments were extended from 300 to 350 C for irradiated and unirradiated specimens of molybdenum, zirconium, and nickel. These anneals were conducted in vacuum, as contrasted to the silicone-oil bath used for temperatures of 300 C and lower. The hardness and electrical resistance changes followed the trends described in the last report. Repeated yielding tests were performed on two unirradiated molybdenum tensile specimens to seek an explanation for the abrupt hardening observed between 250 and 275 C. These tests revealed a yield point at room temperature which did not reoccur upon immediate reloading. Subsequent

annealing of the specimens for one hour at 250, 275, and 300 C did not cause strain aging. The molybdenum stock used in this program has a high carbon content, approximately 0.06 weight percent. To determine if the observed behavior was due to age hardening, specimens were solution treated at 900 C and aged at 500 C for periods up to eight hours. No significant increase in hardness or subsequent decrease due to overaging was observed. These two tests suggest that the hardening and decrease in resistance above 250 C is due to an ordering process involving carbon, such as occurs in other alloy systems prior to precipitation. If such a process occurs, it is likely that neutron irradiation depresses the process temperature by about 100 C degrees based upon the tempering curves for the irradiated specimens.

E. CUSTOMER WORK

Radiometallurgical Examinations

Self-Supported Fuel Elements. Two additional self-supported I & E elements, which had been irradiated under the most severe conditions, were examined. No evidence was found of corrosion damage to the can wall under the support tabs.

Microhardness Tester. Installation of the microhardness tester in D Cell is proceeding smoothly, and cold shakedown runs are expected to start in February.

Tensile Sample Cutter E-101. Fabrication, installation, and shakedown operation of the sample cutter have been completed, and routine use of the machine is in progress.

Lamprey Gas Sampler. An operating model of the Lamprey drilling unit, full-size except for length, has been successfully tested employing an unirradiated UO_2 fuel rod, 1/2 inch in diameter and eight inches in length. A static vacuum of less than 8×10^{-5} atm was obtained both before and after drilling. This is considerably better performance than has been obtained previously with older equipment, and it was accomplished on the first attempt. Design of a full-length Lamprey drilling unit is complete and fabrication will begin soon.

Metallography Laboratories

Requests have been received for electron micrographs of the bond interface of coextruded samples of uranium clad with Zircaloy-2. The specimens varied from 0.5 to one inch in diameter, and some experimentation was necessary to establish operating conditions for the cathodic vacuum etcher to etch the entire bond-interface area satisfactorily. Faxfilm replicas obtained from cathodic vacuum etched specimens are shadow cast with UO_2 and replicated with evaporated carbon. Upon acetone dissolution of the Faxfilm, the carbon has a tendency to break apart at the interface of the U-Zr bond interface. Various laboratory techniques are being attempted to obtain usable replicas of this region.

The study of the effect of annealing time and temperature on the AlSi braze layer of production fuel elements has been "bottlenecked" by lack of sufficient

equipment for annealing specimens. Some samples have been treated at temperatures of 550, 478, and 423 C for various lengths of time and will be analyzed in the near future to determine the effect of heat treatment on the size, shape and distribution of the silicon grains in the eutectic alloy.

Samples processed during the month:

Total samples	436
Carbon replicas	25

Photographs

Micrographs	224
Macrographs	69
Electron Micrographs	20
	313

Special Fabrications

Trans-Plutonium Fuel Element Fabrication. One hundred and forty-four co-extruded fuel elements, containing a total of 12 Kg of Pu, are being fabricated for the Savannah River Laboratory. The fuel elements are to be in the form of rods, 0.95" in diameter by five feet long, and will contain 83.3 ± 4.2 grams of plutonium. The fuel material is Al-7.35 w/o Pu alloy and the cladding is Al (X-8001 alloy). Cladding thickness is to be 0.040-0.120" and fuel core length is 55-57".

Ninety-four coextrusion billets have been cast to date. As in the previous fabrication, the billets were cast to size with one end configuration in order to eliminate as much machining as possible. Further development is in progress in order to eliminate machining completely, concurrently eliminating most of the scrap. The principal difficulty is feeding the solidification shrinkage through a restricted opening; however, this has been overcome by pouring and feeding through a refractory cup. Since removing the hot-top with a cut-off saw leaves a flat spot on the billet, some modification of the end configuration is necessary. The lead-end configuration has been satisfactorily cast. Since the refractory cup greatly reduces the solidification rate, this effect on plutonium segregation must be evaluated.

Closures are being made on the canned billets by the inert gas consumable electrode process, at the rate of 12 seconds per weld. This method produces a vacuum tight closure. The rotating mechanism is sequence timed to operate in conjunction with the welding wire to deposit the same amount of weld metal on each billet.

Current status is as follows: 33 cast fuel cores, 16 machined fuel cores, 16 assembled coextrusion billets, and 29 coextruded rods.

Plutonium-Aluminum Alloy Pins for SROO. Savannah River Plant has requested sixty Pu pins canned in aluminum. Several Al-15.8 w/o Pu pins were cast for fabrication of the 0.032-inch cores to 30-mil wire. The pins were cast to 5/16", 3/32", and 1/16" diameters and will be extruded or drawn to final size. Aluminum cans, 0.015" wall thickness, 0.065" diameter by 0.500" long, have been fabricated, and welding procedures for the closures have been developed.

J. J. Cadwell

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JJ Cadwell:kb

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

JANUARY 1960

FISSIONABLE MATERIALS - 2000 PROGRAM

FUELS

Nuclear Safety

The nuclear safety evaluation of the Fuel Fabrication Facility (333 Building) was continued this month. The study has now considered a fuel enrichment range of from 0.95% to 1.10%. As an example of the magnitude of this range of enrichment on nuclear safety, the minimum critical mass for rods of the 1.1% enrichment is about 60% of the value for 0.95% enrichment. The fuel element design and the layout for the fuel cladding facility are essentially the same as in the past study.

A preliminary review of the fuel cladding facility indicates that the proposed storage and processing areas will be adequate. Some spacing adjustments may be indicated after the detailed 1.1% calculations are completed; however, these adjustments will not require increasing the building size for the production capacity now planned. In the autoclave area, the study shows that the proposed 16 vessels, of 12-inch diameter spaced on 6-foot centers, are critically "safe by geometry" for any loading combination of 1.1% fuel elements. The designer indicates that the 12-inch diameter may be increased to 18 or 20 inches for reasons of economy. If so, the nuclear safety of the autoclave array will be again evaluated. In any event, the over-all study will be continued as the three and five region calculations, for 1.1% enrichment, are completed.

STUDIES RELATED TO PRESENT PRODUCTION REACTORS

Neutron Temperature Studies

Comparison of the experimental data on lutetium with calculations using recent cross section measurements from Brookhaven are being made. A full report on lutetium is being written.

Work leading to measurements of neutron temperature in a lattice cell in the heated TTR thermal column is at a standstill, pending derivation of a detailed program.

In the neutron temperature coefficient program, a new nuclear data tape containing microscopic cross sections for 20 elements has been generated using a portion of the nuclear data tape code. The complete code, which also provides for updating the nuclear data tape, has been converted to the Monitor System. The first two debug runs of this program have failed, apparently because of defects in the program loader routine of Monitor. The Data Processing Operation is communicating with IBM for explanation and possible correction.

Thermal Neutron Spectrum Near a Temperature Discontinuity

A paper on this subject by D. A. Kottwitz has been accepted for publication in "Nuclear Science and Engineering." There has been no active work on this problem this past month because of temporary assignment of personnel to other programs.

Multimaxwellian Group Analysis

Work on FIT-1 has been temporarily suspended. This was done because of the backing of foil data to be processed for the neutron rethermalization experiment; it was felt that a less flexible, more immediately available, program was needed. The latter program has been written and is being debugged. In the process of debugging the simpler program, an error was found in the data being used as a test case for both programs. It is possible that this error has been causing the trouble with FIT-1. The run to check this possibility had not been completed at month's end.

Neutron Rethermalization in Graphite Experiment

The experimental study of neutron rethermalization in graphite in cylindrical geometry has continued through this month. The scheduled series of five irradiations, each for a different set of temperature conditions, was completed. All foils which were activated in these experiments have been counted. Approximately 90% of these data have been normalized and corrected for radioactive decay. The correction of the data for epithermal neutron absorption has just been started.

These experiments were designed to yield traverses of the activity of a "1/v" neutron detector (copper) and of a near-thermal resonance detector (lutetium) across a temperature discontinuity. The analysis of these traverses should yield the magnitude and temperature dependence of the rethermalization cross section of graphite and the effective temperature of thermal neutrons near a temperature discontinuity.

The major portion of the traverses were made in a two-region system in the core of the reactor, although the modified F_3 program will treat the entire reactor. The two regions were a solid cylinder of graphite 15 inches in diameter and an annulus of solid graphite with an inside diameter of 16.5 inches and an outside diameter of approximately 39 inches. The latter is uncertain only from an analytical point of view. This is so since in the analysis of these data the fuel region of the reactor will be homogenized and the "best" radii for defining the homogenized fuel region have not been decided. The two regions were separated by an annulus of lampblack insulation which was contained between two 1/16-inch-thick aluminum cylindrical shells. The insulation was 5/8-inch-thick. In all experiments the cylinder was either heated or cooled while the annulus was held near room temperature. The ends of the cylinder were insulated with 3/4-inch-thick disks of Foamsil.

The cylinder was cooled with liquid nitrogen. One end of the aluminum containment for the lampblack insulation was sealed to form a can around the graphite cylinder. This provided a convenient method of cooling the cylinder. The graphite cylinder was placed in the insulation can and set upright outside the core. Liquid nitrogen was then poured into the can. Voids in the graphite cylinder 5/8-inch-square and running its full length were provided as temporary reservoirs for the liquid nitrogen as a means of accelerating the cooling. The voids were filled with precooled graphite after the cylinder had reached liquid nitrogen temperature. Approximately

150 liters of liquid nitrogen were required to reduce the cylinder temperature to that of liquid nitrogen (-196°C). Immediately after the cylinder had reached -196°C the cylinder was placed in the core and irradiation preparation was started. The detectors which were to be activated were in place during the cooling period.

The cylinder was heated with calrods in place in the core of the reactor. Twenty calrods were placed in the voids (previously mentioned) in the cylinder. Upon reaching the desired temperature the calrods were removed. The voids were refilled with preheated graphite rods and irradiation preparations were started. All detectors which were to be irradiated were in place during the heating period.

In all experiments the temperatures of the two regions were monitored with iron-constant thermocouples and recorded. The approximate temperature conditions for the five experiments at the time of the irradiations were 120°K - 270°K, 300°K - 300°K, 310°K - 470°K, 315°K - 670°K, and 325°K - 790°K in the cylinder and the annulus, respectively.

All detectors, both bare and cadmium covered, were irradiated simultaneously in each experiment. Copper pins were used to obtain radial and axial traverses in the cylinder and radial traverses in the annulus and reflector region of the PCTR. Lutetium foils were used to obtain traverses in the cylinder and annulus. Gold and lutetium foils were used to obtain radial traverses of cadmium ratios in the cylinder and annulus. These cadmium ratios will be used for making epithermal corrections to the bare traverses of lutetium. The neutron temperatures are calculated directly from ratios of these corrected bare activities.

The rethermalization cross sections are inferred by fitting the traverses of the "1/v" thermal activity with a group diffusion model. The fitting of these data will be done with F SUPER, a modified version of F_3 written with neutron upscattering in every region. This program is designed for two thermal neutron groups, one for each experimental region, and a single fast group for all regions. The program is to be used on the room temperature experiment (300°K-300°K) to establish the parameters for the fuel region. Values obtained in this analysis will be used in subsequent analysis of the four remaining experiments.

A paper "Neutron Thermalization Cross Section Measurements in Graphite" by R. A. Bennett and R. E. Heineman has been submitted for publication in Nuclear Science and Engineering.

Instrumentation and Systems Studies

Further work was done this month on reactor speed of control studies dealing with the old reactors. The nature of these calculations was to evaluate the conservatism of the assumptions used in work done several months ago. The document to be issued covering all the speed of control work done in the last 6 months, which is being co-authored with IPD - Reactor Physics personnel, is being held up until the evaluation of the results is completed.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Exponential Measurements of Large Diameter Fuel Elements

Final material buckling values are available for one lattice using a tube-in-tube and a 2.5 x 1.6 I and E fuel element. The final buckling values and one

preliminary value are listed in Table I along with other pertinent information.

TABLE I

Fuel Element	Lattice Spacing (in)	B^2 ($10^{-6}cm^{-2}$)	λ (inches)	Volume Ratios Al/U	H_2O/U	C/U
2.5 x 2.0 with 1.66 x 1.1	8 3/8 dry	-50	1.50	0.493	--	21.12
2.5 x 1.6 IoE	8 3/8 dry	-65	1.50	0.373	--	21.47
2.5 x 1.6 with 1.17	8 3/8 dry	-118	**	0.305	--	15.62

** Preliminary value using an assumed λ of 1.66 inches.

The value of λ listed is the measured side-to-side extrapolation distance. The front-to-rear extrapolation distance was assumed to be 1.03 inches.

The final buckling measurement of the tube-in-tube dry fuel element at a lattice spacing of 8 3/8 inches completes the series of measurements on that fuel element. The crossover point is at a lattice spacing of about 8.25 inches with a carbon to uranium ratio of 20.42. The crossover point is that lattice spacing at which there is no change in buckling upon loss of coolant.

Horizontal traverses have been analyzed separately for a bare counter and a cadmium covered counter. The results are listed in Table II. The shutter method was not used so only the difference in λ is significant, not the absolute value.

TABLE II

Fuel Element	Lattice Spacing	λ(side) (in.)	Counter
2.5 x 1.6 with 1.7	8 3/8 wet	1.37 ± .1	Bare
2.5 x 1.6 with 1.7	8 3/8 wet	1.38 ± .05	Cadmium covered

Another horizontal traverse has been taken down the center of the tube-in-tube fuel element in the front-to-rear direction. These results are shown in Table III. The shutter method was used in this traverse.

TABLE III

Fuel Element	Lattice Spacing	λ (in.)	Position
2.5 x 2.0 with 1.66 x 1.1	8 3/8 dry	1.41	Front half of pile
		0.50	Rear half of pile

The above traverse was taken to aid in checking the previous conclusion that the front-to-rear extrapolation distance is constant at 1.03".

PCTR Measurements of Large Diameter Fuel Elements

The 2.5 x 2.0, 1.66 x 1.1 tube-in-tube experiment is almost complete in the PCTR. In addition to the foils used for the k_∞, f, p and ϵ measurements, lutetium foils were used in a first attempt to use this technique in a lattice to determine the neutron temperature at the cell edge, midway in the graphite, the outer edge of the fuel, and the inner edge of the fuel. Measurements are being made for both the wet and dry cases. The wet case has a negative k_{ex} and a spectrum so soft that it could not be matched even with lucite in the drivers and 36 D_2O tubes in the "flux-adjusting" positions.

The total radiation dose received by personnel while disassembling the fuel containing the foils for the p and ϵ measurements has been reduced to a negligible amount by removing the central cell through the front face and designing the fuel assemblies to be quickly disassembled.

The response of the 2" x 5" crystal to the 60 Kev radiation from Am^{241} was flattened with 1.5 mils of copper. This source is used to simulate the 100 Kev X-rays from Pu^{239} counted in connection with the p measurement.

A Program for Analyzing PCTR Data

APDAC-I, the program for analyzing PCTR foil data, was put into limited production use, under the control of the programmer. Several bugs were located and were removed by changing the FORTRAN deck and recompiling. Shortly after one of these program changes, the program refused to process a batch of foil data. As the trouble is occurring in a section of the program which has not been changed in 6 weeks, the cause is not apparent. An examination of the data cards did not reveal any errors. To check further, some test data, previously analyzed correctly, was put in for processing. The results of this run are not yet available.

Exponential Pile and PCTR Experiments for the NPR

The final lot price for the graphite to be used in the exponential mock-up of N-reactor has been received. The order is expected to be authorized after a classification of chippage specifications is received from the vendor. Delivery has been promised 12-14 weeks after receipt of the order.

For the PCTR experiments, one graphite vendor has specified a 7-month delivery date and other bids are being sought. The orders for both enriched and natural fuel have been placed. The goal for completion of these experiments will thus be delayed a few months.

Instrumentation and Systems Studies

Analog computer results have been obtained for NPR power decay following a scram, assuming (1) constant flow rate, and (2) constant average water temperature. The study neglects the temperature feedback from the heat exchangers so the results should be reasonably valid for at least the first 28 to 60 seconds following a

scram. Results are currently being obtained from the computer for investigating various startup techniques for NPR. It essentially involves the calculation of the various reactivity transients, i.e., xenon, temperature, etc., for prescribed power maneuvers. Plans are currently being made to program the NPR Heat Exchanger System on the computer.

All necessary development tests were completed on the detectors and circuitry for the prototype NPR scintillation area monitor. The high-level probe unit was exposed to gamma fields exceeding 500 r/hr with no damage resulting and with the meter staying solidly off scale (upper end). A satisfactory nonlatching relay and light-flashing circuit was devised for the low-level unit. This flasher will be activated when the low-level probe is exposed to gamma fields exceeding its set-point for alarm and will automatically quit flashing when the field diminishes below set-point. The upper level alarm is the latching type and must be manually reset. The low-level portion covers the range from 0-500 mr/hr and the high-level portion extends from about 100 mr/hr to 10 r/hr.

Fabrication was completed on the prototype, logarithmic, three-decade scintillation, beta-gamma 105-N area monitor and tests have commenced on the unit. Calibration tests have to be done, and the unit will also be tested for neutron response--both thermal and fast.

Development work continued on the prototype NPR Fuel Element Rupture Monitor. A circuit was designed using filters to improve, by 20 to 30 percent, the ratio of reading channel signal to adjacent channel signal.

A study is being made of the application of systems and methods for the simulation of reactors to the prediction of actual reactor operation.

A preliminary study of the various methods of transfer function discovery now in use has been started. In particular, those methods which are adaptable to machine computation with either analog or digital computers are being studied to determine when machine computation can be used to advantage in the determination of system transfer functions. In addition to the more familiar methods which make use of impulse, step and sinusoidal process disturbances, the statistical methods, which utilize the concepts of power density spectra and the various correlation functions, are being studied. It is expected that these techniques will be useful in the development of reactor control systems, both manual and automatic.

The study of reactor kinetic equations continued. An error in the parameters used in the Litton DDA solutions was discovered and corrected. The new solutions are of the same nature as before, but do not check the approximate theory as well. Some time was spent in attempting to get better approximations, with some slight success. It is now thought that round-off errors in the computer may be building up too high. This will be checked by getting solutions on the GEDA soon.

Mechanism of Graphite Damage

A sweep system is being designed that will move the electron Van de Graaff beam so as to give a uniform dose pattern on large samples.

Additional safety features for the electron Van de Graaff were planned and were installed.

STUDIES RELATED TO SEPARATIONS PLANTS

Criticality Hazards Specifications

Nuclear safety studies concerning the design of a dissolver for non-production fuel elements were continued this month. The safe parameters for a dissolver capable of handling 5% enriched uranium metal or 5% enriched uranium oxide were determined and submitted to the Process Design and Development Operation. This particular dissolver vessel would consist of a long, square barrel which would contain a square canister or basket insert. The insert would contain whole or chopped fuel rods. The conditions under which this dissolver design would be critically "safe by geometry" are given below. These conditions apply to a single, fully reflected vessel isolated from other vessels containing uranium and/or plutonium by at least 12" of concrete or equivalent.

a) The dimensions of the canister or basket insert for unlimited height, should not exceed 6.2 in. x 6.2 in.

b) The barrel size should be such that when the canister is centered inside of the barrel, the annular space between the barrel and canister will not exceed one-half inch; it is not necessary that the canister be centered in the barrel during actual operation.

c) The canister should be constructed of material containing neutron absorber equivalent to .020 in. of cadmium.

This latter condition is being considered in order to obtain a suitable safety factor for the case of metal rods. While further study may show that safety can be assured without the absorber, the absorber will be specified until additional data are obtained to indicate otherwise. For the case of UO_2 rods or solution, the absorber is not needed.

Plutonium Critical Mass Laboratory

At the end of the month, Project Engineering listed the facility construction as 67 percent complete compared to the scheduled 61 percent. The corresponding figures for that portion covered by the fixed price contractor are 67 and 81 percent. For G-E engineered and purchased equipment (control and instrumentation, process system and equipment, etc.) the figures are 51 percent complete against a scheduled 65 percent. There has been no further definite word on delivery of the control panels and instrumentation system which were due the middle of January. The reactor room hoods have been received and await preparation of the reactor room for installation.

Actual construction of the building is essentially complete, with most of the work during the month concerned with the installation of services and fixtures. The heating system is operating and the main electrical service has been cut into the new line to the building. The reactor room was completed with the last concrete poured in placing the frame for the large door. Application of the fiberglass reinforced lining of the reactor room interior has started.

Work has started on the design criteria for two control components necessary to extend the startup configurations to clean, water reflected systems. These com-

pcnents are:

a) A drive system for a control rod to be operated in the reflector, and

b) A system providing a remotely controlled, water-filled piston to provide a top reflector for cylinders.

The specifications for a split-half critical assembly machine have been drawn. The design will be carried out by Facilities Engineering Operation. This machine will be used to perform critical experiments with the solid fuels presently being developed to explore critical phenomena in the H/Pu ratio range of 5 to 30. The machine will consist of a fixed table and a movable table. Fuel will be stacked upon each table and the two halves brought together by remote control. The machine will share the power and monitor channels of the solution critical apparatus.

In the development of data analysis systems, a series of problems, representing solutions used in the P-11 experiments, has been run using both C-3 and F-3 codes. The calculated values of the multiplication factor (k) has been too high in each case. The effect of assumed reflector saving will be explored as well as the of the varying concentration upon the spectrum sensitive cross sections. To implement the latter effect, the nuclear data tapes for program C-3 and program F-3 are being revised. The new data tape will contain a matrix of cross sections for the thermal group so that by interpolation of both temperature and concentration a more realistic thermal group average cross section can be obtained. Negotiations are underway to obtain from Atomics International a group of more flexible nuclear codes for the IBM-709 computer. These will include kinetics codes, multigroup diffusion codes, and multigroup transport theory codes.

Experiments with Heterogeneous Systems

Critical approach and exponential experiments were completed for the 0.175-inch diameter rods of 3.063 percent enriched uranium. The rods were 23.5 inches long. They were encased in 0.025-inch wall lucite tubing. Measurements made this month were with a hexagonal lattice spacing of 0.375 inches. This spacing has a H_2O/U volume ratio of 4.06. A value for the extrapolation length, λ, of 6.91 cm was calculated by equating the bucklings from the critical approach and the exponential measurements. This equated buckling value was $14{,}121 \times 10^{-6} cm^{-2}$. The critical mass for spherical geometry was 257 lb.

An extrapolation length of 7.5 cm for the 0.300-inch lattice spacing was estimated from the extrapolation of the plot of λ vs H_2O/U volume ratio. A buckling value of $11{,}477 \times 10^{-6}$ cm^{-2} was calculated from the exponential measurement made last month using this value of λ. The critical mass for cylindrical geometry is calculated to be 560 lb.

From curves of the buckling vs H_2O/U volume ratio the maximum buckling for the 0.175 inch diameter rods was estimated to be $14{,}400 \times 10^{-6} cm^{-2}$ and occurs at a H_2O/U volume ratio of about 5.3.

Experiments with Homogeneous Systems

The measurement of k_∞ for homogeneous UO_3 systems (3% enriched) had been previously performed at nominal H/U atomic ratios of 40, 44, and 48. The values of k_∞

from these experiments did not agree with previous data and it was suspected that the mixtures in these samples were not uniform. Chemical analysis verified this assumption. Because these values of k_∞ were not valid at these H/U ratios, the experiments were re-run and gave the following results:

H/U Atomic Ratio	k_∞
39.77	1.028
43.85	0.996
47.98	0.955

These experiments have verified the previously extrapolated value of the "cross-over point" (point at which $k_\infty = 1$) which had been extrapolated to an H/U atomic ratio of 44.

Critical Mass Theory Development

The program to calculate the solutions to the reactor kinetic equations has been run using input numbers close to a set giving a simple analytical solution. Exactly equivalent numbers could not be used because of certain characteristics of the program. The comparison was quite encouraging. At present the program is being run with more realistic data corresponding to an analytical solution by Triplett in HW-32346.

The program to calculate the fast and thermal leakage from bare subcritical plutonium solutions has been tested successfully on one representative case. At present more consistent data for input to the program are being compiled.

Mass Spectrometry

The instrumentation of this spectrometer was continued in use for development work on the ion pulse counting system. No customer service for isotopic analysis with this mass spectrometer was requested. The original sapphire insulators in the ion source of the spectrometer were replaced with quartz insulators in an attempt to reduce the electrical leakage encountered in the source.

NEUTRON CROSS SECTION PROGRAM

Absolute Fission Cross Sections

Measurements which have been made at Hanford in the past on the fission cross section of Pu^{241} have been re-evaluated. In this review the most recent information published on the U^{235} fission cross section was used as a standard since in the Hanford measurements the calibration of the neutron flux was originally made in terms of either this cross section or the Au^{198} capture cross section. In the course of the review it was discovered that the weight reported by Analytical Laboratories for the sample of 96.6 percent Pu^{241} was in error, and a new value was calculated from the original alpha count data. The standard U^{235} fission cross section was taken to be (590.8 ± 5.4) barns at 2200 m/sec. The 2200 m/sec fission cross sections of Pu^{241} measured at Hanford were evaluated to be (956 ± 43) barns from recent measurements with the 96.6 percent Pu^{241} sample and (941 ± 46) barns from an older measurement with a 19 percent Pu^{241} sample.

No fission foils were received from off-site for intercomparison fission counting.

Slow Neutron Fission Cross Section

A small BF_3 chamber was carefully remounted on the 105-DR crystal spectrometer for use as a neutron flux monitor for fission cross section measurements in the resonance energy region. The chamber efficiency was determined relative to the standard boron chamber from comparison measurements made at 0.8, 0.4, and 0.3 ev. The weighted efficiency was (144.2 ± 1.1) times the boron chamber efficiency.

The beam shutter for the 105-DR crystal spectrometer has failed to operate several times recently. A determination of the trouble with this shutter will be very difficult and can only be attempted during a reactor outage. A new drive motor for the shutter has been ordered for stand-by in the event of complete failure of the shutter.

Subthreshold Fission

Two foils of a sample of enriched U^{234} have been prepared for fission measurements by Analytical Laboratories. The weight assay of these foils by alpha counting has not been completed. The deposition of fission foils of U^{236} and U^{238} is also in progress. Attempts to electrodeposit a sample of Pa^{231} (by Chemical Instrumentation) have not been successful. It is anticipated that a useful foil can be prepared by painting.

Slow Neutron Scattering Cross Sections

The "soft mold" technique of growing aluminum single crystals for the study of neutron monochromators for the crystal spectrometer was used to produce an aluminum ingot with several large grains. The study of the neutron diffracting properties of two of these grains revealed that crystals grown in this manner have a much higher degree of perfection than the crystals previously grown using a large temperature gradient and solid crucible. The measured peak reflectivities of these crystal grains were about 25 percent with angular widths of 0.03 to 0.1 degrees. This is the type of crystal which is necessary to increase the intensity available in the neutron scattering experiments.

One of the neutron beam shutters for the 105-KE spectrometer which has been unreliable in the past has now jammed in the open position. No attempt can be made to repair the shutter until the spectrometer shielding is removed during a reactor outage.

Fast Neutron Spectra

A new chamber for the analyzing magnet on the Van de Graaff has been designed and is being fabricated. The chamber is designed to circumvent some of the problems encountered in the continuing realignment of the beam optical system by providing uniquely-determined rigid positioning of the beam-locating electrodes. The new chamber will also provide for obtaining energy stabilization of the accelerator using the molecular ion beam. The energy stabilization slits will be located behind the shielding wall. This will eliminate the necessity of catching on the target side of the shielding wall a large fraction of the chopped atomic ion beam for energy stabilization and will, hopefully, improve the backgrounds en-

countered in time-of-flight work. The instrument panel for the beam-locating system has also been designed and fabricated. The 60-cycle sweep chassis for presenting an oscilloscope display of the slowly swept beam on the target has also been prepared for use.

Irradiation Cross Sections

The work on this program has been confined to developing the ion counting system of the mass spectrometers to the desired performance level.

Activation Cross Sections

The lutetium foils which were prepared for activation and total cross section measurements were not satisfactory so no further activation measurements have been made.

Measurements were made of the transmission of neutrons through a thick single crystal of beryllium to study the possible use of this crystal as a filter to remove higher order neutrons in a monoenergetic, low neutron energy, activation irradiation. The second order component in a 0.05 ev neutron beam could be reduced to about 2 percent which would be satisfactory for some measurements. The crystal was not of sufficient thickness, however, to be used at 2200 m/sec.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Lattice Parameters for Low Exposure Plutonium

PCTR experiments on the 1.8 w/o Pu-Al 19-rod clusters in an 8-3/8-inch square graphite lattice with air coolant were completed in late December. Analysis of these data is nearly complete.

An approach-to-critical was made with the unpoisoned core loading, as in the case of the 10-1/2-inch lattice. The reactor was made critical with 10 standard drivers located symmetrically at about a 50 cm radius, and all leveling rings at 3 inches. Upon moving all leveling rings in to 0 inches, the reactor was made critical with 8 drivers.

Some difficulty was encountered in hardening the spectrum at the ends of the core to provide adequate longitudinal flux leveling for this lattice. This problem is expected to be more severe when the 6-1/2-inch lattice experiments begin.

Three irradiations have been performed using the TTR internal thermal column with rotator to normalize the plutonium and uranium fission foils used in the 10-1/2 and 8-3/8-inch experiments.

Mass spectrometer analysis of the plutonium contained in the 1.8 w/o Pu-Al fuel rods has yielded the following isotopic percentages:

Pu-239	94.256
240	5.345 ± 0.055
241	0.399 ± 0.009
242	0.025 (estimated)

Lattice Parameters for High Exposure Plutonium

No definite word has been received concerning the procurement of the 20% Pu-240 material. A possibility exists that the scrap from the Division of Military Applications work will be made available.

Irradiation of the MTR-type Pu-Al elements is continuing in the ETR toward the 40% Pu-240 goal exposure.

Lattice Parameters for Self-Shielded Fuel Elements

The goal of specifying the fuel elements to be measured in the PCTR has not been met. Therefore, the goal of completion in September 1960 will not be met. Fuel element specifications will not be forthcoming until calculations of the neutron properties point out the general features of such fuels.

PRTR Startup Experiments

The final drafts of all the approach-to-critical experiments, except the one with a high spike enrichment, are written and have been distributed to the members of the Startup Council for approval.

A rough draft of the approach-to-critical experiment for the loading which contains 49 UO_2 elements surrounded by 36 Pu-Al elements has been prepared. This loading is expected to be critical with all the shim rods out of the reactor and the moderator at full height before all of the 36 Pu-Al elements are loaded. Therefore, it will be necessary to insert the shim rods during the fuel loading process in order to control the excess reactivity of a fully loaded reactor and a high moderator level.

The loading for this experiment will be such that the inner radius of the Pu-Al annulus will remain constant (i.e., always 49 UO_2 elements in the center). The number of Pu-Al elements in the annulus will vary from 18 to 36 elements and data will be taken to determine the critical levels for the loadings in which the annulus comprises 18, 24, 30, and 36 Pu-Al elements. The Pu-Al annulus will be surrounded by UO_2 elements, so that UO_2 fuel must be removed, as Pu-Al is added to the annulus.

Information obtained from this experiment will be used to define an initial full power loading which will allow criticality to be reached with a maximum number of Pu-Al elements and the moderator level near full height.

The Critical Facility of the PRP

The second draft of the Design Criteria was reviewed and recommendations to include withdrawable control rod and moderator dump features were incorporated

in the project proposal.

The differences in the general appearance of an H_2O or D_2O moderated reactor limit the complete flexibility that has been strived for in the design of the Critical Facility. As a result the purpose and scope of the experimental program was reviewed and decisions made concerning which types of experiments should have first priority. These decisions were made to determine which direction the design should progress in order to accomplish specific experiments. Reactivity measurements of irradiated and unirradiated PRTR fuel elements in a D_2O lattice and experiments to provide information for planning fuel loadings for plutonium recycling reactors using D_2O or H_2O moderator were considered most important.

Design changes which allow these experiments to be more easily accomplished and other experiments with lower priority to be conducted with modifications which would be made later were worked out in cooperation with the designers. Control rods of the "shutter" type will be available for reactivity measurements and rods of the "gravity-drop" type will be available as safety rods and for control of experiments in which a clean, unpoisoned lattice is required. Modifications or additions may be required later for specific experiments. Fuel element templates, fuel element hangars required for a special loading, or special fuel and control elements are typical of the modifications or additions which might be required after the facility is built.

Critical Mass Studies on Plutonium Systems - Subcritical Experiments with Plutonium

In support of the Plutonium Recycle Program, critical mass data are needed for Pu-Al alloy fuel elements. These data will be of use in the preparation of nuclear safety specifications for the handling and processing of this kind of fissile material. The critical mass data will also provide desirable check points for correlating critical mass calculations with experiments for heterogeneous Pu systems.

Approach to critical experiments are presently being conducted with 5 wt. percent Pu in Pu-Al alloy rods. These experiments are being conducted in the TTR reactor room using the vessels and safety systems originally set up for the 3% heterogeneous uranium experiments.

The Pu-Al alloy core has a .506" diameter and is 24" long, with a cladding of Zircaloy-2 having a wall thickness of .030". One end cap is .020 inches; the other is .125 inches. The over-all dimensions are, therefore, .566 inches in diameter and 24.255 inches in length. The average rod contains 11.01 gms. of Pu; and has an Al/Pu atomic ratio of 168.2 and a Zr-2/Pu atomic ratio of 134.05. The isotopic analysis of the Pu is:

Pu-239	94.09
240	5.33
241	0.55
242	0.03

In an effort to determine the minimum critical mass for these systems three lattice plates were made for preliminary experiments. Other lattice plates will be made when these preliminary experiments are completed. The following table lists the data from all experiments to date (critical approach and exponential experiments).

H/Pu Atomic Ratio	Volume of H_2O / Volume Pu-Al Core	Lattice Spacing Inches	λ cm	No. of Rods for Crit. Cyl.	Pu Mass in Crit. Cyl. Kgm.	Min-Pu Mass Kgm	B^2 $cm^{-2}x10^{-6}$
582.6	3.06	1.0	7.86	170.1±.3	1.873±.003	1.531±.003	10748±50
755.1	3.96	1.1	7.34	166.5±.1	1.833±.003	1.530±.003	10107±20

The value of λ, the extrapolation distance, is obtained by equating buckling expressions for extrapolated critical size, from the critical approach measurements and the exponential measurements on these systems. An effort will be made to measure the extrapolation distance in the axial direction; however, the radial extrapolation distance cannot be measured as easily as the axial extrapolation distance because of the small radius of these systems. The "built-in" source of spontaneous fission and (α,n) reaction in the Pu-Al fuel allows easy measurement of the axial flux and the size is large enough to give reasonably small errors.

Additional measurements have been made in these systems using U-235 and Pu fission chambers for possible future temperature effect measurements.

Plutonium Contamination Incident - January 20, 1960

During the loading of the 1.1-inch lattice in the criticality studies, the escape of some Pu from the canned fuel elements was detected. The monitoring procedures provided rapid detection (within 4 minutes) and prevented the inadvertent spread of contamination to other nearby areas. The contamination was contained wholly in the TTR reactor room. The apparent events leading to the contamination are:

a) The rod end-cap was machined too thin.

b) The rod was numbered on the wrong end (thin end) with a vibrating tool.

c) The rods were etched with a solution of hydrofluoric and nitric acids prior to shipping.

d) The etching solution apparently leaked into the element through holes opened during the machining and/or numbering causing corrosion which then escaped.

e) The rod was placed in a plastic bag which accidentally, but fortunately, sealed itself, and the bag remained sealed for the approximately 2 months of storage prior to the rod's use in the experiments.

f) The physicist conducting the experiment removed one glove to tear the plastic at the point where it had sealed itself and his bare hand became contaminated; also his clothing and other material and equipment handled subsequently.

g) The contamination was detected in a routine hand check when that loading operation was completed.

h) The second physicist present received minor contamination from equipment handled after the first physicist.

Personnel decontamination was readily achieved; however, 2 days were required to decontaminate the TTR reactor room and equipment. The rods are now being monitored individually as they are removed.

Instrumentation and Systems Studies

A measurement of the PRTR prompt neutron lifetime is desired during the PRTR start-up tests. The prompt neutron lifetime affects the frequency response of the reactor in a known manner. Therefore, the method of measurement involves obtaining the response of the reactor in the frequency range which is modified by the prompt neutron lifetime. The range of interest has been calculated to be centered about 1.5 cycles per second. The proposed method of frequency response measurement utilizes the statistical variations of the reactor neutron flux during steady state operation. Two methods of obtaining reactor frequency response from the statistical flux variations have been reported. The reactor frequency response is proportional to the square root of the power density spectrum of the statistical data. The power density spectrum may be obtained directly by using suitable narrow-band filters and computing circuitry, or, indirectly by computation of the autocorrelation function of the statistical data and subsequent Fourier transformation to yield the power density spectrum. The accuracies of the methods depend on several factors which must be investigated further. Greater confidence in the results of these tests would be obtained if an independent method of measurement were used as a check. Impulse, step and sinusoidal disturbance methods are difficult to make on PRTR at the frequencies of interest. However, the possibility of making some form of disturbance test will be investigated.

A computer program has been started for study of the gas loop. The size of the problem requires that the computer study be delayed until the new computer is in operation.

Acceptance and evaluation tests were completed on 150 phototubes and 87 NaI crystals to be used in the Fuel Element Rupture Detection System. Of the 150 phototubes, 94 were completely acceptable and 16 were deemed useful for temporary replacement. Thirty seven of the eighty-seven NaI crystals were defective and will have to be replaced.

Graphite bearings for the Wide Angle Viewer have been designed to replace the stainless steel ball bearings which we have been unable to obtain. The six non-darkening relay lenses will be shipped by February 25 from Simpson Optical Company in Chicago. The company had been on strike since October; fabrication of these lenses in the Optical Shop would have been necessary had the strike not ended.

Two samples of As_2S_3 glass are being irradiated to 10^6 R, 10^7 R, 10^8 R, and 10^9 R and the spectral transmission from .7 to 12 microns is being measured for each exposure. The tests are being made to determine whether this infrared transmitting material darkens from gamma radiation. Lenses and windows of As_2S_3 are being used on probes which will measure the temperature of PRTR fuel elements.

NONDESTRUCTIVE TESTING RESEARCH

In the broadband eddy current tests, the existence of the difference predicted by theory between signal changes due to unbonded fuel element jacket thickness variations and those due to jacket-to-core gap variations in the broadband test being developed have been reconfirmed. The difference is very small, and although it can be observed when viewed with an oscilloscope, its use in the discrimination between the two thickness variables has not been obtained at the output of the equipment as desired. The sensitivity of the equipment is sufficient to measure either jacket thickness or gap thickness alone, but is not sufficient to permit the independent determination of each while they both vary. An expander type amplifier is now being added to the system in order to better utilize the observed difference in signals to discriminate between the two variables. A new prototype manual probe using no sliding parts and having test coils supported on a cantilever beam spring is performing satisfactorily.

A directional conductivity eddy current probe developed earlier under this program is being applied to measurement of anisotropic conditions in NPR graphite by the FPD-Testing Methods Operation. Consultation was provided in consideration of the stability and design requirements for this application.

The program for the development and evaluation of thermal bondtesting methods for assembled fuel elements is now under way. Modern high sensitivity infrared and eddy current inductive thermometry techniques are being evaluated.

In the infrared investigation, calculations indicate that recently developed indium antimonide infrared detectors will easily sense 0.25-inch diameter 50.1°C hot spot on a 50.0°C aluminum surface. Non-refrigerated indium antimonide photoelectromagnetic type (PEM) detectors have a higher noise equivalent power (the amount of incident infrared power required to give an output signal just equal to noise) than the refrigerated type, but are much less expensive and do not require a liquid nitrogen supply or cryostat. The noise equivalent power of a PEM detector, calculated for a 50°K blackbody from spectral detectivity data, is low enough that it should be capable of sensing the hot spot defined above. A PEM detector has been ordered, and an optical head and chopper assembly suitable for use with different types of infrared detectors is nearing completion. The head has an f:2 arsenic trisulfide lens for high efficiency in the low infrared region.

Lead sulfide photodetectors have a lower over-all detectivity for a 50°C blackbody than the PEM detector. However, locally available lead sulfide detectors are good enough to evaluate methods of heating test specimens for the heat transfer tests while awaiting delivery of the PEM detector. These detectors will also be used for a comparison check of the noise equivalent power of the PEM detector when it arrives.

A commercially made infrared sensing head and amplifier that would probably detect the previously mentioned hot spot can be either purchased or rented. Requests for clarification of some of the specifications have been sent to the manufacturer. Rental on a by-the-month basis is very expensive and therefore the method of heating test specimens should be reasonably well developed prior to renting to permit economical evaluation of the instrument. In addition, the purchase price of the commercial instrument is very high. Therefore, the per-

formance of the relatively inexpensive thermal testing instrument now being fabricated will be evaluated, and it will be used to develop the method of heating test samples prior to the final decision on whether to test the commercial instrument.

The evaluation of eddy current inductive thermometry techniques for use in the thermal bondtesting program will include investigation of both a single frequency system and the broadband system. A General Radio Impedance Comparator will be used in the single frequency system. This instrument has been received and requires some auxiliary circuitry to be built, including (1) a stabilizing crystal oscillator, (2) a phase shifting circuit to permit adjustment of the phase detector reference signal for probe motion discrimination, (3) a preamplifier to increase sensitivity, and (4) an input bridge circuit.

Measurements were made using existing broadband equipment to determine design criteria for the broadband inductive thermometry equipment. Using metals of different electrical conductivity to represent the effect of temperature change, it was determined that the equipment must be stable to within ±3 parts in 10,000 to read the metal temperature within ±1°C at room temperature. The data obtained included measurements of the effect of changes in probe to metal spacing from 0 to 18 mils. An improved automatic gain controlled amplifier is being designed based upon these requirements. This amplifier can also be incorporated in other broadband equipment, and will replace a less stable one now being used in the jacket thickness measuring equipment.

GAS COOLED REACTOR PROGRAM

Lattice Parameter Measurements

Work has been completed on the analysis of the control rod experiment. The results given last month have been refined slightly. The new values for the control rod worth are listed below:

$$\Delta k_{\infty}^{CR}(21.875") = 0.152 \pm 0.012 \text{ for a } 4 \times 4 \text{ array}$$

$$\Delta k_{\infty}^{CR}(29.000") = 0.158 \text{ for a } 4 \times 4 \text{ array}$$

$$\Delta k_{\infty}^{CR}(21.875") = 0.271 \text{ for a } 3 \times 3 \text{ array}$$

$$\Delta k_{\infty}^{CR}(29.000") = 0.278 \text{ for a } 3 \times 3 \text{ array}$$

The measurement of the angular and radial flux dependence within an EGCR fuel tube, and the measurement of the flux perturbation caused by stainless steel spacers have been evaluated and reported. The work is described in HW-63585, and will also appear in "Nuclear Physics Research Quarterly Report - October, November, December, 1959."

A report on the measurement of k_{∞}, f, p, and ϵ for the EGCR lattice has also been prepared for the same quarterly report.

Most of the preparations for the next EGCR lattice experiment have been completed. The reactivity effect of a stainless steel "through tube" (loop) will

be measured, both empty, and filled with a fuel column of 2.6 percent enrichment.

The analysis of the data for the fuel temperature coefficient of a 7-rod, enriched uranium oxide cluster in the Allis Chalmers-Kaiser Engineers, 8-inch, graphite lattice has been completed. A report for the customer has been written and is being prepared for distribution. Final values of

$$\frac{1}{\rho}\frac{d\rho}{dT} = (1.00 \pm 0.10)\left[(-3.61 \pm 0.10) \times 10^{-5} + (2.69 \pm 0.51) \times 10^{-8}\, T\right]$$

and

$$\frac{1}{\Sigma}\frac{d\Sigma}{dT} = \frac{1}{\ell np}\frac{d\rho}{dT} = (1.00 \pm 0.11)\left[(1.87 \pm 0.05) \times 10^{-4} - (1.74 \pm 0.25) \times 10^{-7}\, T + (4.58 \pm 0.68) \times 10^{-11}\, T^2\right]$$

were obtained for the temperature range 50 to 500°C. The second order temperature term in $\frac{1}{\Sigma}\frac{d\Sigma}{dT}$ arises from the temperature dependent expression for ℓnp. This term contributes about 10 percent of the total value of $\frac{1}{\Sigma}\frac{d\Sigma}{dT}$ at 500°C and, thus, has been retained. The uncertainty on the unit multiplier includes the error due to flux and adjoint mismatches. It is considered to be a maximum value since the signs of the spectral mismatches have been assumed to add, and their values have been maximized.

The measured reactivity loss with increasing fuel temperature was fit with a parabolic expression. One would not expect an extrapolation of this expression to yield satisfactory results much beyond the 500°C limit of the experimental data. For extrapolation beyond this temperature range, it is more realistic to use the expression

$$\frac{1}{\Sigma}\frac{d\Sigma}{dT} = 2.49 \times 10^{-4}\, e^{-1.02 \times 10^{-3}\, T(^{\circ}K)}.$$

Perhaps an even more acceptable expression, which has some theoretical justification, is

$$\frac{1}{\Sigma}\frac{d\Sigma}{dT} = 2.90 \times 10^{-3}\, T(^{\circ}K)^{-0.480}.^{*}$$

* Note: These extrapolation formulae use the Kelvin temperature whereas the fits given above use centigrade.

Variation of the Doppler Coefficient with S/M Ratio

The 1.92-inch diameter mock-up has finally been completely assembled. The quartz tube was broken once but was successfully repaired. A new design for the induction heater coil and flexible leads have been tested and proved satisfactory. The full-sized fuel element for the experiments is being completed. No delay is anticipated in meeting the PCTR schedule.

Rod Replacement Analysis

The calculations of control rod worth in the GCR lattice by means of the two-group, small source theory formulation have been completed. A revision of the experimental value of resonance escape probability for the uniform array necessitated re-evaluation of the input parameters in the formulation. In addition, an improved method of calculating the epithermal blackness of the control rod was employed which utilizes the self-shielding factors tabulated in ANL-5800. The calculated values of k_∞ for the 16:1 and 9:1 fuel to control rod ratios are in good agreement with the experimental results, the error being 0.6% and 1.7% respectively for the two cases. In both cases the calculated value is less than the experimental quantity.

RESEARCH - 5000 PROGRAM

Isotopic Analysis

The mass spectrometer for this program operated at 100 percent efficiency during January. About 75 percent of the time was spent on furnishing isotopic analyses of program samples. In addition, isotopic analyses of a uranium sample and a plutonium sample were furnished for Reactor Lattice Physics Operation.

The influence of ion source focusing conditions on measured isotopic abundance ratios was also studied. Small but significant variations in isotopic ratios were observed. A study has been planned to determine how to eliminate or correct the possible errors introduced by the observed mass discrimination effect.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Plans were made for complete reactivation of the sampling grid to 3200 meters distance from the source, including all 20 sampling towers, in preparations for resumption of field experiments. Some modification of the field sampling equipment was made to facilitate startup operations during the cold weather. The portable mast was made ready.

Intensive efforts on the part of Analytical Chemistry group to perfect the phosphorescent technique for assaying ZnS loading on the membrane filters exposed during the summer continued. Some delay was experienced about midmonth when the amplifier-scaler system failed to maintain suitable calibration over the wide range of pigment loadings encountered. Procurement of equipment believed to be adequate was in process at month end.

Preparation of individual chapters for the Geophysical Research papers on the past summer's dispersion and transport experiments continued according to plans made with the Air Force. The chapter on wind prediction and forecasting was essentially completed. Construction of the 15-foot streamlines and trajectories not included in the earlier study of tracer arrival times and transport speeds was completed and analysis started. Stability ratio computations were begun for specified time periods and height intervals from the portable mast data for later

correlation with the dispersion data. Control and edit reports for the portable mast data received from Data Processing were checked, corrected, and returned for compilation in a format suitable for direct reproduction in the final reports.

DOSIMETRY

The Shielded Personnel Monitoring Station was closed January 11 to permit change of the cell door to screw drive so it can be opened from inside the cell if the electric power should fail.

A recalibration of the whole body counter for potassium was completed. Our results for potassium will be 15% higher than those previously reported. This brings them into good agreement with the results of other laboratories. An unexpected result of this recalibration was a change in the correction to the calculation for Zinc-65 that must be made because of the presence of the potassium. The average value of Zinc-65 found in people is decreased 20% by this change. A check of the Cesium-137 calibration was begun. Apparently it must be changed also. The increase will be about the same as for potassium.

Analytical Chemistry Operation measured the elimination of Zinc-65 in urine and feces for several subjects whose body burdens had been measured at the SPMS. 0.06% of the measured burden is eliminated, per day, in the urine. 1.5% is eliminated in the feces.

The positive ion Van de Graaff was not operated during the month. The re-arrangement of the laboratory was completed. A positioning device to help line up the accelerator was installed. The wiring made necessary by these changes has not been completed.

Work on the precision long counter has resulted in a change in the counter in the interest of improved reproducibility. The series of eight holes around the central counter in the classical arrangement has been replaced by an annulus. A slow neutron shield of boron dispersed in polyethylene was found to be equivalent to the B_2O_3 shield now used. It may be used later since there have been differences in the B_2O_3 shields.

Other Activities in Neutron Dosimetry: USNRDL sent us a corrected spectrum for our plutonium fluoride neutron source, but the average energy still does not agree with our double moderator measurement. An antimony-beryllium source for use in the long counter work was activated in a reactor but was found to be contaminated and unusable. Work began on the preparation of a helium ion source for the Van de Graaff. A large tissue equivalent ion chamber was received on loan from Columbia University. A plutonium-beryllium source was borrowed from the University of Washington so we could measure the relative number of fission neutrons produced in a source of different size from any that we have. In the course of our study their source will be calibrated relative to our standards.

The calorimeter used with the electron Van de Graaff was connected directly to the vacuum system of the accelerator in order to eliminate absorption in the exit window. The vacuum system worked properly but there is a heat loss from the calorimeter up the drift tube which has not been eliminated.

A single measurement with the gamma ray calorimeter takes three or four days because of its very long time constant. With calibration and zero level runs this means that an individual source can be measured in about 2 weeks. To cut down these long times a positive power feedback system was designed. Parts of this system were assembled and tested with satisfactory results.

INSTRUMENTATION

Fabrication of experimental transistorized circuitry continues for the alpha air monitor using coincidence counting techniques to eliminate radon-thoron background effects. A majority of the circuitry is complete and portions have been tested satisfactorily. Only a transistorized difference amplifier remains to be fabricated to have the experimental system completed. The alpha air alarm will be better than 10 MPC in 20 minutes.

The prototype transistorized high-level alpha air monitor has operated satisfactorily for one month. This high-level unit will alarm on 8,000 d/m of Pu-239 in about one minute. It will not alarm on radon-thoron background excursions of magnitudes noted at HAPO in the past two years. One interesting check was obtained during the month when the apparent background (radon-thoron) reached 5,000 d/m. Radiation Monitoring Unit personnel obtained an in-building air sample and checked their filter. The correlation between the high-level alpha air monitor and the RMU sample was exact. Complete schematic diagrams and an instrument adjustment-calibration procedure report has been prepared. The unit can be fabricated by anyone wishing it for plant use.

A temperature probe of a small insertion type was designed for use with rats and other small animals that are used in biology experiments. The probe consists of a subminiature bead thermistor encased in plastic tubing. Temperatures are measured and recorded continually during Pu-239 exposure, and temperature changes of less than 0.1°F can be detected.

Preliminary design calculations were performed concerning an electron beam deflection and control system for the electron Van de Graaff. The system is being designed as a co-operative effort with the Radiological Physics Operation. The system will employ electrostatic deflection of the one to two mev beam to produce uniform irradiation on a 1.5-inch square area.

The nonlinearity of the deflection voltages was calculated to be a maximum of 1.25 percent for 3.0 kv peak voltages necessary for the one-mev beam at the full 1.5-inch width. Some of the necessary components have been ordered.

Slight modifications are being incorporated into a transistorized prototype alpha monitor for use with either air-proportional or scintillation probes. Field tests of the original configuration indicated a need for more speaker loudness and a better high-voltage adjustment method for the very critical air-proportional probes. A gated 1.0 kc/s oscillator will be used to produce the loudspeaker indication.

One experimental portable prototype transistorized, scintillation, beta-gamma, dose-rate meter was successfully fabricated and is now undergoing tests. The linear ranges are 0-5 mr/hr, 0-50 mr/hr, 0-500 mr/hr and 0-5 r/hr. These can be changed, if desired, to 0-1 mr/hr, 0-10 mr/hr, etc. Performance tests to date have been quite satisfactory.

Experimental work continues on the four decade (10^2 to 10^6) transistorized logarithmic count-rate meter with circuits being developed to drive a meter and a standard 10-millivolt chart recorder. The circuitry will be on plug-in printed circuit boards.

Some investigations were carried out concerning a circuit for obtaining the ratio of two voltages. The circuit employed a transistor in the feedback loop of an operational amplifier. Since the output would be $E_o = \frac{R_F}{R_{in}} E_{in}$, it was hoped that by using a transistor, R_F could be made equal to K/E_2. The K value varies with collector voltage, however, and the resulting curves of $E_o = \frac{E_1}{E_2}$ are somewhat nonlinear. Over the range of E_1/E_2 equal to 0.4 to 0.9, the errors are about ± 20 percent with greater errors above 0.9 and below 0.4.

Investigations of gamma spectrum analyses from 17 kev to 2.0 mev were made with the two-transistor emitter follower circuit used with a NaI and phototube detector. The system requires only one shielded cable up to 1,000 feet long from the main instrument to the probe. The single cable is used for high voltage to the phototube, power to the emitter follower, and signal transfer from the probe back to the main instrument. Test results were completely satisfactory from 17 kev to 2.0 mev and were as good as could be obtained using the standard method of a vacuum-tube cathode follower plus three separate cables for high voltage, power to cathode follower, and signal.

Investigations were concluded on a three-foot long section of flexible, fiber bundle commercial light piper. Terphenyl-in-polyvinyltoluene, anthracene, and NaI detectors were used with the light piper for the tests. Light losses in the piper were extensive, and the resulting detecting efficiencies varied from nearly zero to a maximum of 2.5 percent. This particular type of light piper is not suitable for such use.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely on a one- and two-shift basis. There were four unscheduled shutdowns with two due to electronic failure and two due to faulty by-passing technique.

The neutron rethermalization in graphite experiment and the 3% enriched UO_3-H_2O, $K_\infty = 1$ experiment were completed. The tube and tube fuel, k_∞, f, p, and ϵ, wet and dry experiment was started during the month.

Critical Mass Physics used the TTR facilities during the entire month. Plutonium contamination caused by a defective fuel element was successfully cleaned up, and the critical mass approach experiments were continued.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	77.0
24-Hour General	62	80.1
Special	121	95.0

Average temperature, average wind speed, and total precipitation were all considerably below normal during January. Total snowfall, however, was near normal. There was at least a trace of snow on the ground during the entire month.

Instrumentation

The bids for the fabrication of the Automatic Data Recording System for PCTR were reviewed and rejected as being too high. The specifications are being revised in order to lessen the cost of the system.

Fabrication was completed on the detector head for a Mask Monitor for the Laundry Operation. For typical fission products, the counting efficiency was found to vary from 1.0 to 1.5 percent over the surface of the probe which fits closely into a mask. Five masks from the Laundry Operation, which were rejected by hand monitoring with a mica-window G-M tube, indicated well above rejection levels using the Mask Monitor.

The mechanical conveyor portion of the automatic laundry monitor for the Laundry Operation is ordered and delivery is expected in February. Several mechanical features were incorporated to reduce operator fatigue.

One of five High-Level Alpha Air Monitors for Redox was obtained from the 328 Electronics Fabrication Shop and is undergoing "debugging" tests.

Three G-M tube detector, transistorized circuitry, beta-gamma air monitors for use at Redox were received from the shop and were "debugged," tested, and calibrated and then delivered.

Twelve scintillation Gamma Nuclear Incident Alarming Monitors, to be used in various 300-Area locations, were received from the shop, tested, calibrated, and are ready for delivery.

Fabrication continues in the 328 Electronics Shop on ten three-decade logarithmic response scintillation area monitors for the HLO Radiation Protection Operation and on three similar, but higher level, units for IPD. The IPD units will be used as reactor elevator monitors and will be alarming units with both low and high-level alarms.

Acceptance tests were completed on the detector phototubes and crystals for the PRTR fuel element rupture detection system, on fifty 0-200 mr self reading pocket dosimeters, on nine CP-TP portable ionization chamber instruments, and on two portable transistorized BF_3 tube detector neutron instruments. Field tests were performed on the line operated transistorized alpha monitor, and the

calibration procedure was written for the transistorized count-rate meters.

Analog Computer

The completion of the PRTR controller evaluation using the analog computer to simulate the reactor marked a first at Hanford for this type of computer application. Other problems on the computer included studies on the speed of reactor control and on NPR transient effects.

The unscheduled down time for the GEDA computer amounted to 22.6 percent of the total possible operating time (total possible operating time minus scheduled down time). The equipment failures encountered during the month were random. No definite trend was apparent.

The new Berkeley "EASE" computer was shipped from the factory on February 1.

Optics

Photo Lab Slit Camera - Modifications were made on the photo lab slit camera to permit the photography of fuel elements of greater length.

Television Scanning Mechanism - An electrically controlled scanning system mounted on a standard Auto-Zoom television camera lens was completed and demonstrated to a group from Redox operation. The unit permits the scanning of more than a complete hemisphere ahead of the lens. It is especially suitable for use where lack of space does not permit the usual pan and tilt scanning.

Zyglo Detector - A photoelectric detection system has been devised to inspect the inside surface of tubes for cracks and flaws. Appropriate filters applied to a light source and to a borescope permit detection of patches of Zyglo fluorescent material in the flaws only 0.0005 square inches in area. Defects are indicated by a lamp which lights up when the photomultiplier current increases to a preselected trip level.

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Chemical Research & Development

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATIONS PROCESSES

Decontamination of Reactor Components

Thirteen different solution compositions were compared with Turco 4306B as candidate decontaminating agents for rear-face piping in existing HAPO reactors. Sections of process tubes and pigtails, that had radioactive oxide films obtained in normal reactor service, were used in beaker-scale evaluation of the solutions. Two proprietary formulations, Turco 4512 and Turco 4518, based on phosphoric and oxalic acids, respectively, were about equivalent to Turco 4306B in removing radioactive contamination. Both formulations are much less corrosive to aluminum and Zircaloy-2 than Turco 4306B.

In recent NPR decontamination studies, carbon steel coupons contaminated with activated corrosion products during exposure in the KER-3 loop mock-up tube have been used. For some, as yet unexplained, reason these coupons do not decontaminate as well during identical treatment as previously used coupons. They had been exposed, as usual, in pH 10 water at 300 C.

Uranium Oxidation and Fission Product Volatilization Studies

The first fission product release experiment using the high exposure meltdown facility was completed. Some manipulation difficulties were encountered and are being remedied. Preliminary results of the test indicate considerable loss of evolved material during off-gas train decontamination and procedures are being revised accordingly.

HW-61851, "A Review of Uranium Oxidation," by A. J. Scott was issued.

Single Isotope Monitors

A preamplifier and pulse height analyzer were designed to provide optimum characteristics for Np^{239} gamma monitoring. Easy replacement of circuit elements, stability, and reliability are emphasized. Readout using a fast printer is being incorporated.

Effluent Decontamination

Laboratory experiments were continued to study the scavenging of radionuclides from reactor decontamination solutions for possible application to the problem of disposal of NPR decontamination wastes. One of the cleaning solutions proposed for the multi-step decontamination process contains permanganate ion. When this is mixed with other cleaning solutions the reduction of permanganate gives a precipitate that scavenges some radionuclides from solution. The amount of radioactive iron remaining in the supernatant liquid four days after two cleaning

solutions were mixed was less than 0.01 per cent of the initial concentration. Previous tests had shown reduction of cobalt and barium to 0.1 per cent of original levels. Iodine and calcium were scavenged to less than 1 per cent of their initial concentrations in similar experiments. No significant scavenging was detected in the case of silver, phosphorus, chromium, or antimony. Additional work is planned with radioisotopes of other elements.

SEPARATIONS PROCESSES

Recovery of Neptunium in Purex

A possible source of the decontamination difficulties encountered in the Purex Plant is the fact that the present flowsheet for recovering neptunium from the 3WB inventory entails processing 3WB in the final plutonium cycle equipment. In particular, if the 3WB contains activity-bearing solids, the present procedure would allow these to deposit in equipment in both the final plutonium and final uranium cycles. Subsequent normal processing could then result in recontamination of both product streams. Accordingly, consideration has been given to flowsheets which would employ the HA column to process 3WB. A flowsheet was desired which would extract uranium, plutonium, and neptunium in the HA column, employ the HS column as a pipe, accomplish separation of neptunium and plutonium from uranium in the 1BX column, use the 1BS column as a pipe, and accomplish separation of neptunium from plutonium and the necessary concentration of neptunium via a spin flowsheet in the 2A-2B columns. An additional advantage of such a flowsheet lies in the fact that the desired products are essentially quantitatively recovered from the 3WB so that this stream could be discarded to waste whenever this appeared propitious.

In a miniature mixer-settler test of such an HA column flowsheet (at 40 C) losses were less than 0.01 per cent for both plutonium and neptunium. Decontamination factors were about 20 for zirconium-niobium and in the case of ruthenium were limited by ruthenium activity "bound" in the (plant) solvent. An attempt was made to test a 1BX column flowsheet in conjunction with this run. However, poor control of 1BX flow rate invalidated the results. Losses of neptunium to the 1BU ran as high as ten per cent under the worst conditions.

In further studies of the spin flowsheet, an attempt was made to estimate the consumption of nitrous acid by Purex plant solvent. A sample of Purex 100 obtained on December 30, 1959 was employed for these studies. The data are sufficiently scattered that an accurate evaluation of the nitrous acid "titer" is not possible. It is estimated to be about 3×10^{-4} moles per liter. The "quality" of the solvent is definitely a factor which must be considered in attempting to establish the necessary catalytic amount of "extractable" nitrous acid. For example, a sample of Purex 100 which had been allowed to stand for two months after spiking to 0.05 M HNO_3 and 5×10^{-4} M HNO_2 and then processed through a laboratory simulation of the plant solvent washing procedure reacted rapidly to consume greater than 3.6×10^{-3} moles nitrous acid per liter of solvent when it was recontacted with 7 M HNO_3 containing nitrous acid.

Processing Nickel-Coated Aluminum Clad Fuels

A suggested method for processing nickel-coated aluminum clad fuels in the Redox plant involves total dissolution in HNO_3-$Hg(NO_3)_2$. In laboratory studies, it was

found that relatively small concentrations of nickel reduce markedly the rate of dissolution of aluminum in such solutions. In 7 M HNO_3-0.002 M $Hg(NO_3)_2$, instantaneous dissolution rates of 1100 aluminum decreased from about 2300 to about 40 mg/(hr)(sq cm) as nickel concentration increased from 0 to 0.096 M. The effect of nickel is less in more dilute acid. In 2 M HNO_3-0.002 M $Hg(NO_3)_2$ dissolution rates decreased from about 1400 to 600 mg/(hr)(sq cm) for the same nickel concentration range. The aluminum used for comparison in these studies had been previously coated with nickel. Tests are in progress with aluminum not previously nickel coated to determine if there is any difference in behavior.

Purex HA Scrub Column Studies

Tests in the Demonstration Unit pilot plant indicate that gross "crud" entrainment in a Purex HA-type column can be significantly decreased by addition of Mistron to the HAS stream. The Mistron destroys the organic-in-aqueous emulsions that characterize the "zebra" cartridge and permits true organic continuous operation throughout the scrub cartridge. Elimination of these zebra emulsions permits the crud held up on each zebra interface to be flushed out of the scrub section by the HAS flow. The Mistron also permits an increase in the scrub flooding frequency. Although visual observation indicates that the addition of Mistron decreases the scrubbing effectiveness slightly, the loss can be regained by increasing the frequency or the HAS flow. The Mistron has no obvious adverse effects on uranium extraction, interface control, or column performance in general.

The crud simulator in these studies was MnO_2 which was formed by reaction of the solvent with $KMnO_4$. This precipitate when produced just below the scrub section forms a finely divided dispersive in the organic stream and apparently behaves like a typical organic-wet crud in the Plant columns.

Purex 1C Column Studies

The high capacity sandwich cartridge (described last month in HW-63303 C but modified by lining up the holes in the polyethylene sandwich) operated at a maximum flow rate of 1500 gal/hr-sq ft with a 1CX and 1CF temperature of 60 C and 50 C respectively. In further tests, the sieve plates (23 per cent free area, 1/8-inch holes) between the sandwiches were replaced with 33 per cent free area sieve plates (3/16-inch holes). This permitted the column to be operated at 2000 gal/hr-sq ft with 60 C 1CX and 50 C 1CF and between 1575 and 1775 gal/hr-sq ft with 50 C 1CX and 50 C 1CF. With 60 C 1CX, 50 C 1CF, the flooding frequencies were 90, 80, 75, and 62 cycles/minute at flow rates of 850, 1260, 1575, and 1775 gal/hr-sq ft. All runs were made with a 1.0-inch amplitude and an aqueous to organic ratio of 1.1. Color line observations indicate that the efficiency of this cartridge is fair.

Purex Organic Treatment

Equipment is currently being assembled and modified to permit plant scale studies of methods of improving the contacting efficiency in the G-1 organic treatment tank of the Purex plant. In the initial studies, organic to be treated will be routed directly into the suction of a deepwell turbine pump where it will be mixed with aqueous solution. The combined mixed phases will be discharged to the Raschig ring zone of the tank which will act as a settling zone.

Y^{91} in Purex Tank Farm Condensate

Yttrium-91 was identified in samples of Purex tank farm condensate. Half-life measurements on a rare earth minus cerium fraction plus a comparison of rare earth plus yttrium sample concentration with the predicted concentration as determined from Ru^{103}/Ru^{106} and Sr^{89}/Sr^{90} ratios served to characterize the isotope.

WASTE TREATMENT

Semiworks Waste Calciner Prototype

One additional run using simulated ICPP waste and seven runs utilizing simulated formaldehyde-killed, threefold concentrated Purex waste as feed were completed during the month in the fluid bed calciner. Operation of the fluid bed calciner with simulated ICPP waste has been generally characterized by:

a) Good particle size control with negligible particle agglomeration.
b) Product bulk densities of 0.6 to 0.7 g/cc.
c) Residual oxides of nitrogen of 0.3 to 3.5 weight per cent.
d) Feasible operation with either steam or air as fluidizing gas.
e) Over all heat transfer coefficients of 50 to 75 Btu/(hr)(sq ft)(°F) calculated from measured sheath temperatures which are probably somewhat lower than actual.
f) Solids entrainment in off-gases averaging 10 to 15 per cent of product rate. Of this amount about one third was separated by the scalping cyclone and remainder by the surface condenser and wet scrubber.

Characteristics observed on the studies to date on Purex-type waste include:

a) Final tapped volume approximately 3 gal solids/ton U.
b) A markedly lower amount of fines carry-over into the off-gases than that observed with ICPP waste. Cyclone tailings have averaged only one to two per cent of product rate; the amount passing the cyclone is also visually lower than with ICPP waste.
c) Atomizing gas/feed ratios as low as 425 result in relatively fine particles.
d) Over-all heat transfer coefficients of 75-90 Btu/(hr)(sq ft)(°F) by calculations from sheath temperatures.
e) A problem of particle agglomeration presumably originating at the feed nozzle. These agglomerates constitute one to two per cent of the product rate under the best conditions tested thus far. External air-cooling of the feed nozzle resulted in negligible effect in preventing agglomerates.

Batch Waste Calcination Studies

Four laboratory-scale runs were made on the calcination of simulated high-level wastes in a heated, unagitated, three-inch diameter pot. The waste was added at a rate sufficient to maintain some solution in the pot and was subsequently fired to a final internal temperature of 800 to 900 C.

The feed sulfate to salt nitrate ratio for the four runs was 1.5, but the relative iron, aluminum and sodium concentrations were varied. The behavior of a run with sodium and aluminum only was very similar to a run with sodium and iron only. Melts with bulk densities of 2.3 to 3 grams/cc were obtained between 800 and 900 C when the

sodium content was at least 1.5 times the iron plus aluminum content. When the sodium content was equal to the total iron and aluminum content, the fired solids were porous but sintered with a bulk density of 1.2 grams/cc. In a run with only aluminum sulfates and nitrate, porous pieces with a 0.2 gram/cc bulk density resulted.

The observed behavior agrees with the relative thermal stability of sodium, aluminum, and iron sulfates. Only sodium sulfate is stable at the terminal temperatures. The iron and aluminum sulfates decompose to the oxides. As a consequence, solutions with the greater sodium content are more apt to form melts (sodium sulfate melts at 884 C). None of the nitrates are stable at 800 C.

Observation Wells

A resurvey of the elevation of the casings of Hanford wells 699-30-31 and 699-24-33 showed that the elevations originally reported were in error by approximately seven feet. The error was introduced through a temporary Bench Mark that had been used as a reference point in leveling. The wells are located southeast of 200 East Area where an anomalous extension of the 200 East mound on ground water contour maps resulted from the faulty elevations. Correcting the casing elevations changed the measured ground water elevation in the two wells and eliminated the apparent extension of the ground-water mound into this region.

The water table elevation was measured in a representative pattern of wells over the Hanford plant area during December. The data were plotted on a map of the plant environs and water table contours were drawn from them. No significant changes were observed in the general contour pattern other than those resulting from seasonal changes in stream flow and those reflecting the above changes in basic well casing elevations.

There were no significant changes in contaminated ground-water patterns under the 200 Areas. Continued increases in beta-emitter concentrations in wells south of the 216 BY scavenged waste cribsite confirmed earlier indications of the southward movement of wastes from this site. Both the southward and previously noted northward movement of wastes from the 216-BY site are in agreement with ground-water contour data. The B-swamp ground-water mound has increased the elevation of the regional water table in the immediate vicinity of the cribsite more than it has increased elevations at locations directly to the north and south of the facility. The movement rate in both directions, which is relatively slow, may be reduced even more by rising ground-water elevations farther to the north and south.

A gamma probing of the 299-W-15-1 well was requested when well sample analytical results showed increases in activity which were unexplainable on the basis of existing ground-water contours. The probing revealed the presence of radioisotopes in the surrounding soil from a depth of 100 feet down to ground water. It was concluded that the probable source of the contamination was the 216-TX-5 specific retention trench located about 300 feet north of the well. A relatively impermeable, southward-dipping caliche bed at a depth of about 100 feet probably diverted some of the waste toward the well. The trench, on the basis of laboratory experiments, had received about 0.3 of the soil column volume of first-cycle

bottoms in 1954. This is additional evidence of the appreciable lateral movement of wastes in the vadose zone under much of 200 West Area and is an example of continued drainage of a waste after the facility is abandoned.

Disposal to Ground

Standard soil column tests to evaluate the 216-A-6 crib utilized three columns operating at flows of 17.5 gal/(sq ft)(hr). It was established that Sr^{90} is the isotope in the waste that limits the capacity of the crib. The three tests indicated a limiting breakthrough of strontium after 47, 48, and 64 column volumes throughput (averaging 53 column volumes). The crib has received about 25 column volumes to date.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Fission Product Purification and Isolation

All equipment and components for the in-cell full-level demonstration of the promethium ion exchange purification process have been received, and installation in A-Cell of the High Level Radiochemistry Facility is about 75 per cent complete. Cold shake-down runs in the equipment are scheduled to begin about February 15, and the first run with full-level Purex plant concentrate for about the first of March (assuming the forthcoming Purex plant test is successful in providing cerium-free rare earth concentrate).

Design of B-Cell equipment for experimental fission product purification and packaging studies is essentially complete, and fabrication and installation is about 50 per cent complete.

Strontium, Cerium, and Promethium Recovery

Intensive laboratory work continued on both the high-sulfate and the lead carrier processes for acid-side strontium recovery. These experiments were aimed both at better understanding of the chemistry involved and at firming up the details of the flowsheets to be used in early Purex plant tests. Most significant findings were as follows:

1. Seventy-eight per cent recovery of strontium can be obtained from 1WW containing as low as 0.5 molar sulfate through the use of 0.02 molar lead carrier. Thus, if quantitative recovery is not required, additional sulfate need not be added.
2. Decreasing the strontium from flowsheet concentration (1.8×10^{-3} M) to trace concentration (ca. 10^{-6} M) increases the fraction carried on the sodium-rare earth double sulfate precipitate from about 30 per cent to a value of about 95 per cent (both in the absence of lead or other added carrier), implying a specific adsorption-type mechanism (as opposed to a solubility product effect).
3. There was some expectation that cesium might be scavenged by the lead-strontium-rare earth sulfate precipitate through an alum-type reaction. This was found not to be the case. Under conditions which gave >90 per cent precipitation of the strontium and >99 per cent of the cerium, less than one per cent of the cesium precipitated.

4. The optimum nitric acid concentration for dissolution of the double sulfate cake from a Purex-type centrifuge was found to be three to four molar.

5. Optimum conditions were established for the oxalate separation of strontium from cerium and the trivalent rare earths. Near quantitative precipitation of the rare earths was obtained in the broad pH range 0.5 to 3.0. Precipitation of strontium is negligible to pH 5.
6. The in-centrifuge caustic metathesis of the rare earth oxalate cake and the lead-bearing rare earth double sulfate cakes have been explored. The oxalate cake is readily metathesized in 30 minutes at 85 C with 20 to 50 per cent KOH (but not with NaOH) to a mixture of acid-soluble, oxalate-free hydroxides. Removal of lead from the sulfate precipitate with volumes of reagent (NaOH or KOH) which can be accommodated in the centrifuge is incomplete, and alternate schemes are being explored.
7. A sample of strontium oxalate has been irradiated for ten days in the cobalt source without evidence of decomposition, suggesting that the oxalate may be as suitable as the carbonate for off-site shipment.

Fission Product Isolation and Packaging Prototype

The General Mills manipulator has been installed in the 321-A Building. This installation will serve to develop a remote repair and maintenance technology. Operationally the unit is satisfactory except for breakage of the chuck jaws. These jaws, which provide the closure of the hand or hook, broke under normal usage. The vendor is investigating the cause so as to supply new jaws corrected for the deficiency.

Studies continued in the use of the hydrolyzer as a dryer for water soluble salt solutions. The problem lies in the transition from a saturated liquor to dry solids. Frequently the mass of wet crystals immobilizes and sticks to the heated surfaces. Means to mobilize these wet crystals are being investigated. Various scraper designs are being tested.

Filtration studies have shown that the present filter system is inadequate for processing the cesium leach slurry from the hydrolyzer is very fine, about 30 hours are required to process one batch with the existing equipment. However, this time can be reduced to about 20 minutes if filter aid is used and the supernate is decanted from the sludge which has settled overnight.

Volatilization of Cesium

In support of fission product packaging prototype development work, studies were made to determine if cesium is volatilized during drying and calcining operations. No evidence of cesium volatilization was found during drying of cesium zinc ferrocyanide at 100 C, heating the dried powder to 400 C and passing steam or air over the calcined powder at 400 C. The experiment will be repeated at 600 C.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Thermal Ionization Mass Spectrometer Filaments

Mass spectrometer filaments of tantalum often break at low current before thermal ionization of thorium samples is accomplished. Microscopic examination of the broken filaments reveals breaks in the area of thorium salt deposit. The filaments also swell to twice normal size and the grain size increases about five-fold. The primary cause of filament failure appears to be chemical attack by the thorium vapors. Rhenium filaments were substituted and have survived the first few tests.

Density of UO_2

The surface area apparatus has been modified to permit density measurements of UO_2 powders by a helium gas displacement method. Precision for each of sixty samples averaged ± 0.5 per cent of the density value. Error was less than one per cent. The former method involving liquid displacement gave a ± 3.0 per cent precision. Air voids in the material during liquid displacement seemed to cause the poorer precision of that method. Cost per analysis by either method is approximately the same.

Identifications by X-ray Diffraction

Films of Al_2O_3 from aluminum corrosion studies were analyzed by x-ray diffraction. αAl_2O_3, $\alpha Al_2O_3 \cdot H_2O$, and $\beta Al_2O_3 \cdot H_2O$ were the various forms of Al_2O_3 identified. Other unidentified materials were present. Also, x-ray diffraction was used to identify $BaTiO_3$ and $SrTiO_3$ in two separate samples.

Ce^{144} Separation from Soil Columns

A rapid method for separating and concentrating cerium from high salt content soil column samples was put in use this month. Cerium was precipitated as the hydroxide and washed with ammonia. The precipitate was dissolved in nitric acid then transferred to a one dram vial for gamma counting in the well of a 3-inch by 3-inch NaI crystal. Average yield was 86-96 per cent.

Technetium-99 Analysis

Tetraphenyl arsonium chloride extracted Tc^{99} from 3BW with a consistent 78 per cent yield and a beta particle purity of approximately 98 per cent. Iron appeared to reduce the yield below that expected.

Analysis of Zirconium in the Presence of Much Plutonium

Controlled potential coulometry was used to adjust plutonium to Pu^{+4} prior to loading it upon Dowex-1 resin from 8 M nitric acid. Zirconium was measured colorimetrically in the effluent using p-dimethylaminophenylazo benzene arsonic acid.

EQUIPMENT AND MATERIALS

Pump Development

A summary report covering the pump development activities for 1959, HW-63358, "Summary Report - Pump and Agitator Development, 1959," was issued.

Purex 1WW Interim Acid Waste Storage

Exposure of samples to 50 per cent concentrated, chromium(VI)-free, synthetic Purex 1WW are completed. Corrosion rates observed were one-half to one-third those observed with chromium(VI) present. However, even at zero molar nitric acid, corrosion rates for 304-L stainless steel were about 0.3 mils/mo. There was little or no intergranular attack in the chromium(VI)-free solutions.

Materials of Construction for Calcined Waste Storage

Studies on corrosion of candidate construction materials in contact with calcined wastes at high temperature have been started. Mild steel (1020); 304-L, 309-L, 316-L and 347 stainless steels; Hastelloy B and C; Ni-o-nel and nickel have been exposed at 800 C to acidic Purex wastes after (a) fluid bed calcination (ANL) and (b) batch calcination with sulfate additions (HAPO). Generally speaking, fluid bed calcined wastes were less corrosive, by a factor of two, than batch calcined wastes possibly due to added sulfate in the latter. However, of these materials, only Ni-o-nel and 309-L corroded at less than 10 mils/mo in contact with fluid bed calcined wastes. Future studies are to investigate lower temperatures and other materials.

Non-Metallic Materials

Tests continued in screening rubbers for potential use in phosgene at 500 F. After 29 days in a room temperature phosgene atmosphere, three out of eight samples showed promise. The three elastomers (1) duPont's Hypalon, (2) Minnesota Mining's 1F4 and (3) Dow Corning's Silastic 7-170 showed negligible dimensional changes and only slight softening.

Samples of polyethylene cut from a Purex HA column perforated plate were tested for flex life after irradiation to 5×10^7 R with a Co^{60} source in the presence of Purex HAX make up solution. No appreciable losses in flex life were noted. Similar samples have been irradiated to 10^7 R in the presence of simulated, cold HAW with no reduction noted in flex life.

PROCESS CONTROL DEVELOPMENT

C Column Instrumentation and Programming Studies

Additional modifications were made to the data reduction FORTRAN code to more fully use the features of the MONITOR system. A general purpose subroutine was written to plot two variables against one another (with about three per cent accuracy) by using the output printer. This subroutine will have immediate use in the data reduction code to plot uranium concentration versus column position.

A satisfactory correction factor involving the mean sample temperature (average of the inlet and the outlet temperatures) has been established to maintain the calibration stability of the traveling photometer to within one per cent for inlet sample temperatures of up to 80 C.

UO_3 Plant Calciner Automation

The final draft of the operation and maintenance manual for the programmer to automate the UO_3 plant calciners was completed this month. This document will be issued early next month as HW-63501 and contains a complete verbal description of the programmer operation and circuitry. Three pictorial views of each chassis comprising the programmer, and a complete miniature set of construction and schematic drawings are included in the manual.

UO_3 Plant C-1 Vessel Calibration

As a result of the vessel calibration experiments conducted recently, the UO_3 Plant incoming uranium inventory vessel C-1 (4000 gallons) is to be recalibrated. The procedures and equipment recommended as a result of the development study will be utilized for this calibration. This vessel calibration may not alter the existing calibration table significantly; however, it is expected that the reliability of measurement will be improved. To aid in this and other calibrations, a jointly authored document by C. G. Hough and C. L. Pleasance, HW-57866 REV 1, "Calibration of Process Vessels," was issued.

Corrosion of Antimony and Tungsten in Purex 1WW

The corrosion of antimony and tungsten in Purex 1WW was determined in connection with the possible use of these materials in pH indicating electrodes. Antimony corrodes at about three inches/mo in boiling synthetic Purex 1WW. Tungsten corrodes at about 100 mils/mo in the boiling solution, nine mils/mo at 75 C and five mils/mo at 65 C.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

Life Test, Stellite Shear Blade. A 304 stainless steel shear blade faced with Stellite #6 was removed from life test after 1800 cuts (about 2500 sq in. cut area) on sand-filled stainless steel tubing. No cutting force change occurred during the test, despite blade bending which increased blade clearance from 0.010 inch to 0.090 inch. The performance of the Stellite blade is slightly better than the best toolsteel previously tested, and indicates the desirability of further testing of Stellite.

Corrosion of Shear Blade Materials in Nitric Acid. Samples of alloys A-2 and D-2 (ASM designations) tool steels and Haynes-Stellite 6-B were exposed to six molar nitric acid at boiling point and at room temperature. Both A-2 and D-2 corroded at more than 100 in./mo at the boiling point; room temperature rates were greater than 100 mils/mo. The stellite 6-B corroded at about five mils/mo at boiling point and less than 0.05 mils/mo at room temperature.

Band Cutting, Yankee Atomic Fuel Element. Scouting studies of Yankee fuel disassembly showed that a manipulator (or crane) operated slitting knife can be used to cut the assembly bands. Future tests will measure the effect of knife shape and thickness, the two most important variables on cutting effectiveness.

Bandsaw for Hardware Cutoff. A bandsaw was used to cut bundles of unsupported rod in order to study its feasibility for hardware cutoff. At low saw speeds (100 ft/min) neither blade breakage nor rod bending occurred. These preliminary studies indicate that the bandsaw may be capable of performing unsupported rod cuts without the shimming and/or "potting" steps found necessary with the cold saw and the hacksaw.

Shear Basin Studies. A cluster of 15 Zircaloy-clad swaged UO_2 rods was sheared to study the dispersion of UO_2 fines in basin fluid. After 120 cuts at a cutting rate of 1-1/2 cuts per minute (130 pounds of U processed), the suspended U concentration four inches below the shear blade was three g/l. Tests with a miniature mockup of the shear and shear basin showed that about 97 per cent of the fines suspended by the shearing operation in quiescent basin fluid can be directed into the catch basket by baffles and funnels. Further, an estimated 99.5 per cent of the total UO_2 processed in such a baffled area is deposited in the catch basket without the use of auxiliary clean-up systems.

Feed Preparation

Dissolution of Uranium-Molybdenum Alloys. Further investigation of the dissolution of U-3 w/o Mo-0.2 w/o Si alloys in concentrated nitric acid confirmed that the solid present (molybdic oxide) carries appreciable amounts of plutonium even after exhaustive washing. In laboratory tests, the solid contained 2.5 per cent of the plutonium present. Different washing techniques aimed at reducing the retention of plutonium are under study. Dissolver solutions at differing nitric acid and uranium concentrations were stored at 25 C and at 50 C for observations of further solids formation. Traces of solids appeared in all of those at 50 C during 25 days storage. No solids appeared in those stored at 25 C during the same or longer periods. Oxidation of plutonium by dichromate (current Redox conditions) was normal in the dissolver solutions following formaldehyde destruction of the excess nitric acid.

The presence of 0.3 M H_3NO_3 had no observable effect on the solubility of uranyl molybdate during dissolution of U-3 w/o Mo alloy in HNO_3-$Fe(NO_3)_3$ solutions.

Removal of Ammonia from Zirflex Dissolver Solutions. A modified Othmer still was used to determine vapor-liquid equilibrium concentrations of ammonia during boiling of Zirflex decladding process solutions. Free ammonia distills from the Zirflex solutions at the same vapor-liquid concentrations as it does when dissolved in water only. The mole fraction of ammonia in the overhead increases from about 1/10 to about 1/2 as the concentration of free ammonia in the bottoms increases from 0.1 to 3 molar. Consequently, it will be necessary to remove greater than one mole of water (as steam) per mole of ammonia produced in order to maintain practical Zircaloy-2 dissolution rates in the Zirflex decladding process.

As an alternate to removing ammonia from the solution, a procedure wherein the ammonia is neutralized with hydrofluoric acid as it is produced is under consideration. In this process, the initial dissolver solution would be 1 M NH_4F-0.5 M NH_4NO_3. Dissolution rates for oxide-free Zircaloy-2 in this solution decreased from 22 to 0.35 mils/hr as the pH was increased from 6.8 to 8.9 by adding ammonia. Further study of dissolution rates versus solution composition and pH is in progress.

Zirflex Batch Studies. Zircaloy-2 tubing (55 mil) was dissolved in Zirflex dissolvent with initial concentrations of 4.8 M NH_4F-0.45 M NH_4NO_3 and an F/Zr mole charge ratio of 7. A boil-off rate of 0.132 lb-mol/(hr)(sq ft) of water was maintained throughout the reaction for the removal of ammonia. A maximum dissolution rate of 23 mils/hr was attained. By comparison, a maximum dissolution rate of 70 mils/hr has been demonstrated in the laboratory for the same initial conditions of the dissolvent. The discrepancy may be attributed to the ammonia effect.

Recirculating Dissolver Studies. Modifications to the recirculating dissolver system were completed to allow the air lift recirculator to be operated with up to 100 per cent submergence. A steam preheater was also installed to permit the use of superheated steam as a motive force for the gas lift recirculator. Tie-ins with an existing centrifuge will permit the complete head end processing of fuel elements; the cycle to include both cladding dissolution and core dissolution.

Zircaloy-2 tubing (55 mil) was dissolved in Zirflex dissolvent with initial concentrations of 5.5 M NH_4F-0.5 M NH_4NO_3 and an F/Zr mole charge ratio of 7. An average recirculation rate of 16 gpm and a boil-off rate of 0.267 lb-mole/(hr)(sq ft) of water were maintained throughout the reaction. A maximum dissolution rate of 35 mils/hr was attained compared to a laboratory rate of 80 mils/hr. This difference in rates is also attributed to ammonia buildup in the pilot plant dissolvent. According to W. L. Swanson's data, the ammonia in the dissolvent may decrease the dissolution rates by as much as a factor of four.

Flooded Tray Dissolver. Ten runs were made to determine the effect of recirculation rate on the dissolution rate of aluminum in mercuric nitrate catalyzed nitric acid. In all experiments, a 0.005 M $Hg(NO_3)_2$ concentration was used.

In acid concentrations of less than 5.5 M HNO_3, penetration rates increased from 10 to 95 per cent of batch penetration rates as recirculation rate increased from 0.12 to 1.2 gallons/(min)(sq ft) charge.

In acid concentrations greater than 5.5 M HNO_3, penetration rates were higher than corresponding batch penetration rates and tended to decrease as the recirculation rate increased.

Sulfex Process. Two bench scale Sulfex dissolution runs were made using the technique of starting the dissolution in 4 M H_2SO_4 after which the decladding solution was diluted to 2 M H_2SO_4. Average penetration rates for the runs were 3-6 mils per hour - about four-fold lower than those obtained in 4 M H_2SO_4.

Total Dissolution of Zircaloy-2 Clad Uranium Dioxide Fuels. In proposed procedure for total dissolution of Zircaloy-2 clad uranium dioxide fuels, the Zircaloy-2 is removed by the Zirflex process. Uranium dioxide cores are then dissolved by adding nitric acid and aluminum nitrate to the decladding solution. In development studies on this procedure, dissolution rates for uranium dioxide were determined in diluted terminal Zirflex decladding solutions [0.6 M $(NH_4)_2ZrF_6$] butted to nitric acid concentrations from 0.75 to 1.5 molar and to aluminum/free fluoride mole ratios from zero to 1.25. Dissolution rates were relatively low and ranged from about 60 down to about 6 mg/(hr)(sq cm). As expected, the rates decreased as nitric acid concentration decreased and as aluminum to free fluoride mole ratio increased.

Solvent Extraction

Recovery of Pu and Np from High Acid Feeds. Batch contact and mini-mixer settler studies are in progress to determine if plutonium and neptunium can be recovered by Redox solvent extraction of acidic feeds without complete oxidation of plutonium. If the heating of dissolver solutions containing iron(III) nitrate and molybdenum can be avoided, a lower iron to uranium ratio could be used without danger of solids formation. Dissolver solution prepared by $Fe(NO_3)_3$-HNO_3 dissolution of U-3 w/o Mo alloy was adjusted to +0.25 M free acid and spiked with Pu(IV) and Np(V). The solution was made 0.1 M in dichromate and, without heating, used as feed for mini runs, simulating Redox first cycle extraction. With neutral scrub and 0.2 M HNO_3 in the hexone, uranium, plutonium, and neptunium losses were 0.011, 0.20, and 0.19 per cent respectively. Reduced feed acidity, neutral extractant and acid deficient scrub resulted in generally higher losses of all three.

Materials of Construction

Testing of Experimental Alloys from Battelle Memorial Institute. Further corrosion tests were conducted on the first twelve experimental alloys produced at Battelle Memorial Institute. As a candidate material for use in the HAPO nonproduction fuels dissolver, the best of these twelve has the basic Hastelloy F composition but stabilized with titanium rather than niobium. Its corrosion resistance is better than Hastelloy F in all decladding and core dissolution solutions contemplated at present for use in the dissolver. "As welded" weldments show little or no preferential weld metal attack even in acid fluoride solutions. "As welded" weldments made with Hastelloy F base metal and the experimental alloy as filler are preferentially attacked at the fusion line in acid fluoride solutions.

Corrosion by Zirflex Wastes. Corrosion rates observed for 1020 mild steel coupons after two months exposure to boiling simulated, neutralized Zirflex decladding waste (pH 9.3) were 0.048, 0.006, and 0.0025 mils/mo in the liquid, vapor, and interface respectively.

Redox Boron Monitor

The boron monitor on the A-2 chemical addition line to the "A" dissolver at Redox was placed into operation this month. Thus far, no boron containing solutions have been added to the process. However, the unit has responded as expected to additions of water, nitric acid, sodium nitrate, and sodium hydroxide.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Complete analytical data have now been obtained for the previously reported "hot" experiment in which a ten gram wafer of UO_2 irradiated to 1.238 a/o burnup of U-235 was subjected to a simulated oxidative clad removal step, a chlorine

dissolution, and a cathodic reduction in molten NaCl-KCl eutectic whereby the UO_2 was recovered as a deposit on a graphite cathode. In contradistinction to the behavior of plutonium in earlier experiments employing unirradiated oxide mixtures, including the UO_2-PuO_2 mixed crystal oxide, the plutonium present in the irradiated oxide dissolved to the extent of ca. 80 per cent. Further, essentially all the plutonium which dissolved also co-deposited with the UO_2 in the cathodic reduction step.

A second experiment in which fresh UO_2Cl_2 and $PuCl_3$ were dissolved in the activity-bearing salt phase resulting from the foregoing experiment and the cathodic deposition step repeated, substantiated the results of the first experiment. In this instance, ca. 83 per cent of the plutonium initially present in the salt phase co-deposited with the UO_2.

Fission product decontamination factors varied considerably between the two experiments. Removal of fission products ranged from 71 per cent (for zirconium-niobium) to 99.9 per cent (for strontium) in the first experiment and 54 per cent (for cerium-praseodymium) to 99.5 per cent (for cesium-barium) in the second experiment.

The possibility that co-deposition of plutonium and uranium can be controlled and utilized to generate a single "blended" product for recycle is an obviously intriguing one and has prompted further studies of plutonium behavior in the salt cycle system. Exploratory experiments completed to date indicate that:

(1) The salt $Cs_2PuC_2Cl_4$ is not appreciably soluble in NaCl-KCl eutectic at 800 C. Since the salt $Cs_2UO_2Cl_4$ is readily soluble under the same conditions, the speculation is that pyrolysis converted the plutonium salt to an insoluble species before it could dissolve.

(2) Exposure of a solution prepared by dissolving $PuCl_3$ in NaCl-KCl eutectic to chlorine for two hours at 800 C does not result in any appreciable oxidation of plutonium, at least when the chlorination is followed by an argon sparge to exclude air and expel residual chlorine from the system.

The cathodic deposition of unirradiated uranium is under study in larger-scale apparatus. The observation of perhaps greatest significance resulting to date from these studies is a tendency to produce much less manageable UO_2 deposits. Whereas earlier work produced cooperative dendritic deposits which could be easily removed from the cathode and which comprised a dense, crystalline powder apparently amenable to compaction by swaging, the recent work has produced very adherent deposits which are difficultly removed from the graphite cathode and then only as hard flakes the acceptability of which as feed for any remotable compaction technique is by no means assured. Variables possibly responsible for this (and currently under investigation) include the fact that the NaCl-KCl salt system was reused through several dissolutions and cathodic depositions (with possible addition or depletion of impurities) and that uranium oxides from several sources were used as feed materials in these studies.

Additional consideration has also been given to means of removing carbon from UO_2 formed by deposition on graphite electrodes. Carbon contents as high as 1000 to 1500 parts per million have been reported for UO_2 deposits formed in earlier work. In experiments aimed at removal of excess oxygen from "UO_2", it was found that reduction with hydrogen at 1700 C likewise reduced the carbon content of a recent sample from 1600 ppm to 70 ppm. However, reduction with hydrogen at 600 C had no effect.

Problems stemming from instability of various instrument components have now apparently been solved, and concrete progress has been made in adapting controlled potential coulometry for determination of the oxygen/uranium ratio in "UO_2". The proposed procedure (as yet not thoroughly tested) entails dissolution of the sample in hot concentrated phosphoric acid, (under an inert gas blanket to avoid air oxidation of U(IV) to U(VI)). An aliquot of this solution is then added to 1 M H_2SO_4, and a coulometric titration made to determine the amount of U(VI) in the sample (whence the O/U ratio can be calculated). Chemical oxidation is then employed to effect quantitative conversion of U(IV) to U(VI). A second titration then determines the total uranium content of the sample. Of several chemical oxidants tested, Ce(IV) was found to be the most satisfactory. The second titration of the excess Ce(IV) and then of the U(VI) can be made about six minutes after addition of the Ce(IV).

It is believed this method will offer significant advantages in sensitivity and precision over the ignition to U_3O_8 as a means of determining the O/U ratio in UO_2. In particular, it should not be subject to uncertainties arising from volatile or combustible impurities (e.g., carbon) in UO_2, and it affords a means of determining not only the O/U ratio but likewise the total uranium content on a single sample.

Aluminum Chloride - Alkali Chloride System

Continued study of the effect of bromide on the distribution of uranium in the system $AlCl_3$-KCl-Al has resulted in distribution coefficients $\left(\frac{g\ U}{g\ Metal} / \frac{g\ U}{g\ Salt}\right)$ as high as 140 if an initial Br:U ratio greater than four is maintained. This value is equivalent to an extraction of 99.3 per cent of the uranium into the metal phase in a single contacting. Since the distribution is almost completely reversed at a very low $AlCl_3$ content, the possibility exists of cycling uranium as aluminum alloy through a salt phase back to an alloy of increased concentration. Such a process would find application to enriched U-235-Al, or U-233-Al fuel alloys.

Dissolution of Al-Pu-Si-Ni Alloy

An investigation of the effect of small percentages of silicon and nickel in Al-Pu PRTR spike elements on proposed dissolution and Redox processing is in progress. A survey of dissolution rates of 1.8 w/o Pu - 1.1 w/o Si-1.35 w/o Ni - 0.35 w/o Fe - 95.4 w/o Al alloy in HNO_3 - $Hg(NO_3)_2$ was made. In thirty-one tests in which nitric acid concentration was varied from 2-8 molar and mercuric nitrate from 0.002-0.05 molar, only four samples dissolved at rapid rates (ca. 30 mg/(min)(sq cm)). The remainder dissolved slowly (ca. 0.5 mg/(min)(sq cm)). There was no correlation of fast and slow dissolving samples with either nitric acid or mercuric nitrate concentration.

Discussions with Plutonium Metallurgy personnel disclosed that the history of the samples used was not known precisely. Chemical composition was reasonably certain but location of the samples on an extruded rod (end or center) was not known. In further studies, only center-section samples from corrosion-passed (high temperature water) rods were used. To date, five such samples representing five

different billets have been tested. All dissolve rapidly (40-60 mg/(min)(sq cm)) in 2 M HNO_3-0.002 M $Hg(NO_3)_2$ but slowly (ca. one mg/(min)(sq cm)) when the nitric concentration is eight molar. Intermediate acidities have not yet been tested. Alloys of Al-Pu, Al-Pu-Si, and Al-Pu-Ni as well as X-8001 aluminum also show this same high dissolution rate in low acid concentration and low rate at higher acid concentrations.

Following complete dissolution of Al-Pu-Si-Ni-Fe alloys (at both high and low dissolution rates), solids representing from one to two per cent (dry weight basis) of the alloy weight were present. Silicon present in the dissolver solution was low ($\leq$ 0.002 M). Dissolver solution produced by slow dissolution was butted to expected Redox feed composition. Dispersion and disengaging time studies with this feed solution and Redox extractant indicated no unusual emulsion forming tendency. Dissolver solution produced by fast dissolution of the alloy will also be tested.

Continuous Ion Exchange Contactor Development

Jiggler Contactor. Several runs using thorium tracer feeds were made during the month. The most successful, operationally, was a cumulative run of eleven hours duration. Wet settled resin to slip water ratio was about one. Some difficulty is being experienced in translating the feed and product analysis to efficiency factors, primarily because of the unknown kinetic effects.

A mechanical dewatering device is being designed to isolate the slip water and the product streams.

Multistage Agitated-Bed Contactor. Fabrication of the 4-inch diameter by 36-inch length two-stage agitated-bed contactor was completed and operational feasibility was demonstrated. The stages are isolated by a resin impervious screen and interstage resin movement is produced by a screw pump. While preliminary observations indicated the resin flow rate to be difficult to control, improvements were made which alleviated the problem considerably. A resin pump of slightly different design, but utilizing the same basic principle of screw transfer is being fabricated.

Weiss Unit. Efficiency runs using thorium have been initiated, but results are not available at report time. Operation at aqueous flow rate of 200 gal/(hr)(sq ft) was quite smooth and stable.

RADIOACTIVE RESIDUE PROCESSING DEVELOPMENT

Radiant Heat Spray Calcination

The alterations to the spray calciner were completed during the month and the unit returned to service. These modifications have resulted in a considerable improvement in the operation and an increase in the capability of the unit. Due to the increased power, time required for startup has been reduced from three hours to less than one hour. A series of shake-down runs have been made with generally satisfactory results. A new water-cooled nozzle insert was used during the last run of the month and proved effective in reducing the buildup of

material around the nozzle, replacing the "doctor blade" previously used to remove this buildup. Only the performance of the ceramic filters has proven disappointing. These filters crack easily and appear to pass a considerable amount of solid material.

A series of runs have been initiated aimed at determining the limiting capacity of the spray calciner. The flow rate of feed (simulated Purex formaldehyde-treated 1WW) has been increased to 1.5 gal/hr (4 gal/(hr)(sq ft)) without difficulty and without any evidence of deterioration in product quality.

One run was made to determine the behavior of ruthenium when processing acidic Purex waste (as contracted with the run with neutralized waste reported last month). Non-radioactive ruthenium was spiked into a high-sulfate, formaldehyde-treated, synthetic 1WW. The upper section of the column was heated to 555 C and the mid-section to 820 C. Flow rate was 0.95 gal/hr. Over 98 per cent of the ruthenium was found in the calcined product with less than 0.1 per cent ($DF > 10^3$) in the condensate and scrub solution. Retention of ruthenium in the solids was apparently at least as good as in the run with neutralized waste. Cesium analyses have not been completed, but those on the previous run indicated near quantitative retention in the calcined solids with a DF of > 600 to the off-gases. These results suggest that ruthenium and cesium evolution may be much less of a problem in the spray calciner than with other types of calcination equipment.

Radioactive Residue Fixation

Mineral Reactions. The effect of accompanying ion on the adsorption of cesium by clinoptilolite was studied within the cesium concentration range of 10^{-6} to 0.1 M. Cesium concentrations in most wastes will be less than 10^{-2} M and in low-level wastes will usually be present as a "trace" such as in Columbia River water (concentration about 4×10^{-9} M Cs). Experiments were conducted with clinoptilolite columns receiving solutions containing 1.0 M Na^+ and various cesium concentrations. The number of column volumes of effluent required to achieve a 50 per cent breakthrough was used as a measure of mineral capacity in each case. The number of column volumes required increased with decreasing concentration down to 10^{-3} M cesium. Below this, the number of column volumes required to reach 50 per cent breakthrough remained constant, implying a constant distribution coefficient in that concentration range.

Fixation of Radioactive Wastes. The first cold run in the pilot plant equipment was completed using demineralized water and a bed of clinoptilolite. Purpose of the run was to determine system reliability and to develop satisfactory operating techniques and practices. Modifications are being made to correct deficiencies where difficulties might be expected under SWP conditions. Modifications are also being made to the 271-CR Building air conditioning system to insure proper air flow in the vicinity of the test equipment.

Plutonium Recycle Test Reactor. Ceramics Fuel Development was assisted in estimating uranium contamination on several suspect fuel rods. Nuclear films were employed for spot checks. A scintillation alpha particle counter for testing large areas was designed and parts ordered fabricated.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Excretion Rate of Zn^{65}

Gamma ray spectrometric measurements of the Zn^{65} in bioassay samples from ten individuals with measured Zn^{65} body burdens up to 2.3×10^5 d/m were made. Positive values were obtained on only two urine samples from which the excretion rates were 0.06 and 0.14 per cent body burden per day. The six feces excretion rates varied from 0.4 to 2.7 per cent body burden per day. It should be possible to detect 0.1 per cent of the maximum permissible body burden by urine bioassay and 0.01 per cent by feces bioassay using 500 ml samples and the large scintillation well counter.

Phosphate Addition to Reactor Coolant Water

Small quantities of phosphate were added to the coolant water for two in-reactor tubes for several days. The P^{32} analyses of the effluent water which were made throughout the period and for many days thereafter showed some striking differences from the previous arsenate addition tests. Immediately upon starting the addition, the P^{32} concentration in reactor effluent water increased a factor of three to four, fell rapidly during the next eight hours, and then increased in a manner similar to the arsenate case. Immediately upon discontinuing the addition, the P^{32} value dropped to 60 per cent the original value, then rose during the next few hours to a value somewhat higher than the original value and then showed a decrease similar to the arsenate. Further studies will be needed to explain this unusual behavior.

Strontium-90 Procedure

The influence of calcium on the precipitation of strontium nitrate from concentrated nitric acid was investigated. The data showed that the strontium nitrate solubility was increased when large amounts of calcium were present and this increase in solubility could account for the loss in chemical yield of strontium observed under these conditions.

[redacted]

Geology and Hydrology

The drive barrel method of drilling, in place of the rock bit and bailer method, again proved valuable. In this method an open tube, slightly smaller than the well casing, is driven into the sediments in the well bottom and withdrawn with the contained sediments. No bit is used and no water is added thus the samples are less disturbed than by drilling with bit, intermingling of sediments from different depths is minimized by the dry drilling, and determination of natural moisture content is possible. The drillers, although initially inexperienced in its use, have been able to use it about 30 per cent of the time, and in ideal materials, drill appreciably faster than with bit and bailer. Samples obtained by this method are being compared to those from the same geologic horizons in adjacent wells drilled by earlier methods to afford a cross-check and to determine the full desirability of further use of the method.

In deriving and testing a mathematical model for unsaturated flow of water through a porous medium it was found necessary to introduce a term which may be considered to represent the part of the moisture content of the medium which does not effectively contribute to the flow rate. In this sense, the term is introduced in the formula as an empirical correction on the measured total moisture content. Other experimenters refer to this empirical term as the "tortuosity" of the system when it is introduced in a slightly different way. The Hanford unsaturated flow formula contains two empirical "ineffective moisture content" terms, one under the conditions being considered (μ) and the other representing saturated conditions (μ_s). These two unknown terms require that an iteration process be used in solving the equation. It is possible to evaluate μ directly if a flow range can be found within which moisture content (M) varies but μ remains essentially constant. Experimental unsaturated flow data for seven different soils were examined to test the extent of such a region. In all cases it was possible to select narrow ranges of flow across which $\Delta \mu / \Delta M$ approached zero. From this, a method can be proposed for direct approximation of μ by relatively simple means without resorting to exhaustive iteration procedures.

The application of the principle of specific retention of wastes by soils has been used at Hanford in past years. The concept of a constant moisture retention property of soil is generally used in defining this disposal method. This concept is recognized as being inadequate since the phenomenon it attempts to describe really involves transient unsaturated flow. A study was initiated to study such a flow system. It will be possible to apply the previously derived unsaturated flow formula to this study in the case of certain soils but for others direct solution of the problem is not possible. Accordingly, finite difference formulation is underway for numerical solution in those cases.

Soil Chemistry and Geochemistry

Study was completed on the relative effect of other cations on the capacity of clinoptilolite for Cs adsorption. In 1.0 N solutions, the effect of various ions was in the decreasing order Rb^+, K^+, Sr^{+2}, Na^+, Ca^{+2}, Mg^{+2}, Li^+.

The capacity of clinoptilolite for strontium removal was studied in greater detail to examine possible methods of improvement. At the present time the two materials that seem most suitable as adsorbers for strontium are clinoptilolite and Linde-4A zeolite. The pelletized form of the synthetic zeolite has a limited capacity for strontium removal and has poor acid resistance. Methods of improving the usefulness of both materials for adsorbing strontium are being sought.

It was found that both the strontium capacity and strontium adsorption rate of clinoptilolite can be increased by raising the temperature of the system. Longer residence time in the columns (slower flow rates or longer columns) also improved strontium removal. These results suggest that the removal of strontium from solution by clinoptilolite is controlled by a diffusion mechanism. It may be that the selectivity of the mineral for cesium is caused in part by differential diffusion rates for various cations in the pores or along the surfaces containing the adsorption sites. Experiments were conducted to measure the influence of strontium concentration on the capacity of clinoptilolite for adsorbing strontium from solution. Columns flowing at 100 gal/(sq ft)(hr) at 25 C were used in these experiments. The loading capacity of the mineral was calculated from the throughput volume required to obtain a 50 per cent breakthrough, assuming a symmetrical breakthrough curve. These experiments revealed a capacity of 30 meq/100 g at a strontium concentration of 1×10^{-3} M and 57 meq/100 g at a strontium concentration of 0.05 M.

Laboratory work was continued to characterize the reaction of soils with zirconium isotopes in waste solutions. In the case of 3.2×10^{-2} M solutions, the zirconium is apparently greater than 99 per cent precipitated over the entire pH range studied from pH 1 to pH 13. In the lower concentration, zirconium systems studied (10^{-4}, 10^{-5}, and 10^{-7} M), the zirconium was always associated with the solid phase in systems with a solution pH under 8. In similar systems having a solution pH higher than 8, as much as 20 per cent of the zirconium could not be centrifuged from the supernatant solution. It is possible that precipitated zirconium was peptized to a colloidal form in this pH range, or the zirconium may be associated with peptized soil colloids. The presence of as little as 0.05 M NaCl appeared to prevent the formation of this peptized colloid. Above pH 12.8 no evidence of peptization was found.

Ground Waste Investigations

Laboratory research data evaluating the effect of competing ions on the soil adsorption of Sr were obtained, using both flowing columns and equilibrium experiments. The adsorption of strontium from a 0.1 ppm solution was examined in systems containing various concentrations of one of the three accompanying ions studied. The three ions examined were Na^{+}, Ca^{+2}, and Mg^{+2} in concentrations ranging from 10 ppm to more than 100,000 ppm. The 0.5 C/C_o breakthrough point was used as a measure of soil "capacity" in the case of column experiments. This was found too highly correlative with the distribution coefficient determined from equilibrium experiments. The correlation indicates the applicability of these simple batch experiments to the evaluation of soil adsorption columns having flow rates comparable to these experimental ones (4.3 ml/cm^2/hr). The data were used in comparative evaluation of the influence of the concentration of accompanying ion on strontium adsorption

and indicated that at low accompanying ion concentrations magnesium competes with strontium more strongly than does calcium. At concentrations near the high end of the range studied, the opposite order was found with calcium competing more strongly than magnesium.

The field experiment with a model crib continued with a total of 3,527 gallons of strontium-spiked calcium nitrate solution having been added to date. The small (6-inch by 6-inch) crib will accept the solution only at the very low rate of about 4 gal/day. It was found that this small rate of addition resulted in such slow concentration changes in the ground water that samples from surrounding wells need be obtained but once a week. The gradual increase in nitrate and radiostrontium concentrations in the ground water in wells adjacent to the crib continued no significant deviation from previously established trends being observed.

Field Apparatus Development

Work continued in the development of apparatus for the laboratory determination of moisture in soils. Measurement of the electrical resistance of hydrophobic materials (Teflon shavings and Dri-filmed Ottawa sand) in contact with the wet soil showed some promise as a method. High initial sensitivity is obtained but the calibration changes on cycling from dry to wet soil.

A well-water multi-depth sampler was designed and a single unit ordered fabricated. The sampler will permit samples from several depths to be taken simultaneously.

Micromeritics

The minor influence of surface roughness on deposition rate by turbulent impaction of two and four micron particles was demonstrated. The deposition constant was measured in 3/4-inch pipe whose internal surface roughness ranged from polished to as-manufactured finish. For equal Reynolds numbers (3,000 to 17,000), the deposition constant for the various surfaces was not appreciably different.

Equations were developed which empirically related important variables affecting particle deposition. The pipe diameter enters into the relationship as part of two dimensionless parameters yet the data indicate that a third parameter including the diameter term is required to explicitly define particle deposition rate.

L. P. Bupp

Manager,
Chemical Research & Development

LP Bupp:lg

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

No significant changes in organization took place during the month.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

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

Location	μc/g Wet Wt. Average	μc/g Wet Wt. Maximum	Trend Factor
Prosser Barricade	2×10^{-3}	3×10^{-3}	-
Wahluke Slope	1×10^{-3}	2×10^{-3}	- 2
4 Miles SW Redox	1×10^{-3}	2×10^{-3}	- 3

Columbia River Contamination

Concentrations of gross beta emitters in whitefish flesh were about the same as observed one year ago. Values follow:

Location	μc/g Wet Wt. Average	μc/g Wet Wt. Maximum	Trend Factor
Priest Rapids	7×10^{-6}	7×10^{-6}	- 11
F-1	2×10^{-4}	2×10^{-4}	- 3
Ringold	3×10^{-4}	8×10^{-4}	-

River ducks found in a weakened condition on private farmland in the Pasco area were the subject of newspaper publicity which insinuated their disability was from "radioactivity". Tissues of two specimens contained background amounts of alpha emitters and concentrations of gross beta emitters one-half the amounts observed in ducks from the river during November and one year ago. Average amount of beta emitters in flesh was 5×10^{-5} μc/g wet weight.

Fallout Contamination

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

Sample Type	μc/g Wet Materials Average	Trend Factor
Feces	2×10^{-5}	-
Bone	1×10^{-5}	- 2
Muscle	4×10^{-6}	- 2
Liver	4×10^{-6}	-

Effect of Reactor Effluent on Aquatic Organisms

Routine monitoring of the effluent from the 100-KE reactor was continued with juvenile chinook salmon which began feeding about the middle of the month. The conditions under test are:

1. Reactor effluent at concentrations now occurring in the Columbia River.
2. Concentrations of effluent predicted for about five years hence.
3. Control.

Survival has been exceptionally good in all lots and no indication of adverse effects have been noted.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Phosphorus

Exposure of cichlids to water containing radiophosphorus was continued. The single mortality which has occurred to date was in the controls and there has been no evidence of radiation damage in any of the experimental lots. The hoped-for spawning of these fish has not yet occurred.

Gonad Dose (Zinc)

Ten to twenty per cent of an ingested dose of Zn^{65} was absorbed from the gastro-intestinal tract of a ram. Tissues measured showed a high uptake of Zn^{65} as compared with blood plasma. Most tissues had a rapid turnover of radiozinc (but not as rapid as has been observed for smaller animals such as the mouse and rat).

Five days following intravenous administration, the liver, kidney cortex, testes and pancreas, respectively, showed the highest uptake. Voluntary muscle and bone had much slower rates of turnover, and after 20 days showed concentrations only slightly lower than liver.

Retention of radiozinc by the red blood cells was great enough to suggest that the Zn^{65} was firmly bound in the red blood cells in a form almost unavailable for ion exchange. Therefore, the tagging of red blood cells with Zn^{65} might provide a new method for measurement of their life span.

Although the average uptake of Zn^{65} in the liver was comparable to that previously reported for other large experimental animals, the concentration found in the kidney cortex was in all cases more than twice that in the kidney medulla. This could be related to the location of specific enzyme systems in the kidney or to relative amounts of parenchymatous tissue.

Strontium

Preparations are still under way for an experimental test to determine the effects of Sr^{90}-Y^{90} fed to rainbow trout. A slight delay in getting this experiment started has bee occasioned by the development of improved techniques for administering the isotope to the fish and the training of technicians in the new methods.

No significant changes in the cellular components of the blood of any of the groups of miniature swine were observed during this month.

(X-ray plates -- approximately 120 -- were taken of representative animals in the adult and F_1 generations on chronic Sr^{90} feeding and their controls. The films are being examined for evidence of bone pathology.)

An experiment was initiated to study the effect of simultaneous variation of phosphorus and calcium levels in the diet on the retention and excretion of a single dose of Ca^{45} and Sr^{90} in rats.

Iodine

No important changes were observed in any of our iodine studies with sheep or swine during this month.

Cesium

Bean seedlings were grown on soil maintained at 10, 40, 70, and 100 per cent of available soil moisture. Concentration of Cs^{137} in leaves and stems of plants grown with low moisture was approximately twice that in plants grown with high moisture. The Observed Ratio was also higher in plants grown with low moisture.

Plants grown in solutions containing varying ratios of Cs/K gave evidence of metabolic competition between these two ions while uptake appears to be non-competitive. Distinct yield reduction was noted when the Cs/K ratio in the solution exceeded 1. Visible symptoms of this toxicity were similar to that seen with K-deficiency although K concentrations in the plant were not reduced.

Plutonium

Three pigs were treated with a single dose of DTPA one hour following plutonium administration. Blood and excreta samples were obtained for several days. The animals were then sacrificed and will be analyzed for plutonium content. No data are yet available.

In a continuation of the cooperative study between the Animal Farm and Metabolism Operations on Pu^{239} burdens in miniature swine, three animals were injected intravenously with Pu^{239} followed by administration of DTPA.

Comparative Toxicity of Ra^{226}, Pu^{239} and Sr^{90}

The study to determine the comparative toxicity of Ra^{226}, Pu^{239} and Sr^{90} was initiated in October 1959 with 6-week, 6-month, and one-year old miniature swine. In the six-week old groups, blood inorganic phosphorus levels at one month following intravenous administration were significantly lower for Ra^{226} ($P < 0.01$) and Sr^{90} ($P < 0.05$) groups, while albumin values were lower for the Pu^{239} ($P < 0.002$) and Ra^{226} ($P < 0.05$) groups, as compared to their controls.

This month three one-year old miniature swine were given intravenous injections of Ra^{226} (6.4 μc/kg of body weight), and a similar group were injected with Pu^{239} (1.3 μc/kg of body weight). Both groups will be held for long-term toxicity manifestations.

(The 165 x-ray plates made of all the animals in the comparative toxicity study are now being evaluated.)

Radioactive Particles

Histological preparation of tissues from mice killed 500 days after inhalation of plutonium oxide or ruthenium-106 oxide is complete and examination of the tissue sections will be concluded within a few weeks.

Five beagle dogs were exposed to plutonium oxide aerosols for a study of the acute toxic syndrome. In other studies with beagle dogs, the acute lethal dose of inhaled plutonium oxide is less than earlier estimated. Tissue analyses are not complete, but estimates of the plutonium lung burden with the whole-body monitor suggests that the initial lung deposition of dogs dying within two months after exposure was less than 50 μc.

Progress is being made in the assembly of instruments for the control of respiration during the inhalation of plutonium oxide and the measurement of physiological parameters as criteria for the biological effects of inhaled plutonium.

Gastrointestinal Radiation Injury

The effect of intestinal radiation on the fecal excretion of intravenous administered PVP was shown to occur only after single large doses of radiation. Total doses of 1000 to 1500 r accumulated in 250 r increments twice a week were ineffective in eliciting the response. A response similar to that obtained with radiation doses in the lethal range was seen in animals treated with the radiomimetic agent, nitrogen mustard.

C. Lectures

a. Papers Presented at Meetings

W. J. Bair, "Radionuclide Toxicity from Pulmonary Absorption," Training Program of the Sanitary Engineering course entitled "Radioactive Pollutants in Air," January 29, 1960, Cincinnati, Ohio.

b. Off-Site Seminars

J. J. Davis, January 12, 1960, - "Radioecology at Hanford", Washington State University, Pullman, Washington.

L. A. George, January 12, 1960 - "Radiation Biology at Hanford," Grandview High School.

c. Seminars (Biology)

J. R. McKenney, January 13 - "A Report on the Bioenergetics Symposium held at Brookhaven Laboratory"

H. E. Erdman, January 13, "Radiobiological Analysis of Sterility and Lethality Induced when Electromagnetic Irradiations are an Environmenal Factor during Significant Life Cycle States of Habrobracon juglandis (Ashmead),"

W. J. Clarke, January 27, "Biological Effects of Strontium-90 in Miniature Swine. I. Experimental Design and Preliminary Results"

P. A. Olson, "The Uptake of P^{32} by Fish," January 27.

Dr. Laurence Kulp, Prof. of Geochemistry at the Lamont Geological Observatory, Palisades, New York, January 22 - Fallout Studies.

d. Seminars (Local)

J. J. Davis, January 18, - DASA, "Radioecology"

W. C. Hanson, January 21 - Lewis and Clark 4th and 6th grades, "Narrated color slides of Alaska".

W. C. Hanson, January 26, "Project Chariot - Environmental Studies," Naval Reserve Research Unit, Richland.

L. K. Bustad, January 23, "Hanford Biology," Annual Mtg. of Washington State Business and Professional Women, Richland.

D. Publications

a. HW Publications

None

b. Open Literature

R. F. Foster, "The Need for Biological Monitoring of Radioactive Waste Streams," Sew. and Ind. Wastes 31 (12) 1409-15 (1960).

Tissue Transplantation for Radiation Therapy

Two of three miniature swine exposed to 900 r total-body x-irradiation were given injections of 70-day-old fetal swine hematopoietic tissue, the third animal serving as a control. Since all three swine died within 14 days, it appears that 70-day fetal cells are too immature to protect the irradiated host from the radiation syndrome.

Microbiological Studies

Initial studies of the early growth phases in yeast show a clearly defined lag phase in both irradiated and control cultures when turbidity was measured. No lag phase in control cultures was noted when viability was measured but a distinct lag was observed in irradiated cultures. It is hoped that these studies will clarify the manner by which cell growth is slowed under conditions of chronic irradiation.

Effects of Strontium-89 on Populations

Cultures of a grain infesting insect were established in media spiked with different concentrations of Sr^{89} to study uptake by and effects upon the populations.

F P Hungate

Acting Manager
BIOLOGY OPERATION

FP Hungate:es

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - JANUARY, 1960

ORGANIZATION AND PERSONNEL

R. J. Brouns transferred to the operation on January 18, 1960 to assume responsibility for a special study.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Simulation Model

Debugging and testing of the GCL estimation program continued. Preparations have been made for a final test program to be run early in February.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

A review was made of the methods of collecting and reporting FPD measurements used in the quality certification program. It was found that the manner in which total count data were recorded resulted in inefficient use of the data, and recommendations for improvements were made and adopted.

The first post-irradiation measurements have been taken on fuel elements charged under the quality certification program. These are being used to test several hypotheses concerned with groove pitting and hot spot formation. It is planned to issue reports monthly once the program is in full operation. Steps are being taken by IPD personnel to utilize IBM equipment in this connection.

Fuel Element Failures

Further assistance was provided in the design of a test intended primarily to investigate rupture performance in high-powered tubes carried to high exposures. The proposed test has been designed to yield additional information helpful in evaluating the potential benefits of the quality certification program, and in estimating the potential of the alsi-dip canning process.

Basic rupture rate relationships are expressed on a tube basis. The rupture rate of a reactor can be expressed as a simple function of the tube rupture rates, but the mechanics of computing this function leads to practical difficulties, especially when rapid approximate answers are desired. Within a given reactor, there is enough consistency in the flux distribution to permit expressing the reactor rupture rate as a function of operating data for the highest powered tubes. Such expressions were found for the different reactors.

Optimization of Reactor Operations

A primary consideration in evaluating the effects of operating reactors under different sets of conditions is the total downtime required. Since extrapolation to some conditions results in an increased number of unscheduled

outages, it is essential to consider how downtime is utilized in unscheduled outages. In attempting to determine this, contact has been made with production personnel in IPD who are also interested in reviewing basic definitions used in charging downtime to various causes, and in obtaining consistency in such efforts. A study is being made in this general area.

Process Tube Leak Detection and Replacement

A selection was made of tubes to probolog during the scheduled February 1 outage. It is anticipated that the method used to select these tubes will not result in an appreciably better percentage of success than that experienced in recent outages. It appears that a higher percentage success (i.e., selecting tubes for probologging which show severe or medium external corrosion attack) can only be achieved by probologging fewer tubes, viz., those most likely to have severe attack. The question really resolves itself into a determination of the optimum probolog schedule, balancing the real costs of probologging against the benefits obtained. Additional effort in this problem area will be directed toward this end.

Z-Plant Information Study

The AEC bid request for computing equipment to be used in the Z-Plant study was issued January 28. It is presently estimated that the purchase order for lease will be issued late in February barring difficulties in the interpretation of specifications.

The Z-Plant study team has been active in re-creating the logic and definition for future plant processes. The problem has become much more complex due to the inclusion of additional models and components.

Reliability Studies

Work on the K reactors system reliability study continued.

Further work has been done on the NPR reliability study. The system parameters have been defined, numerical values assigned to them, and the mathematical model is ready to be programmed for computation.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Roughness data were analyzed from several more co-extruded tubes. Recommendations made previously with respect to methods of measuring the roughness (variation in clad thicknesses) have resulted in quicker and more meaningful measurements.

Data were analyzed from two previously designed aluminum component cleaning experiments recently conducted in the 306 pilot plant. One was concerned with the use of ultrasonics, and the other compared two de-oxidizing agents. The design permitted an estimation of block effects, where the block was time. A large block effect, consistent over two days of operation, in one of the experiments has led to investigation of the cause(s) of such an appreciable difference in effectiveness of cleaning as a function of time of day.

Vibrators are used in the canning process to improve bond integrity. Recent work has shown that the vibration frequencies are far from constant which has led to an investigation of the effects of such frequencies. Two experiments were designed in this connection to be conducted in the pilot plant. The one involved 3 factors at 3 levels and a cuboctahedron design, replicated, was used. The time blocking was such that this design can be replicated once in a half day. The design is also orthogonal, is more efficient than the 3^3 on a per point basis, and provides a true estimate of the residual error since the center points are replicated.

A report was issued in connection with the experiment on nickel concentration in the baths. It was pointed out in this report that the time effects could not be separated from the nickel concentration effects, so that the conclusions drawn are largely speculative.

Data were analyzed from the experiment previously designed to estimate the incidence of striations in acceptable fuel elements. The motivation behind this is the possible savings currently associated with bare core striation rejects. It was thought that the acceptable pieces also had striations which were imbedded and hence unobservable. In this experiment, the effect of canning on warp was also investigated.

Two sets of data concerned with bond strengths have been evaluated. One dealt with bond strengths as a function of operating conditions used to affix the stud, and was conducted in order to determine how much latitude in such conditions can be tolerated. The other pertained to an evaluation of the bond strength of fuel elements boiled in caustic nitrate.

In connection with determining whether NPR fuel elements should be autoclaved individually or in groups, probabilities of simultaneous failure of more than one fuel element in a given autoclave were determined.

Irradiation Processing Department

A study is being made of the possibility of accurately pre-setting panellit gauges. Considerable savings can result if it is possible to predict the flow through a given tube based on tube and/or fuel element characteristics.

As an aid in assessing the effect of process tube wear on fuel element behavior and the evaluation of proposed corrective mechanisms, mathematical formulas were developed to calculate various critical water annulus dimensions as a function of fuel element radius and process tube rib heighth.

Chemical Processing Department

The rough draft presentation of part by part acceptance has been completed. Revisions are being made prior to approval by CPD personnel. The final document will then be submitted to LASL personnel for approval. Preliminary attention is also being given problems of demonstrating conformity to specifications for the expected new model types.

The application of the use of the minimum variance inventory calculation of BPID's was explained to Production Operation personnel. Further attempts

are being made to have this method incorporated in CPD control systems.

A report was issued describing the recommended procedure for calibrating process vessels. The C-1 vessel was calibrated during January using this procedure, and the data are currently being analyzed.

The design specifications of two cams to be employed in the guiding mechanism of the Gorton lathe during the continuous machining of proposed weapons components were computed and submitted.

Several mathematical models were constructed and the properties of their solutions studied in an attempt to evaluate the heat dissipation behavior of large casks designed to transport quantities of radioactive materials over long distances. In particular, bounds on the extreme temperatures resulting from possible accidentally induced severe environmental conditions were obtained.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Reactor Studies

Study continued on the behavior of the solutions to the three-parameter differential equation of reactor kinetics. Approximate solutions have been obtained for appropriately restricted values of the parameters, and all exhibit the unpleasant phenomenon of instability. Further investigations are being made to extend the validity of the solutions to greater ranges in the values of the parameters.

Two mathematical models are being studied in order to better understand the physical processes involved in the so-called non-destructive frost test for reactor fuel elements.

Chemical Development

Further analysis of sulfex data must await the completion of the GCL program for the estimation of parameters in a linear structural model. A study of the literature was made to learn more about the kinetics of metallic dissolution reactions.

In support of the study of the Zirflex process, an experimental design was recommended to investigate the effect of $(NH_2)ZrF_6$ and pH on the dissolution rate of zirconium. A pilot study involving 8 experimental runs at various combinations of these two factors is currently being carried out. Analysis of the resulting data will indicate whether or not a more comprehensive study is necessary to determine the effects and interaction of the two variables on dissolution rate.

Mathematical assistance is being given in constructing a model of ground water flow in the vicinity of a large source of radioactive wastes. In particular, the hodograph method proposed by Dutch soil scientists appears to be promising.

Zirconium Corrosion

The statistical analysis of zirconium corrosion data was completed. The results of the analysis will be used to calibrate future autoclave experiments to investigate the relationship of ambient temperature and pressure conditions on the corrosion rate of zirconium samples. An experimental design was recommended to minimize the biases due to sample position within the autoclave, and a method for calculating 95% confidence interval estimates for average corrosion rate was suggested for future tests of this type.

A mathematical model was derived for the corrosion of zirconium as a function of time. The model expresses total corrosion as an interaction of parabolic and logarithmic corrosion mechanisms. Consideration is being given to the problem of estimating the parameters of this model both from current zirconium corrosion data and from designed experiments.

Zirconium Physical Properties

Statistical analysis was continued on data from a recent experiment to investigate the effect of hydrogen content, ambient temperature, and notch orientation on fracture angle, fracture moment, and impact breaking strength for both annealed and cold work zirconium samples.

4000 Program

Swelling Studies

Further analysis of the distribution of uniform diameter balls in a "scotch" medium has been made in order to establish a correction factor for distortion introduced in the processing of the micrographs.

Consideration is being given to improved methods of reading the micrographs in line with what can reasonably be interpreted as a significant change in pore diameter distributions. A method was derived for correcting pore density estimates and volume fraction estimates for the bias introduced by failure to observe pores with apparent diameters below a convenient visual resolution value. When a large portion of the pores are of small diameter, the bias effect on a pore density estimate is quite serious. In this connection, the exact solution to a Volterra integral equation of the first kind was obtained.

General

Instrumentation

In connection with the study to determine the feasibility of automation of gamma spectroscopy, data from scans of known isotopes are being processed to determine the relative magnitude, compared to counting statistics fluctuations, of instrument instability in several routinely used

instruments. A set of monoenergetic sources is being prepared for the empirical study of the similarities in monoenergetic spectra in hopes that a nominal set of monoenergetic spectra can be used to generate all such spectra in the less than 3 mev. range.

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:kss

PROGRAMMING OPERATION
JANUARY 1960

A. FISSIONABLE MATERIALS - 2000 PROGRAM

Special Radioisotopes

With the preparation of a report on "A Proposed Research and Development Program on The Recovery and Utilization of Thorium-230 (Ionium) From Uranium Ore Milling Processes" the work on this study was completed.

B. REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. The IBM-709 versions of the GPR and Puck codes were completed. These codes allow the complete calculation of fuel cycle costs starting with the basic physics parameters for any reactor together with a wide variety of desired economic parameters. MELEAGER, an IBM-709 computer code for the calculation of fuel reactivity and composition during exposure, was also completed. A written description of the MELEAGER code is under way.

The last of the cross-section portion of the basic library of the RBU code was coded and punched on IBM cards. The task was quite lengthy - more than 10,000 IBM cards were required.

Plutonium Fueling Analysis. Work started on an extension of the material published in HW-59758 REV.(1) The first parameter to be studied will be the effects of changing the moderator to fuel ratio in a reactor lattice.

PRTR Startup. Work in support of PRTR Startup continued. Topics emphasized included analysis and review of Process Specifications and Critical Tests.

PRTR Plans and Schedules. Commission approval was granted for the program to prepare about 40 kg of high exposure plutonium.

Study of fueling schedules for the Plutonium Recycle Program continued. Investigation of the timing involved in scrap recovery showed that some savings in high exposure plutonium utilization may be possible. Further analysis will be required to determine feasibility of the operations required.

The Plutonium Recycle Program Annual Report for FY-1959 was issued.

(1) HW-59758 REV., "A Calculation of the Reactivity Worth of Plutonium and Uranium-235 as Enrichment in Thermal Reactors", D. P. Granquist, 8/8/59.

SPECIFIC FUEL CYCLE ANALYSIS

Physics design data for the Advanced Pressurized Water Reactor Study described in TID-8502, Part I, were received from Combustion Engineering. These data will be used with the MELEAGER code to study various plutonium fueling schemes.

Significant progress was made on the development of a single-pass plutonium fueling economics code. The code will permit study of reactors utilizing four discrete fueling zones, use of batch as well as continuous charge-discharge, any price schedule for enriched U-235, any interest rate, and features fully automatic optimization. This code, coupled with the MELEAGER physics code, will permit the very rapid study of the variety of fueling schemes using plutonium feed of various compositions.

C. BIOLOGY AND MEDICINE - 6000 PROGRAM

Radiological Consultation

Consultation was rendered on the hazards of thorium and research required to better define the problems, on the influence of radioactive material on local water supplies, environmental monitoring, and the need for research on relative biological effectiveness of radiations.

Other matters undertaken include revision of Handbook 42, and inhalation hazards.

D. OTHER ACTIVITIES

A review of Hanford's 6000 research and development programs was arranged in conjunction with a visit of the Advisory Committee to the Division of Biology and Medicine.

A review of Hanford's current and potential near term participation in the AEC Division of Reactor Development programs was arranged in conjunction with a visit by senior personnel of the DRD.

Assistance was rendered in arrangements for nine tours (involving 124 people) through HLO and HAPO facilities.

Manager, Programming

LH McEwen:dl

RADIATION PROTECTION OPERATION MONTHLY REPORT -- JANUARY 1960

A. ORGANIZATION AND PERSONNEL

Emily H. Szymanski was deactivated for personal illness on January 10, 1960. G. R. Yesberger terminated on January 15, 1960. Fumia Ono transferred into the Radiological Evaluation Working Group on January 18, 1960. Two beneficial transfers were made within Radiation Monitoring Operation to broaden experience. The force of the Radiation Protection Operation totals 132.

B. ACTIVITIES

Two minor plutonium deposition cases were confirmed during the month. The total number of deposition cases that have occurred at HAPO is 246 of which 178 are currently employed.

Plutonium contamination up to 80,000 d/m on an employee's hands and personal clothing occurred during the loading of the lattice in the critical mass approach tank in the TTR Room, 305-B Building with 5 w/% plutonium aluminum (Pu-Al) zircaloy clad fuel elements. Although the elements were surveyed and found to be free of surface contamination on shipment from the 200-W Area, subsequent investigation showed that excessive machining on one end cap penetrated the weld and allowed subsequent corrosion penetration of the cladding. Decontamination of personnel and equipment was successful.

Consultation was provided to Construction Engineering following a survey which revealed uncontrolled exposure to contractor personnel during radiographic testing of welds at the PRTR site.

Surveys were made at Riverland in preparation for removal of most of the transportation equipment from that location and excessing the buildings. Nominal, permanent control of the maintenance pits will probably be required because of residual contamination. Repair and maintenance work on regulated transportation equipment formerly performed in the 269-W regulated garage was transferred to the new transportation facilities in the 2713-WB Building, 200-W Area

A Richland residence of a Plant Laundry employee who had received shoe contamination of uncertain origin was surveyed. No contamination was found.

Difficulty with high background of NTA slides continued in the Bioassay laboratory. Contact with Rocky Flats personnel indicated that similar trouble had been experienced with recent shipments of film. The vendor was informed of the problem and has decided to move NTA slides from the special products category to routine manufacturing where quality control measures will improve the product. The design of a replacement evaporation hood in the Bioassay laboratory was completed and requests for fabrication bids were initiated.

The Whole Body Counter was out of operation from January 11 to January 26 for safety modifications to the door opening mechanism. The new screw drive is operable, but apparently was under-designed. A large screw shaft and pillow

blocks will be required. Difficulty with the operation of the 256-channel analyzer continued. The difficulty was attributed to low voltage service to the WBC building. Transformer installation close to the building is expected to resolve the problem. Only 13 routine and three post-incident examinations were made during the month in the WBC.

Containers were designed and ordered for the 90 criticality dosimeters which were received from the AEC in late December. Arrangements were made with the SS Accountability Operation to write off the plutonium wafers for accountability purposes. The Oak Ridge criticality dosimeters are being calibrated and readied for field use. The Radiological Chemical Analysis group is studying their capabilities to perform the necessary counting and radiochemistry work required for the evaluation of these dosimeters.

Equipment was fabricated and initial exposures were made for comparing exchange badges between the Savannah River Plant, Rocky Flats Plant, Los Alamos, and Hanford. No results were available at month end.

The use of technical grade tetrasodium EDTA for skin decontamination was approved by Industrial Medicine. Distribution of this agent for field use is in progress.

Findings in the environs were about as expected for this season of the year. No unusual trends or incidents occurred. Preparation of the annual HAPO environmental report was started. Fabrication of the copper clad tank for the continuous Columbia River monitoring station was started. Assembly of the associated electronic equipment and housing cabinets indicated that scheduled completion dates for the station will be met.

Contributions were made to a working group comprised of emergency procedure specialists from FPD and HLO on standardizing of emergency alarm signals.

C. EMPLOYEE RELATIONS

There was one medical treatment injury during the month for a frequency of 0.46. No security violations occurred during January.

One suggestion was received for evaluation. No suggestion evaluations were made during the month. There are two outstanding suggestions at month end. No awards were made.

Radiation Protection Training included: Tours and lectures for Defense Atomic Support Agency group including lectures on "Monitoring of Personnel" and the "HAPO Bioassay Program"; a one-hour lecture on radiation protection presented to 30 Reactor Lattice Physics and Experimental Nuclear Physics employees; 2 one-hour talks on orientation in radiation protection to Plutonium Metallurgy personnel; a talk on portable instrument calibration work given to Purex radiation monitoring personnel; and a lecture series presented to certain IPD personnel on "Quick Sort Procedures" was completed.

D. SIGNIFICANT REPORTS

HW-61980 "Gamma Angular Dependence on HAPO Film Badge" by G. A. Little

HW-63332 "Report of Trip to Rocky Flats and Los Alamos to Compare Practices Regarding Treatment of Contaminated Patients" by K. R. Heid and Dr. Katherine G. Brockman.

HW-63557 REV "Analysis of Radiological Data for the Month of December, 1959" by R. L. Junkins

HW-63561 "The Routine Deposition of Plutonium - Deposition Based on Single Void Sample" by G. D. Brown.

HW-63710 "Monthly Report - January 1960, Radiation Monitoring Operation" by A. J. Stevens.

ENVIRONMENTAL MONITORING RESULTS (Mid-December 1959 - Mid-January 1960)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.6	% MPC_{GI}*
Separations Areas	Gross Beta	2.6×10^{-7}	µc/cc
Pasco	Isotopic	6.6	% MPC_{GI}**
Kennewick	Isotopic	1.4	% MPC_{GI}**
Richland	Gross Beta	$<3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	***	µc/cc
100-F Area	Isotopic	2.4	% MPC_{GI}*
Hanford	Isotopic	2.3	% MPC_{GI}*
Pasco	Isotopic	17	% MPC_{GI}**
McNary Dam	Gross Beta	1.7×10^{-6}	µc/cc
Vancouver, Washington	Isotopic	0.6	% MPC_{GI}**
Atmosphere			
I^{131} Separations Areas	I^{131}	2.8×10^{-13}	µc/cc
I^{131} Separations Stacks	I^{131}	1.1	Combined c/day
Active Particles - Project	-	2.6	ptle/100 m^3
Active Particles - Environs	-	0.4	ptle/100 m^3
Vegetation			
Separations Areas	I^{131}	1.2×10^{-5}	µc/gm
Residential	I^{131}	3.4×10^{-6}	µc/gm
Eastern Washington and Oregon	I^{131}	$<1.5 \times 10^{-6}$	µc/gm
Fission Products less I^{131} - Wash. & Oregon	Gamma Emitters	1.9×10^{-5}	µc/gm

* The % MPC_{GI} is the per cent of the maximum permissible limit for occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

** The % MPC_{GI} is the per cent of the maximum permissible concentration for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

*** This location is now sampled quarterly. The most recent result is tabled.

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents Above Permissible Limits

	Whole Body	Localized
January	0	1
1960 to Date	0	1

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
January	17,598	246	1	2
1960 to Date	17,598	246	1	2

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	mr(s)
January	9,972	937	161	39	27	10.32	20.85
1960 to Date	9,972	937	161	39	27	10.32	20.85

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
January	1,746	0	0	0	5
1960 to Date	1,746	0	0	0	5
Fast Neutron					
January	317	29	3	0	3
1960 to Date	317	29	3	0	3

Bioassay

	January	1960 to Date
Plutonium: Samples Assayed	734	734
Results above 2.2×10^{-8} µc/sample	50	50
Fission Products: Samples Assayed	741	741
Results above 3.1×10^{-5} µc FP/sample	0	0
Uranium: Samples Assayed	309	309
Confirmed Plutonium Deposition Cases	2	2*

*This brings the total number of plutonium deposition cases which have occurred at Hanford to 246.

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples	Following Period of No Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples
Fuels Preparation	49	5.8	56	15	2.6	52
Hanford Laboratories	25	4.5	33	35	8.6	37
Chemical Processing	122	8.9	61	8.2	2.6	60
Chemical Processing*	-	-	-	-	-	-
Special Incidents	2	1.3	4	-	-	-
Random	1.2	0.7	3	-	-	-

* Samples taken prior to and after a specific job during work week.

Thyroid Checks	January	1960 to Date
Checks Taken	0	0
Checks Above Detection Limit	0	0
Hand Checks		
Checks Taken - Alpha	29,090	29,090
- Beta-gamma	45,507	45,507
Skin Contamination		
Plutonium	25	25
Fission Products	24	24
Uranium	8	8

CALIBRATIONS

Portable Instruments	Number of Units Calibrated January	1960 to Date
CP Meter	873	873
Juno	274	274
GM	759	759
Other	167	167
Total	2,073	2,073
Personnel Meters		
Badge Film	1,200	1,200
Pencils	-	-
Other	400	400
Total	1,600	1,600
Miscellaneous Special Services	154	154
Total Number of Calibrations	3,827	3,827

A R Keene
Manager
Radiation Protection

AR Keene:kc

1249274

LABORATORY AUXILIARIES OPERATION MONTHLY REPORT - JANUARY, 1960

GENERAL

Safety performance of the Operation was considered satisfactory. There were no major injuries; the minor injury frequency rate was 2.89, which is below average experience.

There were no security violations charged to the Operation.

TECHNICAL SHOPS OPERATION

Total productive time for the month was 16,449. This includes 13,773 hours performed in the Technical Shops, 1,417 hours assigned to Minor Construction, 109 hours assigned to other project shops, and 1,146 hours assigned to off-site vendors. Total shop backlog is 17,994 hours of which 40% is required in the current month with the remainder distributed over a 3-month period. Overtime hours worked during the month was 2.4% (432.8 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	2169	13.0
Irradiation Processing Department	412	3.0
Chemical Processing Department	860	5.0
Hanford Laboratories Operation	12761	78.0
Construction Engineering & Utilities	157	0.9
Miscellaneous	26	0.1

Customer requests for priority work increased slightly with the majority of the requests emanating from the PRTR, PFPP and Plutonium Metallurgy groups. With the timely assistance of Minor Construction and other project shops, the work was completed with nominal overtime.

New equipment received during the month included a small bench type straightening press. Used equipment transferred to us included a power driven saw from 321-A Building and one upright drill press from 306 Building. This machine to be installed in the Graphite Shop of the 3730 Building.

RADIOGRAPHIC TESTING OPERATION

A total of 5,254 tests were made, of which 758 were radiographic (including x-ray and gamma-ray) and 4,496 were supplementary tests. Out of a total of 2,910 man-hours, 569 (19.5%) were in connection with radiographic tests, and 2,341 (80.5%) were used on supplementary tests. The supplementary test work included; autoclave, borescope, dimensional measurements (micrometric), eddy current, helium leak detection, penetrant (fluorescent O.D. and I.D.), surface treatment (alkaline cleaning, pickling, and vapor blasting), and ultrasonic (flaw detection and thickness measurement).

The number of pieces handled this month totaled 5,558 items. The feet of material represented by these items amounted to 59,096 feet. Continuing the trend of the previous month the large number of pieces handled and the correspondingly high footage achieved, is the result of tubular products currently being tested.

Work was done for 18 differenct organizational components representing most of the operating departments and service organizations. A total of 47 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 22 different occasions for advice and information on general testing theory and applications for other than the jobs tabulated in Part II - Testing Statistics.

The testing and treatment of PRTR process tubes has been completed except for straightness checking of the last 46, and referee testing for ultrasonic suspect tubes. Contributing substantly to the successful completion of the PRTR tubes was good operation of the pickling and autoclaving. Of the last 46 tubes only minor O.D. staining occurred and in only one case was I.D. corrosion product found.

Lacking the facilities to completely demonstrate the testing of the full sized NPR process tubes, short sections up to 17 feet long will be used. Preparations are being made to demonstrate ultrasonic and fluorescent penetrant testing to three potential suppliers. Preliminary handling of the one full size NPR process tube in the tube shop demonstrated some of the problems to be encountered. The 40 ft. spreader bar was inadequate to fully support the tube; also the allowable straightness tolerance will create problems in rotating the tube at the various test stations. No physical work by Kaiser engineers has yet been performed in the C-25 Building.

More than 1,000 tubes of the 1,100 zircaloy tube sheath tubing order have been examined. The scope of sheath tube testing work has been extended to include I.D. fluorescent penetrant inspection of the 0.505" I.D. tubing. Ultrasonic flaw detection are being made routinely on all tubing. Overall quality of the sheath tubing appears to have been significantly improved under the new tubing procurement specification.

Field work is proceeding routinely with coverage being given to all of the operating departments. Increased activity has occurred in the fabrication of process vessels. Special assistance was given 100-B operation in finding rear face helium leaks to achieve timely reactor start-up.

Testing Statistics

Component	No.of Tests	Ft. of Weld or Material	No. of Pieces	Description
CE&U	170	85	1	X-ray welds on pressurizer stand pipe - PRTR Project.
CPD	105	64	25	Radiograph welds on titanium tube bundle and radiograph welds on (Redox) multipurpose dissolver; Flaw detection of 1/2" steel plate on multipurpose dissolver.
FPD	174	552	174	Radiograph welds on extrusion press piping (carbon steel); I.D. and O.D. of NPT fuel element.
HLO	4,649	58,259	5,288	Radiograph end core welds on zirconium clad fuel elements; .505" I.D. x .030" wall, zr-2 tubes; 9/16" O.D. UO_2 fuel rods; .680" I.D. x .035" wall, zr-2 tubes; Radiograph 3 irradiated graphite blocks; Palm Fab and Dev. Program; x-ray welds on Y-header part of Hi-press, Hi-temperature loop; Cast aluminum pipe; Calandria (PRTR) and radiograph welds on S/S nozzle (PRTR) Project; Fluorescent penetrant test welds and can wall of zirconium clad fuel elements; Pressure vessel survey (300-Area).
IPD	156	136	70	Radiograph closed ends of resistance test cables, and end welds on three (3) neutron chambers; Fluorescent penetrant test reactor pigtails; Helium leak test on rear face of 105-B Reactor.
Total	5,254	59,096	5,558	

CONSTRUCTION OPERATION

During the month sixteen CPFF work orders and two supplemental orders were issued to J. A. Jones Company, amounting to $206,200. There were twenty-nine existing HL orders at the beginning of the month with a total remaining unexpended balance of $104,298. Total expenditures during the month were $99,800.

There were a total of eleven old CE&U orders active at the beginning of the month and five of these were closed during the month. Project CG-790 was reopened. Total remaining unexpended balance of the seven orders is $102,442. One supplement was issued in the amount of $5,000 which is included in the aforementioned figure.

J. A. Jones Company expenditures on all HL work during January was $93,634.

Summary

	No.	HL Unexpended Balance	No.	CE&U Unexpended Balance
Orders outstanding beginning of month	29	$ 104,298	11	$ 134,152
Adjustment (Closed out Unexpended Bal.)		+ 145		- 1,113
		$ 104,443		$ 133,039
Issued during the month (Inc. Supplements)	16	$ 206,220	0	$ 5,000
Expenditures during the month		$ 64,203		$ 35,597
Balance at month's end	28	$ 246,460	7	$ 102,442
Orders closed during month	17	$ 26,209*	5	$ 22,523*

J. A. Jones Expenditures	$ 93,634
Construction Operation Cost	6,166
HL Orders Issued (Inc.Supp.)	211,220
Total Orders Closed	48,732*
Total Backlog	348,902

* Face Value of Orders Closed.

In addition to the above listed orders we have received a release of $110,000 on Project CA-744 for installation of equipment in 306 Building. This order does not reflect in the above total as it has not yet been issued to the J. A. Jones Company. It is expected that this release will be issued during the first two weeks of February so that work can commence on February 15, 1960.

Three new heat exchangers have now been installed in Building 325. We expect to have this job complete by the middle of February if the fourth unit is turned over to us by February 8, 1960.

In 231-Z Building the installation of the Monarch Lathe has been completed and fabrication of the hood has been started.

Distribution of current work is as follows:

4 - 100 Areas.
3 - 200 Areas.
12 - 300 Area.
12 - WB Shops.
4 - C-25 Building - WB.

FACILITIES ENGINEERING OPERATION

Projects

There were 22 authorized projects at month's end with total authorized funds of $6,735,000. The total estimated cost of these projects is $8,720,000. Two project proposals were submitted to the Commission and three projects are in preparation. The following summary and attached project report contain detail information.

The following summarizes the status of HLO project activity:

Number of authorized projects at month's end:	22
Number of new projects authorized during month:	0
Projects completed during month:	0
New project proposals submitted to AEC during month: CGH-832 Fuel Scale Physical Constants Testing Reactor CAH-885 Geological & Hydrological Wells	2
New projects awaiting AEC approval: CGH-874 Consolidation of Plutonium Metallurgy Facilities CGH-832 Fuel Scale Physical Constants Testing Reactor CAH-885 Geological & Hydrological Wells	3
New project proposals in preparation: Uranium Scrap Burning Facility Biology Addition Stress Rupture Test Facility	3

The attached project report details the status of individual projects.

Engineering Service and Plant Improvement

Title	Status
Glycol Heat Exchangers - 325-A	Field work complete on two of four units.
329 Building Cooling Problem	Design complete; installation work depends on availability of funds.

Title	Status
Air Conditioning Room 4 141-H Bldg.	Work essentially complete except for control corrections.
Fire Detection System - 146-FR	Installation is 45% complete.
Electrical Modifications - Room 24-A 326 Building	Work order has been issued for field work. Materials on order.
Modifications, 3707-C Building	Materials on order for office alteration.
108-F Building Solvent, Acid & Cylinder Storage, & Loading Dock	Field work approximately 25% complete.
Electric Hoist - Graphite Shop - 3730-C Building	Quotations are being received for larger capacity crane and hoist.
Refrigerated Air Conditioning Room 130 146-FR Building	Specifications for air conditioners prepared.
Reactor Room Exhaust Ventilation Control 325 Building Basement	Design is continuing and vendor information is being obtained.
Improve Ventilation for Exhaust Hood, Room 211-108-F Building	Engineering in progress.
Revision to Cell Door Mechanism 747-A Building	Work complete except for correction of deficiencies.
Particulate Filter - Vacuum Pumps 325 Building	Design is being performed on a filter to remove particulate mother from vacuum system.
HLO Area Improvements Study	A study is being performed to improve HLO buildings and grounds.
Pressure Vessel Study	Audiogaging program is in progress as well as safety valve inspection.

Several small jobs are also being performed as well as about twelve (12) studies for major plant additions which will be considered a part of the FY-1962 and revisions to FY-1961 Plant Acquisition and Construction and Equipment Budgets.

Design & Drafting Services

The two remaining Kirk Contract personnel in the drafting operation were terminated as of December 31, 1959. The work will be performed by our employees, and it is not anticipated that Bovay personnel will be required in HLO.

Design and drafting work in progress includes the following:

1. PRTR prototype loop - "As-Built" - 314 Building.
2. Calandria "As-Builts" - PRTR (Job 95% complete, work consisted of 109 new drawings and revisions to 91 vendor drawings).
3. Miscellaneous equipment for high level radiochemistry cell - 325 Building.
4. PRTR Fuel Examination Ducts (12 drawings - 90% complete).
5. PRTR Gas Loop - In-Reactor (14 drawings - 80% complete).
6. Transfer Hood with Conveyor - 308 Building (9 drawings - 95% complete).
7. Fuel Rod Wire Machine - 308 Building (12 drawings - 90% complete).
8. Break away Corrosion Loop (5 drawings - 25% complete).
9. PRTR Fuel Handling Machine (4 drawings - 60% complete).
10. Special Tools - Scope - High Level Utility Cell - 327 Building.
11. PRTR Fuel Element Rupture Facility - Scope (approximately 10 drawings started).
12. Shim Rod Control PRTR - (7 drawings - 75% complete).

In addition to the above work, miscellaneous small design-drafting jobs are in progress including "As-Built" project work.

Maintenance & Building Engineering - Landlord Functions

Costs: November - $161,651
December - $178,352
Total for first half of FY-1960 - $767,810

Analysis of Costs: The $767,810 expenditure for half FY-60 represents 52.7% of the budget. This is within 4% of the forecast expenditure amount. Plant improvements have been reduced. Building maintenance costs have increased slightly. Steam consumption through December was lower than predicted.

Improved Maintenance:

Item	December	1st Half FY-60
Heating & Ventilating Correction	$ 24,251	$ 43,135
Relocation & Alteration	1,818	11,186
Paint	166	11,736
Electrical Improvements	32	1,374
Lighting	21	413
Crane Installation	24,910	24,910
Miscellaneous	11	1,777
	$ 51,209	$ 94,531

Special Activities

A. An expansion of the maintenance shop under the west end of the equipment room of 326 Building is underway. Arrangements are being made to store or excess the material which has formerly been stored in this space.

B. Conversion of a part of the 3707-C Building lunchroom into office space has begun. By a series of moves, these new offices will provide more office space for the computer personnel.

C. A major concern in plant operation has been the quality of absolute filters. Representatives of customer departments and stores, purchasing and traffic, discussed ways of preventing damage to the filter mediums. Revisions to AEC standards were proposed. All absolute filters for HAPO use will be DOP tested by Industrial Hygiene.

D. A study has been performed to standardize emergency alarm signals. It has been decided to use bells for fire warning, sirens for civil defense, and klaxons to denote criticality incidents.

E. The repartitioning of the north end offices on the first floor of 328 Building has been completed.

F. The operating manual for the building machinery in 308 Building has been completed, and copies have been provided to the building operators.

G. HLO and IPD Landlord and Property Specialists are cooperating in an effort to resolve custodianship of property, and responsibility for maintenance of facilities following relocation of the 100-F Area exclusion fence. OPG's will be amended to reflect the changes agreed upon.

Miscellaneous

Approximately 165 drawings including sketches, work sheets, and formal drawings were completed during the month of January by the Drafting Component.

Approximately 15,000 square feet of prints were reproduced during the month.

The total estimated value of the 10 requisitions issued during the month was $8,000.

TECHNICAL INFORMATION OPERATION

As indicated in last month's report, the Hanford Operations Office is establishing closer controls over all classified documents being sent off-site from Hanford, except for formal Research and Development reports distributed via the Standard Distribution Lists (M-3679). At the present time, clearances are being arranged on a document-by-document basis, with resultant delays. To correct the situation, an effort is being made to get advance HOO approval for documents routinely sent off-site. This information will be transmitted to HOO so that advance approvals can be obtained. Technical Information will then be responsible for monitoring uncategorized classified documents going off-site to make certain that they relate to cleared programs.

The review of HAPO originated documents in categories C-66, C-67, and C-68 is getting underway. Reviewers have been appointed from most Departments, and about 250 reports (there are 700 to be reviewed) pulled and sorted. Reviews will begin early in February.

The annual inventory of Secret Research & Development reports and Atomic Weapon Data reports was started on January 4. The inventory of AWD reports was completed with 647 copies all accounted for. Four thousand two hundred eighty-eight R & D reports have been inventoried out of approximately 10,000.

A cumulative list of "unaccounted for" documents from all AEC installations was received from HOO Security. The list (314 copies) was checked against Files records. Results of check: 1 copy had been destroyed at HAPO, 1 document had been declassified, 1 document had been downgraded and 1 document was unclassified. Our check will enable the respective installation(s) to reduce their list of missing documents.

A memorandum was received from HOO which set forth certain requirements for classifying information on NPR fuel element geometry. This information was combined with other classification requirements relating to NPR fuel elements and distributed to the field as HW-63530, "Classification: NPR Fuel Elements". Additionally, topics covering NPR fuel element design and dimensions in more detail were suggested to HOO.

A new guide for Atomic Weapon Data was prepared by CPD personnel and was reviewed in a meeting of interested HAPO and HOO personnel. It will now be put into final form and submitted to the AEC for approval.

In late October, the AEC was asked to approve for inclusion in the Hanford Classification Guide, topics covering the classification of reactor production data. The comments of the HOO members of the HOO Classification Committee on the proposed topics were received. A letter was sent to HOO reaffirming the HAPO position on two of the questionable items (one of which was the downgraded conversion factor) and agreeing with the HOO position on the third.

The final report of the Inter-Departmental Task Force appointed to study the control of access to documents in the Classified Files has been reviewed and approved. The recommendations of the Task Force are being transmitted to the Hanford Operations Office. If acceptable, the details of the program will be worked out with the appropriate Divisions of HOO.

A critical review of Data Processing costs revealed two reports which do not appear to justify their expense. These reports will be discontinued on January 7, 1960. Annual savings will amount to about $1400 (based on December charges of $117). Formal report backlog at end of reporting period stands at 11, a reduction from 16 listed at the last reporting period. Two additional informal reports are also in backlog.

Work Volume Statistics

	December	January
Document Distribution and Files		
Documents routed and discharged (copies)	12,989	14,940
Documents issued (copies)	14,240	14,041
Documents sent off-site (copies)	7,474	7,303
Document reserves filled (copies)	561	572
Documents picked up and delivered	18,486	17,256
Document Accountability		
Holders of classified documents whose files were inventoried	446	596
Documents inventoried in Files (copies)	24,561	6,906
Documents destroyed or retired (copies)	6,906	5,052
Documents revised (copies)	514	862
Documents pulled and documents filed (copies)	9,416	11,550
Documents reclassified	213	385
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	208,837	207,230
Reference and Publication		
Books cataloged (new titles)	118	147
Books added to the collection (volumes)	243	373
Ready reference questions answered by professional staff	80	105
Literature searches by professional staff	97	101
Reports abstracted (titles)	187	240
Formal reports prepared (titles)	14	11
Off-site requests for HAPO reports (copies)	164	330
Reports released to CAP (titles)	24	38

Library Acquisitions and Circulation

	December	January
Books ordered (volumes)	242	361
Periodicals ordered	531	164
Books circulated (volumes)	1,614	1,864
Periodicals circulated (issues)	2,893	3,609
Inter-Library Loans	70	91
Films borrowed or rented	9	15
Industrial film showings	44	63
Bound periodicals added to the collection	181	228

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	28,544	8,333	1,543	2,001	40,421
No. of bound periodicals	13,209	1	1,431	96	14,737
	41,753	8,334	2,974	2,097	55,158

Classification and Declassification

	December	January
Documents, including drawings and photographs reviewed for downgrading or declassification	10	190
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	25	21
Documents submitted to Declassification Branch, Oak Ridge	8	7

J. L. Boyd

Manager,
Laboratory Auxiliaries

JL Boyd:jcw

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63740 MONTH January, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.
CG-731	Critical Mass Laboratory	$1,000,000	$1,000,000 3-23-59	100 100	61 67	5-22-58 6-4-59	- - - 6-30-60	2-24-59 6-30-60
		USING COMPONENT: Physics & Instruments R & D				FEO ENGINEER: D. S. Jackson		

REMARKS: The fixed price contractor is 81% complete compared to a scheduled 67%. General Electric Company furnished engineered equipment procurement is 51% complete compared to a scheduled 65%. The reactor hoods were shipped from Cedar Rapids, Iowa on January 21, 1960. Nothing has been resolved that will expedite delivery of the main instrument panel before March, 1960 by Minneapolis Honeywell. The vendor promised delivery of this equipment, costing approximately $75,000, by November 23, 1959 when he accepted the purchase order. The pipefitters returned to the job on January 8, 1960, one month after walking out, following award of installation of the cylindrical ventilation ductwork to sheet metal workers. all concrete surfaces were sacked and etched ready for application of paint or other protective coatings. The area around the large shielding door was formed and poured. The door operates smoothly and easily on its hinges even before installation of the mechanical door operator. The reactor hoods were received January 28, 1960.

CA-744	Metallurgical Development Facility - 306 Building	$2,650,000	$2,685,000 11-5-58	100 100	* **	6-30-58 3-20-59	- - - 9-1-60	9-30-59 9-1-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: J. T. Lloyd		

REMARKS: Jensen-Rasmussen schedule, revision 2 indicates 70% completion for period ending January 31, 1960. There are good indications this will be met. Completion of all floor slabs was accomplished January 29, 1960. Installation of equipment in rooms 170 and 171 is scheduled to start February 15, 1960. Equipment procurement is proceeding satisfactorily. A meeting with the Portland Copper & Tank Works representatives on January 26 resolved all outstanding problems concerning the chemical processing tanks. Completion of this order within the established schedules is quite certain. The Frank Lohse contract is being started with installation of piping in the chemical processing facility. Some delay may be experienced in installation of partitions due to the effects of the steel strike. * Total project 44%; Jensen-Rasmussen new schedule 71%; J.A. Jones 20% Frank Lohse 10%. ** Total project 43%; Jensen-Rasmussen new schedule 70**; J.A. Jones 20%; Frank Lohse 10%.

CGH-790	High Level Radioactive Receiving and Storage Addition - 327 Building	$349,000	$345,000 4-23-59	100 100	100 85	6-23-58 10-9-58	- - - 2-1-60	12-31-58 6-1-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: J. J. Peterson		

REMARKS: The project proposal requesting an extension of time was transmitted to contract accounting on January 27, 1960. Completion date for the fixed price portion of the work has been extended to February 6, 1960. Delivery of the decontamination chambers, which is holding up completion of the job, are scheduled for delivery January 29, 1960. Work is progressing on interior wall liners. Fitters are working on piping. Light weight aggregate has been placed on roof for saddles. Crane door has been hooked-up electrically. CPFF forces are working on piping to complete tie-ins.

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

BUDGET CLASSIFICATION: General Plant Projects - FY 1959

HW - 63740

MONTH: January, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED or Actual COMP. DATE
				DESIGN	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CAH-827	Automatic Columbia River Monitoring Station		$39,000	100	90	4-3-59*	- - -	6-18-59*
		$39,000	6-30-59	100	91	11-6-59	3-31-60	3-25-60
		USING COMPONENT: Radiation Protection				FEO ENGINEER: D. S. Jackson		

REMARKS:

Plant forces work was confined to fabrication of monitoring equipment during the month. The copper clad steel plates to be used in fabricating the monitoring tanks were received and are scheduled to be rolled in the 200-W Area shop.

* A-E only.

CAH-837	Animal Pens, Isolation and Examination Facilities		$80,000	100	100	3-30-59	- - -	6-5-59
		$80,000	3-17-59	100	99	7-10-59	4-1-60	2-29-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS:

The mens' rest room has not been finally accepted; escutcheon plates are lacking on shower fixtures. The AEC has informed FEO that the contractor is having these made in Spokane. The AEC has been advised that the General Electric Company considers the tile work very poor and corrective measures should be taken. The AEC has tentatively agreed to provide a number of items not included on the contract, if funds are available. This work would be done by the construction service contractor.

CGH-840	Sheet Metal Shop Addition - 328 Building		$40,000	N.S.	100	6-22-59	- - -	9-1-59
		$38,000	6-18-59	100	85	6-25-59	5-1-60	3-1-60
		USING COMPONENT: Laboratory Auxiliaries				FEO ENGINEER: J. J. Peterson		

REMARKS:

Electrical connections of equipment are in progress by plant forces.

BUDGET CLASSIFICATION: General Plant Projects - FY 1959

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63740
MONTH: January, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION: AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT: CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE: DESIGN / CONST.
CAH-848	Geological & Hydrological Wells - FY 1959	$56,600	$56,600 6-18-59	N.S. 100	94 90	5-12-59 7-16-59	- - - 5-31-60	7-6-59 3-30-60

USING COMPONENT: Chemical R & D
FEO ENGINEER: H. E. Ralph

REMARKS:

Fourteen of the sixteen wells have been developed. 3000 feet of new hole have been completed. Snow and continued cold weather has delayed drilling this month.

General Plant Projects - FY 1960

CGH-819	Increased Laboratory Waste Facilities - 300 Area	$193,765	$30,000 11-24-58	100 100	0 0	3-30-59 5-1-60	- - - - - -	4-1-60 3-1-61

USING COMPONENT: Chemical R & D
FEO ENGINEER: J. J. Peterson

REMARKS:

The revised project proposal requesting total funds has been approved by the local AEC and is being sent to the AEC-Washington, D. C. for final approval.

CGH-860	Access for PRTR Fuel Elements - 327 Building	$81,000	$81,000 10-8-59	72 67	N.S. 7	10-19-59 1-4-60	- - - 8-15-60	4-1-60 7-1-60

USING COMPONENT: Reactor & Fuels R & D
FEO ENGINEER: J. J. Peterson

REMARKS:

The design schedule was approved by the Commission on January 8, 1960. Drawings and specifications for the fixed price portion of the work are being routed for signatures. Work is progressing by CPFF forces on reinforcing plates on rigid frames and crane rail support beams and brackets.

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63780

MONTH: January, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION — AMOUNT / DATE	PROJECT PROGRESS IN PER CENT — DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT — CONST. SCHED. / CONST. ACTUAL	STARTING DATE — DESIGN / CONST.	DIRECTIVE COMP. DATE — DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE — DESIGN / CONST.
CAH-864	Shielded Animal Monitoring Station - 100-F	$46,000	$46,000 / 8-6-59	100 / 99	N.S. / 0	10-22-59 / 4-1-60	- - - * / 4-1-60	2-1-60 / 5-15-60

USING COMPONENT: Biology

FEO ENGINEER: J. T. Lloyd

REMARKS:

Special conditions were given to the AEC contract group on January 7, 1960. The specifications and tracings were approved by Facilities Engineering and given to the AEC. The bid package is being prepared.

* Scheduled date, January 1, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION — AMOUNT / DATE	PROJECT PROGRESS IN PER CENT — DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT — CONST. SCHED. / CONST. ACTUAL	STARTING DATE — DESIGN / CONST.	DIRECTIVE COMP. DATE — DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE — DESIGN / CONST.
CAH-870	Facilities for Recovery of Radioactive Cerium - 325-A Building	$490,000	$40,000 / 12-9-59	90 / 83	0 / 0	9-18-59 / N.S.	- - - / - - -	2-15-60 / 9-1-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS:

The structural steel, concrete, instrumentation, mechanical (less one), electrical, heating & ventilating drawings and all specifications have been issued for comment. To be issued soon are the drawings for vault liners, architectural, piping, special shielding, vessel scrubber and plot plan.

A revised project proposal for construction funds is being routed for approval within HLO.

The A-E is approximately 7% behind his schedule.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION — AMOUNT / DATE	PROJECT PROGRESS IN PER CENT — DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT — CONST. SCHED. / CONST. ACTUAL	STARTING DATE — DESIGN / CONST.	DIRECTIVE COMP. DATE — DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE — DESIGN / CONST.
CGH-874	Consolidation of Plutonium Metallurgy Facilities	$285,000	None / None	0 / 0	0 / 0	1 * / 2 *	- - - / - - -	5 * / 11*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: J. T. Lloyd

REMARKS:

The project proposal was received from the AEC and altered in accordance with changes suggested by Chemical Processing Department. The revised pages were distributed.

* Months after authorization.

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63740
MONTH: January, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CGH-877	Pyrochemical Test Facility - 321-A Building		$70,000	20	N.S.	12-8-59	- - -	4-17-60
		$70,000	11-17-59	25	0	2-17-60	9-30-60	9-30-60
		USING COMPONENT: Chemical R & D				FEO ENGINEER: R. C. Ingersoll		

REMARKS:

The design schedule was submitted January 25, 1960. Orders for the induction heating units were placed January 20, 1960; the 15KW - 10KC unit from Tocco and the 15KW - 3KC unit from Ajax. Design of the Mg hood is complete.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CAH-878	Additional Facilities for Isotope Study on Animals - 141-C Building Addition		$61,000	N.S.	0	12-7-59	- - -	2-3-60
		$61,000	11-18-59	95	0	N.S.	4-15-60	5-1-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS:

The tracings have been approved. Comments are being incorporated into the specifications. Special conditions are being written for the AEC bid package.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CAH-885	Geological & Hydrological Wells - FY 1960		None	0	0	2-15-60	- - -	4-1-60
		$69,000	None	0	0	4-15-60	- - -	11-1-60
		USING COMPONENT: Chemical R & D				FEO ENGINEER: H. E. Ralph		

REMARKS:

The project proposal was approved by the AEC Project Review Board on January 28, 1960; to date the directive has not been received.

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 60-a-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - [illegible]
MONTH January, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CGH-832	Full Scale Physical Constants Testing Reactor	$915,000	None None	0 0	0 0	- - - - - -	- - - - - -	- - - - - -
		USING COMPONENT: Physics & Instruments R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

A project proposal for preliminary engineering funds in the amount of $30,000 was submitted to the AEC for approval on January 28, 1960.

Equipment Not Included in Construction Projects - Program Class 2900

CG-661	Additional Heat Generation Facility - 189-D Building	$450,000	$664,000 9-18-57	100 100	100 99	12-6-56 12-3-58	- - - 8-31-59*	10-15-58 - - -
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: J. J. Peterson		

REMARKS:

Two hundred ten (210) replacement fuses were received from the vendor; these have been installed. A total of 336 replacement fuses are required for completion; the remainder of these are expected in the near future.

* Beneficial use was attained.

CG-785	In-Reactor Studies Equipment - 105-KW Building	$276,000	$276,000 12-8-58	100 99	0 0	1-5-59 N.S.	- - - 12-31-60	1-31-60 12-31-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H. Radow		

REMARKS:

The drawings for the capsule removal facility have been approved and procurement of this facility is being initiated. Fabrication delays on the instrument panel assemblies and console orders have caused anticipated delivery dates to lag further.

UNCLASSIFIED

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 65740
MONTH January, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CGH-801	X-Ray Diffraction Cell - 327 Building	$170,000	$170,000 / 10-1-59	40 / 40	0 / 0	6-10-58 / N.S.	- - - / - - -	- - - / - - -
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS: A project proposal for cancellation of this project will be submitted to the General Manager for his approval.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CGH-805	High Temperature Tensile Testing Cell - 327 Building	$170,000	$150,000 / 2-25-59	100 / 100	0 / 0	8-26-58 / 8-1-60	- - - / 3-1-60	6-15-59 / 2-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS: Quotations were received from the three bidders who had previously bid on the cast iron cell structure, at substantially the same price. Washington Iron Works, Seattle, Washington is again low bidder at $40,553. This is approximately $18,000 higher than the estimate. In addition a premium will have to be paid Washington Iron Works to expedite their delivery from 180 days after receipt of order to June 20, 1960. Procurement is proceeding on other items. bids were received and rejected on 8 viewing plugs as they deviated from the specifications. New bids will be sent out. A project proposal requesting $20,000 additional funds and an extension of time is awaiting transmittal to the General Manager.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CGH-834	Modifications and Additions to High Pressure Heat Transfer Apparatus - 189-D Building	$700,000	$700,000 / 4-8-59	93 / 95	53 / 53	4-20-59 / 4-22-59	- - - / 10-15-60	2-9-60 / 10-15-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H. Radow		

REMARKS: Shipment of the first pre-heater has been held up because of gasket leaks during pressure testing. Since strength and safety aspects of the vessel have been well proven, the possibility of relaxing the leaking requirements at the gasket is being checked. Current construction scheduling was based on receipt of this vessel by the end of the month and delay of this vessel will significiantly hamper construction progress. Orders have been placed for all major items of equipment except the high speed valves. This order has been in negotiation for some time with the only bidder. Since there were no competitive bids the vendor was requested to submit a cost breakdown of his quotation. Thus far, he has failed to submit one satisfactory to the Commission and current status of the order is in doubt. These valves are the longest delivery items of the procured equipment and further delay will seriously affect the project completion date and overall cost.

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64700
MONTH January, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR Actual COMP. DATE DESIGN / CONST.
CGH-857	Physical and Mechanical Properties Testing Cell - 327 Building	$500,000	$75,000 / 10-1-59	0 / 0	0 / 0	10-20-59 / N.S.	- - - / - - -	4-1-61 / 1-1-62
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

As the using component did not have any available funds, no work was done on this project this month nor for the past four months.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR Actual COMP. DATE DESIGN / CONST.
CGH-858	High Level Utility Cell - 327 Building	$500,000	$70,000 / 10-1-59	2 / 2	0 / 0	10-20-59 / N.S.	- - - / - - -	1-1-61 / 11-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

A revised project proposal, requesting a change in scope of work from vendor design of specialized cell tools to design by General Electric Company, is awaiting transmittal to the General Manager for approval.

Preliminary design on the plug mounted lathe and milling machine has been started.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR Actual COMP. DATE DESIGN / CONST.
CGH-866	Shielded Analytical Laboratory - 325 Building	$750,000	$10,000 / 8-12-59	0 / 0	0 / 0	9-5-59 / N.S.	- - - / - - -	12-15-59* / 6-1-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

Preliminary design and a design criteria were completed in December, 1959. A revised project proposal for detailed design funds was transmitted to the Commission on December 28, 1959. It was approved by the local project review board and forwarded to the AEC, Washington, D. C. office for approval. There has been no report on this approval.

BUDGET CLASSIFICATION: Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63740

MONTH: January, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CGH-879	High Temperature, High Pressure Autoclave Facility - 306 Building		$46,400	N.S.	70	8-3-59	- - -	1-22-60
		$46,400	12-3-59	100	71	12-18-59	3-31-60	3-25-60

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: D. S. Jackson

REMARKS:

The CPFF Construction Service Contractor has installed the majority of the electrical switch gear, but has not strung the wire yet. Construction of the pit in the 306 Building floor is complete. The instrument panel is in place but not wired. The autoclaves have not been installed.

USING COMPONENT:

FEO ENGINEER:

REMARKS:

USING COMPONENT:

FEO ENGINEER:

REMARKS:

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of January 31, 1960, the staff of Hanford Laboratories totalled 1300 employees, including 615 exempt and 685 nonexempt. There were 524 employees possessing technical degrees, including 312 B.S., 113 M.S. and 99 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for January was 1.41 as compared with 1.56 last month. There were 2 security violations during the month.

A HAPO-wide study of Pressure Systems continued throughout the month with initial steps being taken toward development of recommendations for uniform HAPO procedures. Arrangements were made for a review by a representative of GEL of HAPO's pressure equipment problems.

Consultations were provided to 16 operations on 32 problems pertaining to a variety of safety, chemical hazards and chemical toxicity and security questions.

PROFESSIONAL PLACEMENT

Seven northwest colleges and universities were visited during the month for BS/MS recruiting. Student turnout was excellent in total numbers but lower than past years in overall quality. An increasing percentage of the top students are interested in industrially supported educational opportunities. Intensive competition is being encountered for electrical engineers and mechanical engineers. During January, 30 offers were extended and 5 acceptances received.

Recruitment of experienced BS/MS personnel slowed down during the month with 9 offers being extended and 2 acceptances received.

During the month 7 Ph.D. candidates visited Richland. Three offers were extended and one was accepted by a Ph.D. veterinary physiologist for assignment to the Biology Operation. HAPO participated in the Company's coordinated Ph.D. recruiting at the American Physical Society Meeting.

Nine Technical Graduates accepted permanent assignment, 7 Engineering and Science Program members transferred to other sites and one Technical Graduate terminated for other employment. At month's end there were 43 Technical Graduates and 7 Technician Trainees on the Program rolls.

TRAINING

Courses in Applied Creativity and PBM-I continued during January. The Information and Orientation Series concluded with Program VIII - The PRTR and the Plutonium Recycle Program.

EMPLOYEE COMPENSATION

L. W. Wright, Chemical Research and Development, retired on February 1.

EMPLOYMENT

Seven requisitions were filled during the month. With the receipt of 4 new requisitions there are currently 5 openings with 4 candidates in process and 1 transfer pending.

Manager,
Professional Placement
and Relations Practices

TG Marshall:bo

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Dec.	Jan
Requisitions		
At end of month	8	5
Cancelled	3	0
Received	14	4
Filled	10	7

Nonexempt Transfer Request	Dec.	Jan.
Transfers		
Active cases at end of mo.	73	72
Cancelled	6	2
New	5	1
Transfers effected	2	0

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	493	111	21	23	12	5	2	7
Exp. BS/MS	257	58	42	2	49	28	3	33
Prog. BS/MS	196	-	-	-	39	8	30	5

*Offer totals include offers open on 9/1/59
Ph.D. 3
Exp. BS/MS 6

**On the Roll totals include 1958/59 Carryover acceptances and one 1957/58 Ph.D. Carryover.

B. Technical Recruiting Activity - HLO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	493	111	21	23	9	4	2	6
Exp. BS/MS	177	23	14	2	9	7	-	11

*Offer totals include offers open on 9/1/59
Ph.D. 3
Exp. BS/MS 3

**On the Roll totals include 1958/59 Carryover acceptances and one 1957/58 Ph.D. Carryover.

In addition to the above activity, 8 exempt employees have transferred into HLO from other HAPO departments and 7 technical graduates have accepted off-Program placement in HLO to date.

C - Technical Graduate and Technician Training Program
Month ending January 31, 1960

	TG Program	TT Program
Number of Personnel on Assignment	43	7
(HAPO Tech Grad Program..... 42		
(Western District E. P. 1		
Distribution of Assignments by Departments		
HLO	20	2
CE&UO	0	0
FPD	1	0
IPD	14	5
CPD	7	0
C&AO	1	0
Distribution of Assignments by Function		
R&D or Engineering	32	7
Other	11	0

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FINANCIAL OPERATION MONTHLY REPORT
JANUARY 1960

Personnel

There were no personnel changes during January.

Activities

GENERAL ACCOUNTING

Chapter Nine of the Manual - Authorization and Performance of Work was completely revised and the revision distributed. Activity in publishing HAPO and HLO OPG's was unusually heavy.

[redacted] activity reported for the month was less than normal due to a relatively short reporting period. Recent improvements in procedures have reduced the work load substantially allowing time for analyses and more current reporting.

The reconciliation of the physical inventory of HLO Reactor and Other Special Materials is still in progress in Contract and Accounting Operation.

A report of results was issued for the physical inventory of movable cataloged equipment in the custody of Biology Operation. Seven hundred and sixty-nine items were physically counted valued at $533,392. One item valued at $105 was not located during the inventory. Analysis of the physical inventory indicates close control by custodial personnel and the use of proper procedures.

All field work in connection with inventory of movable cataloged equipment in the custody of Physics and Instrument Research and Development Operation is complete. Inventory papers were forwarded to C&AO for their use in updating HLO records and completing the inventory reconciliation. One item valued at $112 was determined to be missing.

Preparations were completed and a procedure distributed for the inventory of movable equipment in custody of Reactor and Fuels R&D. The inventory will begin February 4, 1960 with an anticipated completion date of March 25, 1960.

Classification activity included the review of 631 purchase requisitions and 725 work orders for capital-expense determination.

$417,307 accumulated in Equipment Work In Progress on miscellaneous work orders, purchase orders and appropriation requests was transferred to Plant records.

A meeting of IPD and HLO personnel (including landlords and property specialists) was held to determine custodial responsibility for property in the vicinity of 100-F and a new policy for maintenance of the property. It was decided transfers to HLO books would include that portion of fences, general land grading (including pastures), roads, walks and paved areas identifiable with HLO. Separate sewer facilities will also be transferred to HLO. Upon completion of a review of Biology project unitization reports to determine HLO facilities recorded on IPD's book, a transfer will be made.

Thirty-seven items valued at $14,948 were received for storage at the Laboratory Equipment Pool building during January. Thirty-five of the items received were cataloged equipment and two valued at $375 were uncataloged. One item with a recorded value of $52 was placed in lieu of placing a requisition and five items valued at $2,274 were placed with other components prior to processing a declaration of excess. Total value of the 57 items in storage at January 30, 1960 was $18,896.

A revised quarterly expenditure forecast for Equipment Not Included in Construction Projects was prepared and forwarded to C&AO. A brief summary of our submission is shown below:

(Amounts in Thousands)	1st Half Actual	Expenditure Forecast 3rd Qtr.	4th Qtr.	Total	6-30-60 Commitments
2000 Program					
Projects	$269	$ 41	$ 170	$ 480	$1 220
Equipment	314	412	666	1 392	400
Total	583	453	836	1 872	1 620
3000 Program					
Equipment	10	15	30	55	-
4000 Program					
Projects	20	225	590	835	154
Equipment	121	96	211	428	100
Total	141	321	801	1 263	254
6000 Program					
Equipment	31	22	47	100	20
Total All Programs	$765	$811	$1 714	$3 290	$1 894

Budget forecasts for FY 1962 and revision of the FY 1961 forecasts were consolidated for certain specialized equipment and forwarded to CE&U who is charged with the responsibility of budgeting and controlling this equipment. These budget forecasts included Office Equipment, Automotive and Heavy Mobile Equipment, Photographic Equipment, and Radio and Audio Visual Equipment.

The status of Equipment Work In Progress activity at January 31, 1960 is compared with the status at January 31, 1959 which reflects an increase in all phases of activity:

(Amounts in Thousands)	1-31-60	1-31-59	FY 1960 Increase	% of Increase
Allocation	$3 356	$2 761	$595	22%
Expenditures	939	851	88	10%
Commitments	2 125	1 689	436	26%
In Process	708	412	296	72%

COST ACCOUNTING

The following progress was made during January in the preparation of Budget for FY 1962 and Revision of Budget for FY 1961.

1. Fourteen research and development proposals pertaining to new programs have been prepared and will be submitted to Contract and Accounting for review.

These represent approximately 3.5 and 4.0 million dollars for FY 1961 and FY 1962 respectively, and will be treated as supplemental or "additive" to the normal budget submission.

2. Ten additional research and development proposals were prepared and will be submitted to Contract and Accounting for review. These represent expanded current programs and, in the case of two, propose to sponsor work with the Division of Reactor Development that is currently sponsored by the Division of Production.

3. Personnel requirements were received from all components. Consolidation of data is underway.

4. A letter was issued to all components requesting estimates of maintenance costs, other than landlord functions, for the FY 1961 Revised Budget. Actual costs for the first six months of FY 1960 plus an estimate for FY 1960, by sub-section, were prepared and included in an attachment to the letter.

The HLO control budget was adjusted for January reporting as follows:

1. Amounts previously "labeled" charges to CE&U that are, in reality, Construction Work in Progress charges were transferred to the CWIP account. The amounts were $115,000 in Laboratory Auxiliaries, $75,000 in Reactor and Fuels and $9,000 in Radiation Protection for a total of $199,000.

2. The additional funds from IPD for NPR Research and Development in the amount of $223,000 were officially received by Hanford Laboratories. As a part of this adjustment, IPD also transferred $100,000 of Reactor I funds sponsored with HLO to the NPR program. This adjustment was as follows:

Physics and Instrument - NPR	$ 33 000
Reactor and Fuels - NPR	290 000
Reactor and Fuels - Reactor I	(100 000)
	190 000
Total HLO Increase	$223 000

Preliminary manpower data have been obtained for various steps involved in fabricating the UO_2 fuel elements for the initial loading of PRTR. Effort is currently being directed toward determining reject rates at the various points in fabrication and in calculating the costs associated with specific components of the fuel element.

Pending expansion of the account classification coding system for HAPO, provisions have been made for utilizing "expense codes" ("I" series work orders) to accumulate PRTR maintenance costs by specific piece of equipment. There are several disadvantages to the use of expense codes for accumulation of maintenance cost which will limit their application to other HLO components and which make the use of an expanded account classification code preferable. Therefore, further effort is being held up until completion of the study on the expansion of the HAPO coding system.

A report listing HLO planned expenditures of $5,000 or more for each item of materials, off-site contracts and prototypes procured for Research and Development programs during FY 1960 was prepared and transmitted to Contract and Accounting Operation. The totals reported for the 2000 and 4000 Program were $269,000 and $527,000, respectively.

Changes in procedures and format of weekly work order cost-to-date reports were proposed by Contract and Accounting and agreed to by HLO Cost Accounting as follows:

1. Estimated cost will show hours, labor and material.

2. Cross orders from others will be identified by department symbol.

3. Date of last activity, words "overrun" and "complete" will be relocated on report to be more meaningful.

4. Machine overrun report will be discontinued and replaced by a manually prepared report. Routine work orders will be reported based on an average of the most recent three months and is considered to be a significant improvement in cost control.

Meetings were held with representatives of the work order servicing components to describe the above changes and to put them into effect.

A proposal was made by Construction Engineering and Utilities Operation regarding changing the processing of stores withdrawals from once a week to twice within a four week accounting month and three times during a five week month. Apparent disadvantages from Hanford Laboratories standpoint were: (1) the delay in material changes to work orders would result in some lack of control and, therefore, unnecessary overruns, and (2) it would have a detrimental effect on cost control where we are the customer of services performed by other departments. Because of the amount of savings claimed by Purchasing and Stores, HLO Cost Accounting agreed to the proposal for a trial period of three months, after which time we requested a review be made.

In order to eliminate the majority of unmatched work order items, a new procedure was initiated during the month. On the last Friday of the accounting month, all new work orders are to be delivered to HLO Cost Accounting by 10 a.m.; an employee of Contract and Accounting Operation will then pick them up and process them into the HAPO Work Order System. Through the use of the new procedure, it is anticipated that approximately 50% of HAPO unmatched work order charges will be eliminated.

Action as indicated occurred on the following projects during the month:

	New Funds Authorized to HLO	Physical Completion Notice Issued	Transferred To Plant	Construction Completion - Cost Closing Statement Issued
IR-243 Relocation of 200 East Testing Equipment				x
IR-246 Alterations to Positive Ion Accelerator				x

	New Funds Authorized to HLO	Physical Completion Notice Issued	Transferred To Plant	Construction Completion - Cost Closing Statement Issued
IR-247 Normal Electrical Service - Experimental Animal Farm				x
CAH-822 Pressurized Gas Loop	$120 000			
CAH-828 Central Storage Facility		x		
CGH-829 325 Bldg.- Basement Improvements			x	
CGH-838 Fission Product Volatilization Studies Test Facility		x		

There were 16 new authorizations for $208,315 and 2 supplements for $2,905 issued to J. A. Jones Construction Company during the month. This sizeable increase in dollar value of authorizations resulted from one order in the amount of $163,296 on Project CA-747, PFPP, for equipment installation. Work was physically completed on 22 authorizations during the month and 36 authorizations were still open at month end.

A schedule of all authorized miscellaneous capital work orders and proposed orders chargeable to FY 1960 funds was prepared for Contract and Accounting Operation. Review conducted in preparation of this schedule indicated that it would require $148,582 as compared with budget requests for $150,000. HLO requirements are to cover $109,842 already committed ($86,335 expended as of January 24) and $39,740 of essential work planned but not authorized to date. The review also resulted in deferring until next year the construction of offices on the second floor of the 325 Building, authorized in the amount of $10,733. All other authorized jobs are progressing and are scheduled for completion prior to June 30, 1960.

GENERAL

The first rough draft of Hanford Laboratories' contribution to "1959 at HAPO" was forwarded to CE&UO on January 11.

Exempt IBM force reports for December were transmitted to Section Managers on January 15, 1960, as working paper for recording of recommended and approved salary action. Percent to position rate was included on these listings opposite each employee's name for information. A letter of transmittal was prepared explaining the listings and outlining the action to be taken in completing required information.

A 2.5% increase was given to each non-exempt employee participating in the Savings and Security Plan effective January 15, 1960.

A .59% cost-of-living adjustment on base rates was paid to all non-exempt employees effective January 25, 1960, to be included in salary checks received on February 5, 1960. The accumulation of the 2.5% General Adjustment plus the .59% cost-of-living allowance has increased Area Allowance to exempt employees from $45.44 per month to $46.60 effective February 1, 1960 for those employees participating in the S&S Plan.

Patent Awards of $125.00 each were granted and paid to four Hanford Laboratories employees during January.

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 315	632	683
Additions and Transfers In	13	4	9
Removals and Transfers Out	28	21	7
Employees on Payroll at End of Month	1 300	615	685

Overtime Payments During Month	January	December
Exempt	$2 325	$2 486
Non-Exempt	6 139	3 808
Total	$8 464	$6 294

Gross Payroll Paid During Month		
Exempt	$509 462	$516 861
Non-Exempt	306 387	386 586
Total	$816 349	$903 447

Participation in Employee Benefit Plans at Month End	January Number	January Percent	December Number	December Percent
Pension Plan	1 119	99.1	1 131	99.0
Insurance Plan				
Personal Coverage	1 292	99.8	1 311	99.7
Dependent Coverage	921		927	
U.S. Savings Bonds				
Stock Bonus Plan	78	29.4	76	38.0
Saving Plan	92	7.1	93	7.0
Saving & Security Plan	1 038	89.9	1 061	90.0

Insurance Claims	January Number	January Amount	December Number	December Amount
Employee Benefits				
Life Insurance	-	-	-	-
Weekly Sickness & Accident	21	$ 1 142	9	$ 444
Comprehensive Medical	102	6 778	53	4 263
Dependent Benefits				
Comprehensive Medical	183	11 248	119	10 200
	306	$19 168	181	$14 907

Good Neighbor Fund	January	December
Number Participating	919	933
Percent Participating	70.7	70.6

W. Sale
Manager - Finance

W. Sale: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.

INVENTOR	TITLE OF INVENTION OR DISCOVERY
Orville F. Hill	The Use of High Density Ion Exchange Resins in Continuous Ion Exchange Contactors.
A. S. Wilson	A Procedure for the Non-Aqueous Dissolution of Uranium Dioxide in Tributyl Phosphate. (HW-63454)
R. H. Moore	Pyrochemical Process Applicable to Reprocessing of Uranium-235 Aluminum Alloy Fuels. (HW-63694)

H M Parker