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HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

APRIL, 1960

MAY 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
APRIL, 1960

Compiled by
Operation Managers

May 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE April 30, 1960

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	130	104	234	128	102	230	3	3	1	1
Reactor & Fuels Research & Development	196	169	365	194	169	363	3	1	1	1
Physics & Instrument Research & Development	68	35	103	66	35	101	2	0	0	0
Biology Operation	37	44	81	37	45	82	0	0	0	1
Operation Res. & Syn.	16	4	20	16	4	20	1	0	1	0
Radiation Protection	35	99	134	34	100	134	1	0	0	1
Laboratory Auxiliaries	53	191	244	53	189	242	0	3	0	1
Financial	14	14	28	13	13	26	1	1*	0	0
Prof. Placmt. & R. P.	52	18	70	60	19	79	4	0	12	1
Programming	18	4	22	16	4	20	3	0	1	0
General	1	2	3	1	2	3	0	0	0	0
Totals	620	684	1304	618	682	1300	18	8*	16	6
Totals excluding internal transfers.	620	684	1304	618	682	1300	10	7	8	5

* 1 Nonexempt added not counted by requisition.

BUDGETS AND COSTS

Costs for April were $1,893,000, a decrease of $179,000 from March. Fiscal year to date costs are 76% of the amounts currently authorized to Hanford Laboratories. The major portion of the decrease in April occurred in the programs sponsored by IPD and CPD.

Hanford Laboratories research and development programs have the following cost-budget relationship as of April 30.

(Dollars in Thousands)	Cost	Budget	% Spent
HLO Programs			
2000 Program	$ 447	$ 615	73%
4000 Program	5 850	8 208	71
5000 Program	475	636	75
6000 Program	1 835	2 200	83
IPD Sponsored	2 772	3 605	77
CPD Sponsored	1 512	1 090	79
FPD Sponsored	10	10	100

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels Research and Development

The Phase III PRTR contractor is estimated to be about 79% completed versus a scheduled 90%, based on the official AEC schedule. The bottom PRTR shield has been installed and filled with shot, the weld repairs on the calandria have been completed, and a fifth valve has been added to the moderator level control system to limit reactivity addition at low moderator levels. The PRP Critical Facility project has been approved by the AEC in the amount of $360,000.

The excessive vibration of the PRTR pumps is being corrected by stiffening the pump supports which had a critical vibrating frequency close to the pump speed, and by adding heavier flywheels, installing new bearings, and precision balancing the assembly.

Comments received from the ACRS after their review of the PRTR Final Safeguards Analysis in January were concerned with void coefficient effects, pressure tube ruptures, automatic control, rate of reactivity increase, and certain system interlocks. Additional analyses have been made and a supplement to the Final Safeguards Analysis issued in response.

[redacted]

The PFPP is estimated to be 92% complete. The oxide preparation line and the zirconium etch facility were accepted from construction during the month.

Unsatisfactory autoclave films on the Zircaloy cladding of the PRTR Al-Pu fuel elements are delaying final assembly of the first 30 clusters. Further conditioning of the autoclaves and the availability of permanent etching facilities are expected to correct the present difficulties.

A 19-rod Zircaloy-clad half-length PRTR spike element successfully irradiated to high Pu burnout at full power in the ETR showed partial bonding of the core and cladding.

As little as one mole per cent PuO_2 in ZrO_2 stabilized the tetragonal form at room temperature enough to yield dimensionally stable pellets. However, some monoclinic ZrO_2 persisted up to 25 mole per cent of added PuO_2.

The compound $PuAlO_3$ has been produced from stoichiometric mixtures of Al_2O_3 and PuO_2 in eight hours at 1500 C in hydrogen. Some compound has been formed at 1100 C under the same conditions. The melting point of the compound is 1810 C.

Prototypical PRTR tubular UO_2 fuel elements have been fabricated by vibrational compaction. A full size tubular PRTR fuel element will be fabricated by vibrational compaction, using integrally ribbed cladding tubes extruded by NMI.

Fuel rods, composed of various UO_2 powders contained in various cladding materials, were successfully hot swaged at cladding temperatures up to 1000 C. Significant improvements on densities obtained by room temperature swaging were achieved in some instances.

Post-irradiation examination of the second purposely defected Zircaloy-2 clad, swaged UO_2 rod revealed long stringers of zirconium hydride, in excess of the original 50 ppm concentration. A third defect test, employing Zircaloy-4 cladding has just been completed in the MTR.

Experiments performed to investigate the effects of changes in wire wrap orientation on the coolant temperatures throughout a cross-section of a 19-rod PRTR fuel element indicate little change in mixing efficiency.

During April two KER loops operated with enriched tube/tube fuel elements at NPR conditions of heat flux and internal temperature. The exposure of the Loop 2 charge is now 2400 MWD/T. Tube/tube elements under irradiation in KER Loop 4 at similar thermal conditions were discharged on April 24 at 1200 MWD/T exposure after indications of rupture.

The ruptured 20-mil Zircaloy-2 clad rod from the KER Loop 1 failure of February 8, 1960, received further examination. A section cut through the base of the split revealed a five-mil wide radial crack in the uranium immediately under the split in the clad. This is the first time a fuel defect has been found to be directly associated with clad failure in testing of coextruded elements.

In simulated NPR fuel rupture tests of coextruded, unirradiated samples at 400 and 500 C, induction times were comparable, but the rate of rupturing was about twice as fast as at 300 C.

In the use of a beryllium-containing braze compound for closure of coextruded Zircaloy-2 clad uranium fuel elements, the high brazing temperature of 1050 C has been found to cause undesirable bond growth and crystallographic transformations. It now appears that these effects are much less severe using uranium alloyed with 2% Zr as core material.

Sheffield steel performs satisfactorily as the bearing surface on a fuel element support down to contact areas between the bearing and autoclaved process tube surfaces of approximately 1/8" diameter. However, by adding a lubricant such as water soluble oil, the contact area can be reduced to a point contact and cause no scratch damage to the autoclave film.

Preliminary radiometallurgical examination of the remains of 15% cold worked Zircaloy-2 cladding capsules previously burst tested in-reactor resulted in an estimate of two to three per cent of uniform strain. Control specimens burst ex-reactor showed 17%.

[redacted]

Results of corrosion tests on zirconium show that all heat treatments in air, helium, or vacuum at temperatures of 300 to 700 C for times of 10 to 1000 minutes improved corrosion behavior over the as-worked states. This contrasts with a deleterious effect due to heating in air or helium previously observed with Zircaloy-2 and Zircaloy-3.

Hydrogen which diffuses slowly through a good, protective ZrO_2 film into the underlying Zircaloy metal tends to diffuse uniformly through the metal without causing massive local hydriding, as long as the rate of entry is slow relative to the diffusion rate in the metal and the solubility limit of hydride is not exceeded.

Neither dry nitrogen added to a dry hydrogen atmosphere nor a surface plate of chromium successfully prevented hydriding of Zircaloy by molecular hydrogen.

A mathematical equation was derived to express the outlet water temperature limits for Hanford reactors as based on thermal hydraulic considerations. The equation is based on a considerable amount of experimental data and is expected to save time in determining limits as compared to the graphical method now in use.

A full-scale test section for heat transfer experiments has been designed to simulate the downstream half of a charge of NPR tube and tube fuel elements.

The final formal report on the shielding properties of ferrophosphorus concrete as a function of temperature has been written. The total dose rate (due to both neutrons and gammas) through four feet of this material in the as-cured condition was found to be due primarily to gamma leakage. After loss of water through prolonged heating at 300 C, the principal contribution came from resonance neutrons.

2. Chemical Research and Development

Design was completed for a pilot plant facility at 100-KW to study reactor effluent decontamination by means of aluminum metal beds.

A promising method was reported for producing stable uranium (IV) suitable for use as a partitioning reductant in the Purex process.

The method involves straight-forward chemical steps and could prove superior to the Flurex process developed earlier.

Two weeks of continuous operation proved flawless the performance of the ion exchange equipment in the A cell of the High Level Radiochemistry Facility. A synthetic mixture of rare earths typical of fission product ratios was satisfactorily separated and purified fractions recovered.

Twenty per cent of the technetium entering the Purex Plant was found to follow through with the uranium product and occur at 4 ppm in the uranium oxide shipped offsite.

The addition of ferric oxide to the cesium-zinc ferrocyanide slurry proved effective in stabilizing following hydrolysis and filtration steps in the Fission Product Packaging Prototype. These tests also provided the bases for revised design of leaching and filtering equipment.

As one of a number of tests in a recirculating dissolver prototype, several swaged UO_2, Zircaloy-2 PRTR fuel rods were de-jacketed using the conventional Zirflex process. Uranium loss to the decladding solution was 0.03 per cent.

The novel incorporation of a hydroclone in a by-pass line to canned motor pump bearings gave encouraging preliminary results and may prove to be an innovation which will significantly extend bearing life.

Lowering the Salt Cycle temperature from 750 to 700 C during electrodeposition of UO_2 appears to improve the oxygen to uranium ratio. The first batch made at the lower temperature had a ratio of 2.01; the lowest produced to date (electrochemically). LiCl-KCl eutectic was tested as a lower melting alternate to NaCl-KCl but some expected difficulty was observed because of the hygroscopic nature of the lithium salt. Dissolution of U_3O_8 on chlorine addition to the LiCl-KCl melt at 450 C was as rapid as a similar operation in NaCl-KCl at 725 C.

Very precise measurements showed UO_2 solubility to be extremely small in molten NaCl-KCl; less than 16 ppm.

[redacted]

Engineering scale data from a multi-stage agitated-bed ion exchange contactor (called MABIE) showed 80 per cent theoretical stage efficiency with excellent system stability over wide ranges of aqueous and resin flow rates.

No significant change in cesium absorption was noted for clinoptilolite irradiated to doses up to 5.5×10^8 r. Laboratory studies are reported wherein aged Redox high level waste tank supernate was diluted and passed through a clinoptilolite bed with very encouraging cesium extraction resulting. The question of long term radiation stability of the bed material must await further tests.

Over 100 basalt flows were revealed from examination of the drilling logs acquired from the Standard Oil Company test well on the Rattlesnake Hills. Seventy per cent of the 10,655 foot section is basalt.

No significant gross beta activity concentration differences were noted between samples taken at the top and bottom of the ground water aquifer in 19 wells tested.

3. Physics and Instrument Research and Development

In the NPR program, development and fabrication of the full-scale mockup of the dual scanning type fuel failure monitor is proceeding on schedule. Development results to date were reported in an interim status report, HW-64639. Development of several of the NPR building radiation monitoring instruments is nearing successful completion. Study of lattice physics parameters continued and good agreement was obtained between PCTR, exponential piles, and theoretical calculations for a tube-in-tube type fuel in one lattice. However, because of the relatively complex geometry, the prediction of neutron capture during the moderating process is not yet generally satisfactory.

In the automatic control field, analysis of dynamic behavior of reactor power levels encountered difficulties when analog computer results failed to confirm analytic work. The source of the difficulty is being sought further.

In the nuclear safety program, determination of the maximum safe concentration of plutonium in hydrogenous solvents was the object

of a series of experiments begun in the PCTR. Additional information was also obtained on the use of boron to prevent criticality in dissolving enriched uranium.

The last major hindrance to completion of the Critical Mass Laboratory was passed with delivery on April 8 of the control panels and instrumentation. Installation of these is under way.

In the Plutonium Recycle Program, experiments continued to determine reactivities of Pu-Al rods in light water with indications that the minimum critical mass will be near 1.5 kg. Reactor physics parameters were also obtained for two plutonium fueled graphite lattices. Development began on instruments to make in-reactor measurements of PRTR process tube diameters and gas gap spacings between the process and shroud tubes.

Our agreed target date of April 30 for obtaining basic lattice parameters of the more highly enriched (2.6%) Gas Cooled Reactor lattice was met. Effects of fuel temperatures were obtained with one slug diameter up to 750 C.

Encouraging results were obtained in two facets of the Nondestructive Testing research. The two variables, clad thickness and air gap thickness in unbonded fuel elements, are now being resolved by improved broadband eddy current methods. Small unbonded areas in bonded fuel claddings also were successfully detected by infrared techniques.

Performance of a laboratory model of a personally carried alarming dosimeter has been satisfactory and design of a packaged prototype for field testing was started. Work continued on development of a number of other radiological instruments. Development of a transistorized beta-gamma scintillation dose rate meter was completed. A previously developed portable gamma energy analyzer was modified for use at low (10-150 Kev) energies. The large scintillation crystal for the Biology Total Body Monitor was received and tested and is now ready for installation.

Instrument development assistance was provided for a variety of customer problems. One major new problem is the calibration and evaluation of linear motion transducers for in-reactor creep measurements on metallurgical specimens.

[redacted]

In the basic data field, fission of U^{236} and U^{238} by low energy neutrons was determined to be much lower than predicted by current simple theories, in the case of U^{236} by a factor of 100.

4. Biology

Contamination of terrestrial life forms went down during the month, but it went up in aquatic forms.

It was found that fish gills can excrete strontium against a concentration gradient.

With the annual survey of geese nesting on the Columbia River starting, it appears that this will be a record year for numbers of nests.

5. Programming

Information was received that a significant amount of high exposure plutonium may be available from Canada. Following chemical re-processing, yet to be arranged, this material could be used advantageously for physics testing in the PCTR.

Status and recent progress in the Plutonium Recycle Program were reviewed with D. H. Stewart, Assistant Director for Civilian Reactors, Division of Reactor Development, AEC-Washington, on April 12, and with C. W. McLaughlin, AEC Division of Reactor Development, and H. B. Rahner, Savannah River Operations Office, on April 26 and 27.

A group of senior Hanford Laboratories personnel visited the General Electric Research Laboratory for a general review of research and development programs plus detailed discussions on technical topics of special interest.

TECHNICAL AND OTHER SERVICES

Subject to Commission approval, the use of minimum variance inventory estimates to compute book-physical inventory differences will be instituted within CPD beginning July 1, 1960.

Work in the area of the statistical evaluation for reliability has continued to expand. The single branch reliability matrix technique previously

developed has been found to be directly applicable to the simplification of switching circuits.

A document was issued discussing the statistical analysis of the Phase I pressure test of the PRTR containment vessel and recommending procedures to be used in designing the Phase III test.

Work on eight operations analysis programs continued during the month. In addition, statistical and mathematical assistance on 27 problems was given within HLO and to other departments and operations.

There were five cases of plutonium deposition confirmed during April. The total number of deposition cases that have occurred at HAPO is 254 of which 185 are currently employed. Four of the recent deposition cases appeared to be minor, involving less than 10% of the maximum permissible body burden (mpbb). The other case involved a contaminated injury to an HLO employee. A small sliver of plutonium containing about 33 μc Pu was removed at the 200-W First Aid Station. A residual amount of .04 μc Pu (one mpbb) was subsequently excised from the wound area. Medical treatment with CaDTPA was administered. Preliminary bioassay data indicated the body deposition probably is from one-quarter to one mpbb.

Two reactor area employees were momentarily exposed to high dose rates to their hands when they touched a solid aluminum slug which washed out of a process tube on the front face of the 105-H reactor. The maximum whole body dose as measured by the film badge for the period covering the incident was 220 mrads including 190 mr. The localized dose to the hands was estimated to be less than 5 rads.

Topics covering the NPR were incorporated in the Hanford Classification Guide. Several other changes were also made in the guide to bring it up-to-date. A total of seventy pages were revised.

There are 23 currently active HLO projects having combined authorized funds in the amount of $23,948,000. The total estimated cost of these projects is $29,063,000. All but 4 of the authorized projects are on or ahead of schedule. Of the 4 only Project CGH-834, "Modifications and Additions to High Pressure Heat Transfer Apparatus - 189-D Building" is more than three per cent behind schedule. A revised schedule is being prepared for this project.

Development work on the pickling of the NPR process tubes has been initiated using short lengths of tubing so that the existing autoclave

installation can be used. Preliminary data using liquid ANN solutions appears to be satisfactory as a stop bath. Prior to this time the solutions were made up using crystal chemicals. Testing has been started on nine additional Harvey NPR process tubes received this month.

There were 53 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $262,004. Fifty-three new orders, seven supplements and adjustments for underruns amounted to $74,196. Expenditures during the month on HLO work were $182,769. Total J. A. Jones backlog at month's end was $153,431. Fifty-seven orders were closed out during the month.

SUPPORTING FUNCTIONS

A new authorization of $350,000 was received to fabricate elements for DMA.

Travel by Hanford Laboratories remains at approximately the FY 1959 level. Trips started during the first ten months of FY 1959 were 1,044. For the same period FY 1960, the trips started were 1,048.

Preliminary information indicates that San Francisco Operations Office is providing $11,300 for Project Chariot this fiscal year. A further authorization of $30,200 will be requested to support the cost of this work during FY 1961.

As of April 30, 1960, the staff of Hanford Laboratories totalled 1304 employees, including 620 exempt and 684 nonexempt. There were 528 employees possessing technical degrees, including 313 B.S., 114 M.S. and 101 Ph.D.

The medical treatment frequency for April was 1.68 as compared to 2.01 last month. There were three security violations during the month, bringing the total for the year to date to nine.

Three offers were extended to Ph.D. candidates, and one offer was accepted by a Ph.D. pharmacologist. Seventy-four acceptances have been received from candidates for assignment to the Technical Graduate Program. There are currently 39 Technical Graduates, including 10 employees of the Engineering and Science Program assigned to program rolls.

A. J. Nerad, General Electric Research Laboratory, discussed "Superpressure Research and Man-Made Diamonds" at a Hanford Science Colloquium on April 13.

H M Parker for prepared by L P Bupp

Manager
Hanford Laboratories

HM Parker:pmg

[redacted]

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Zircaloy Hydriding Mechanism. When an autoclaved Zircaloy-2 coupon is placed in pure dry hydrogen, an induction time is observed before the hydriding reaction begins. A series of autoclaved coupons were placed in 400 mm pure dry H_2 at 500 C. Samples were then removed during the induction periods, after the first detectable H_2 pickup and during the period of rapid hydriding. Metallography of these samples revealed the hydrogen initially is dissolved in the metal phase and uniformly distributed. The level of soluble H_2 increased as hydriding progressed. Then a very local precipitation of pure zirconium hydride occurred just under the oxide surface. This massive hydride phase advanced as a sharp front into the metal with cracking and spalling of the hydride phase.

If the autoclaved sample is scratched to break through the oxide film, no induction time occurs, the massive hydride diffusion front forms immediately and cracking and spalling occur. Very little hydrogen diffusion occurs in the metal phase ahead of this front, and the balance of the sample is unaffected. This has been observed both at 400 and 500 C.

These results confirm a proposed hydriding mechanism which states that if transport of H_2 through the oxide is slow, the hydrogen level in the sample builds up uniformly until the solubility limit is reached, whereupon precipitation of the second phase material breaks up the oxide and allows rapid attack. However, if the entry of H_2 at the metal surface is rapid, such as at a scratch, severe local hydriding occurs independent of the hydrogen level in the balance of the sample.

Rate of Hydriding Studies. Vapor-blasted Zircaloy-2 surfaces appear to hydride more readily than etched surfaces, especially when the partial pressure of H_2O oxidant in the hydrogen atmosphere is quite low, say 0.1 mm. This is interpreted to indicate that either it is more difficult to form a protective film on the rough vapor-blasted surface or that the reactive surface of the vapor-blasted sample is depleting the available water supply, leaving a dry hydrogen atmosphere. An experiment under flowing conditions to assure constant water content is planned to resolve this point.

The addition of up to 60 mm partial pressure of dry N_2 gas was ineffective in stopping the hydriding of a vapor-blasted Zircaloy-2 sample at 400 C and 375 mm hydrogen pressure. On the other hand, anodizing of a vapor-blasted Zircaloy-2 surface appeared to reduce the hydrogen pick-up rate in preliminary tests at 425 C.

A chromium plate on top of an iron flash coating on Zircaloy-2 failed to prevent hydriding of the Zircaloy at 500 C.

Fuel Element Rupture Testing. Defected, uranium core, Zircaloy clad, coextruded rod elements have been ruptured at 500 C and 200, 1000 and 2000 psig; and at 400 C, 2000 psig. These are the initial experiments in a more complete study of rupture behavior in steam. Induction times varied from 16 to 63 minutes decreasing with increasing temperature and pressure. Rupture rates increased with increasing pressure and temperature during the initial phases of rupture. After extensive reaction (100 grams of uranium), the rates attained for both 400 and 500 C were about 19 grams per minute compared to maximum rates of about five to eight grams per minute at 300 C. The Zircaloy cladding was severely hydrided and brittle after every test.

Sample Exchange with Harvey Aluminum. A cooperative test program, to help resolve differences in the results of corrosion tests of Zircaloy-2 has been initiated with Harvey Aluminum. A series of 112 samples have been prepared consisting of 40 samples of sheet stock Zircaloy-2 and 72 samples cut from nine NPR tubes recently received from Harvey Aluminum. The samples have been divided into four parts and will be handled as follows:

Part A: Etched and autoclaved at Hanford.
Part B: Etched and autoclaved at Harvey Aluminum.
Part C: Etched at Hanford, autoclaved at Harvey Aluminum.
Part D: Etched at Harvey Aluminum, autoclaved at Hanford.

Weight gain data and visual appearance of these samples are expected to establish where Hanford and Harvey Aluminum testing methods differ.

Etching of NPR Process Tubes. Small scale experimental studies have been continued to evaluate the etching of NPR process tubes by a continuous method whereby the tube is never out of solution during the etching and rinsing cycles. Several samples have been successfully etched and autoclaved. Two more have been recently completed. In both recent tests the etching acid was diluted to one-half the normal strength. The etching acid used was 13.6% HNO_3 and 0.875% HF. The first sample was rinsed in 25 C deionized water while the second sample was rinsed in 55 C tap water. The first sample gave a satisfactory autoclave film, but the second sample was acid stained on the inside.

Studies were made to determine the temperature rise when a large Zr-2 area to acid volume ratio is used. Seven liters of diluted etching acid were used to etch 40 grams of Zircaloy-2 in five minutes. The dilute acid gave a slower etching rate with less rapid gas evolution and more time to dissipate the heat. The result was a measured temperature rise of 7 C per mil etched.

Radiometallurgy Laboratory Studies

Room temperature tensile tests were made on two irradiated uranium samples that had been cycle annealed for ten cycles between 100 and 625 C. Four uranium samples from Zr-2 clad cluster rods were dissolved and submitted to Radiochemistry Operation for U-235 burnup analysis. Six ruptured capsules from the test of in-reactor strength of Zr-2 fuel element jackets have been sectioned and the samples mounted in plastic for subsequent metallography and replication.

A transverse section was removed from the rupture area of the defected rod from the third ETR rupture test and examined metallographically. Hydriding of the Zr-2 cladding was found to range from 50 to 100 ppm H_2 in the rupture area. A sample eight inches from the rupture was found to contain 50 ppm H_2 in the cladding. The U-Zr-2 bond strength was found to be good from a test on a sample removed from the non-ruptured portion of the defected rod (RM-564).

The first defected rod has been sent to Coolant Systems Development as part of their study to determine the effects of irradiation on the rupture performance of coextruded uranium - Zr-2 fuel elements. A natural uranium rod clad in 30-mil Zr-2 and irradiated to 1250 MWD/T was defected by drilling a 25-mil hole 40 mils deep near the center of the rod.

Four irradiated thorium tensile specimens annealed at 750 C for one hour and four specimens annealed at 750 C for 100 hours were tested along with two control pieces.

A graphite capsule containing various samples of reactor materials exposed to reactor atmosphere was disassembled, sorted, and delivered to the Physical Metallurgy Operation for further evaluation.

A 7-rod cluster of 1.6% enriched uranium clad in 20-mil Zr-2, which had failed in KER Loop #1, was received for examination. The failure was a longitudinal crack about one inch long located four inches from the end of a peripheral rod. A scratch or an extrusion flaw in the cladding was found extending one and one-half inches down the rod from one end of the failure. Examination is continuing to determine the mechanism of failure of the cladding (RM-562).

Results and conclusions from the above tests will be reported in connection with the development programs of the Fuel Element Design and Physical Metallurgy Operations.

Basic Metallurgy Studies

Radiation Effects in Fissionable Materials. The design of advanced fuel elements depends upon some knowledge of the effects of irradiation on the significant mechanical and physical properties. A program to obtain this information for uranium irradiated under PT-3NA was completed during the month with the tensile testing of two specimens given ten thermal cycles

between 100 and 625 C after irradiation to 0.075 and to 0.1 a/o burnup. Both specimens exhibited surface cracking after annealing. The properties of the 0.075 a/o specimen were as follows: Yield strength - 28,500 psi, tensile strength - 37,200 psi, and total elongation 1.0 percent. The same properties for the 0.1 a/o burnup specimen were 73,400, 83,700, and 1.0 percent, respectively. The total elongation of 60% may be compared with the as-irradiated value of 0.5 percent and similar increases observed after 600 C anneals of irradiated uranium in earlier experiments. Although both the yield and tensile strengths of the 0.1 a/o burnup specimen agree with as-irradiated values, the strengths for the 0.075 a/o burnup specimen are abnormally low. This suggests that in the latter case internal cracks reduced the effective cross section. Since the more highly exposed specimen exhibited better integrity, the anisotropy and, hence, the magnitude of thermal stresses caused by cycling might have been reduced by the higher irradiation.

Alloys of thorium containing one w/o oralloy (93 percent U-235), four w/o oralloy, and 5.4 w/o oralloy have been obtained for high temperature, high burnup irradiation tests. These tests are designed to determine the changes in mechanical properties and the extent of swelling in an isotropic fissionable material. Three capsules with specimens of each alloy (totaling nine) were sent to the MTR for insertion prior to cycle 138. It is planned to irradiate the alloys at equal power levels (735 F maximum core temperature) to total atom burnups of 0.2, 0.5, and 1.0 a/o.

Testing of irradiated thorium, an isotropic cubic metal, would yield data that can be interpreted more simply than that for dimensionally unstable uranium, although both undergo damage from fast and thermal neutrons. Eight thorium specimens representing two different ingots and two levels of exposure were annealed at 750 C and tensile tested during the month. Unlike uranium which recovers little ductility with post-irradiation annealing, thorium specimens irradiated to 0.04 a/o burnup underwent nearly full recovery of total elongation after a 750 C anneal. The increase was from about 10 to 40 percent elongation for the as-irradiated and as-annealed conditions, respectively. compared to an unirradiated value of approximately 45 percent.

Recovery in strength at 750 C was independent of time between one and 100 hours after 0.011 a/o burnup, but was more extensive at 100 hours than at one hour after 0.04 a/o burnup. The stress-strain curves for the two different grades of thorium fell below the curves for the control specimens after a combined irradiation to 0.011 a/o burnup and anneal at 750 C. An important effect of annealing was the recovery of work hardenability which was lost due to irradiation. The range of easy glide after initial plastic strain was substantially greater for the irradiated and annealed specimens than for the unirradiated specimens.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel materials after irradiation is a direct way of detecting radiation damage in these materials. Thin films and foils suitable for electron microscopy offer advantages, since radioactivity is a minimum.

[redacted]

During exposures of thin films of UO_2 and ThO_2, fission fragment tracks are observed in the films; sandwich films of C and ZrO_2 coated with UO_2 or ThO_2 also show surface fission fragment tracks after removal of the fissionable layer. If the fission fragment causes deformation or localized migration of the atoms in its vicinity, deformation of the underlying matrix, C or ZrO_2, may also arise. This possibility is being investigated by examination of the free surface of the substrate. Multiple layered specimens of UO_2 with Cr, Ge, Pt, and Pd have been irradiated in air filled capsules to establish whether a relatively good thermal conductor being bombarded with fission fragments will disclose fission fragment tracks similarly to C and ZrO_2. The irradiation of such films has yielded perplexing results. After exposures as high as 2.7×10^{17} nvt (thermal), all films irrespective of the exposure, showed that the UO_2 film had formed isolated spongy droplets on the metallic substrate. During examination in the electron microscope, the droplets oscillated and after low temperature vaporization occurred, the droplets became stable shells. This behavior of UO_2 was certainly not expected and differed from the behavior of UO_2 + C duplex films irradiated simultaneously. The phenomenon will be investigated in greater detail.

The following papers were presented at the 14th AEC Metallographic Group Meeting, held at Nuclear Metals, Inc., April 5 and 6, 1960: (1) An Improved Method of Etching by Ion Bombardment, (2) Novel Uses of Replicas and Autoradiography, and (3) Swelling in Uranium as a Function of Post-Irradiation Annealing.

Solid State Reactions. The effects of irradiation upon zirconium and Zircaloy-2 are being investigated to aid in prediction of behavior under reactor service. Percent cold work, irradiation rate and integrated exposure have been chosen as variables. Six sample assemblies for irradiation in the MTR rabbit facility have been finished this month. These contain twelve samples each as follows: two annealed Zircaloy-2; two ten percent cold worked Zircaloy-2; two 25 percent cold worked Zircaloy-2; two annealed zirconium; two ten percent cold worked zirconium; two 50 percent cold worked zirconium. Pre-irradiation determinations of lattice spacings and structure by x-ray diffraction techniques is complete. Microhardness has been measured and typical microstructures have been photographed.

Studies of the effects of prior heat treatment on the corrosion of zirconium in water at 680 F were completed last month. Results show that all heat treatments in air, helium, or vacuum at temperatures of 300 to 700 C for times of 10 to 1000 minutes improved corrosion behavior over the as-worked states. From a practical standpoint these heat treatments produced equivalent corrosion results. There was no deleterious effect due to heating in air or helium as had been observed with Zircaloy-2 and Zircaloy-3. A breakaway point occurred after 292 days in test after which corrosion results (in terms of weight gain per unit area) were unpredictable due to flaking and spalling. The average penetration at breakaway was calculated to be less than 0.1 mil.

Metallic Fuel Development

Cluster Fuel Elements. Further Radiometallurgy examination was made on the defected rod of the third ETR rupture test. The examination showed that the uranium was badly cracked in the region where the cladding was swollen and cracked. The Zircaloy-2 basket which enclosed these fuel elements in the ETR was sectioned at a point opposite the defect and examined for hydrides. No hydrides were found.

The ruptured 20-mil Zircaloy-2 clad rod from the KER Loop 1 failure of February 8, 1960, received further examination. A section cut through the base of the split revealed a five-mil wide radial crack in the uranium immediately under the split in the clad. This is the first time a fuel defect has been found to be directly associated with the clad failure. The cladding is separated from the core for about 90 degrees on either side of the split. Extensive internal cracking is visible throughout the uranium in this section. Sections made in the center of the split and one-half inch below the base of the split do not show cracking of the uranium. Two sections were made through a longitudinal defect that was thought to be a scratch in the cladding. Examination showed the clad to be reduced by approximately 50 percent in thickness, but no evidence could be found to indicate this thinning was caused by mechanical damage. In one of these latter sections, cracks were also observed in the uranium. It is believed that uranium cracking caused an increase in rod diameter (between two and four mils in the region of the longitudinal defect) which possibly caused the Zircaloy-2 cladding to neck down in a localized section. The average diameter increase for all rods of this cluster was less than one mil. The average diameter increase for all rods of a 30-mil clad from the same charge was 2.9 mils.

Tubular Fuel Elements. A KER loop irradiation is being prepared to determine the effect of heat treating variables on the behavior of Zircaloy-2 clad tubular fuel. Coextruded material, 1.470 inch OD x 0.400 inch ID, will be used as a single element irradiation with a stainless steel sleeve to adjust the water flow. Six separate heat treating conditions have been used with these being characterized for uranium grain size and structure, crystallographic textures, and clad to uranium bonds. Nine-inch long elements of the same material will make up the balance of the charge. The elements and sleeves have been prepared and autoclaved and upon completion of measurements, will be ready for charging.

Production Test IP-300A consisting of eight 20-inch long TIG welded outer tubes and hot headed and projection welded inner tubes was charged into KER Loop 4 on April 25, 1960. They are fabricated from Zircaloy-2 clad natural uranium coextruded by both NMI and FPD. Goal exposure is 2500 MWD/T.

Two KER loops operated with tube/tube fuel elements during April. These elements are KER size, but are enriched so that they operate close to NPR conditions of heat flux and internal temperature. The charge in Loop 2

is made up of four elements, each 18 inches long. Two elements are Zircaloy-2 clad uranium and two are Zircaloy-2 clad uranium - 2% zirconium. The exposure of the Loop 2 charge is now 2400 MWD/T. The coolant outlet temperature was held at 275 C during equilibrium operation of the reactor. The maximum fuel temperature in the inner tube is 440 C.

The charge in Loop 4 was made up of three tube/tube KER size elements. These elements operated with very nearly the same thermal conditions as those described above for Loop 2. They were discharged on April 24, following a burst of delayed neutron activity in the loop coolant. The delayed neutron monitor rose to scram level over a period of ten minutes. Previous failures have given more definite and faster rates of neutron activity rise. The elements have not been examined in Radiometallurgy. No obvious signs of failure can be seen on the outer surfaces of the elements. One element has some surface bumping. The exposure at discharge was 1200 MWD/T.

Some of the material extruded by FPD at NMI for KER inner tube stock has shown by metallographic examination to contain zirconium hydride near the copper-zirconium interfaces.

A completed fuel element with autoclave film was made from this type of material and subsequently cut up for hydrogen analyses. Several samples were taken and various sample preparation techniques were used. Listed below are the averages of these analyses:

Sample Preparation Procedure	Analyses ppm	No. Samples Taken	Avg. Metal Removed per Surface Inch
1. Uranium removed by machining	78	6	--
2. Uranium removed by HCl	250	6	--
3. Uranium removed by HCl followed by vapor blast	93	2	0.0008
4. Uranium removed by HCl followed by vapor blast and bright etching	70	2	0.0013

If an acid milling procedure is used for end closure preparation, it is essential that the acid machining be followed by bright etching and possibly by vapor blasting and bright etching in order to avoid hydrogen pickup in the Zircaloy clad.

Fuel for Present Reactors. Two hot pressed I & E fuel elements are being irradiated in the MTR as tests GEH-4-42 and GEH-4-47. These elements were removed from the reactor during a normal shutdown after 2-1/2 cycles of operation after accumulating approximately 900 MWD/T. Examination

revealed no evidence of hot spot operation or of pitting corrosion. These elements will be reinserted into the MTR on May 30, 1960 (cycle 140), for another cycle of operation. After this cycle the fuel elements will be discharged and returned to HAPO for detailed examination. The exposure at that time will be approximately 1350 MWD/T.

Component Fabrication. Tubing has been expanded by drawing a plug through the tube. In this case the plug ends are simply hydraulic seals as the expanding is accomplished by high pressure oil that is pumped through the draw bar to the center of the plug. Accurate tube sizing may be accomplished by confining the OD expansion to predetermined limits.

NPR elements and other sizes being tested require a multiplicity of support sizes and contours. To simplify making these supports, a contained neoprene type die bed has been built. This will accept any male die 1/4" wide and up to four inches long. Since it eliminates the female die, the cost of changing support geometry is greatly reduced. One lot of Sheffield stud stock supports and one lot of Zircaloy-2 supports have been formed to date with excellent results.

Nine 17-inch lengths of KER inner and outer tube stock of enriched (1.6 percent) uranium - 2 w/o Zr alloy were heat treated prior to closure for irradiation test elements. The heat treatment used was 730 C, seven minutes in Nusal salt, followed by a water quench. The treatment was selected to give optimum acid machining rates. Dimensional changes and warpage were recorded and sections taken for structure examination of clad and core.

Closure and Joining. Experimental work has continued in the development of a brazed end closure for coextruded Zircaloy-2 clad uranium fuel elements. Both KER inner and outer tubular elements have been brazed using a 5% Be - 95% Zr eutectic alloy. Brazing is accomplished by vacuum induction melting the braze alloy in contact with the uranium core and the Zircaloy end cap, and holding for two minutes at 1050 C. Although a corrosion resistant braze is formed, there are two undesirable qualities with this braze alloy. First, the relatively high melting point of 950 C necessitates a brazing temperature of 1050 C to produce an adequate braze to uranium bond. This higher temperature causes a very extensive and undesirable growth in the coextruded bond as well as causing crystallographic transformation of both the uranium and Zircaloy. A second undesirable feature is the presence of beryllium in the braze, which presents concern as a possible health hazard. However, when this braze technique is applied in the 2% Zr alloyed uranium core, the time at temperature can be halved and the coextruded bond does not show the dramatic growth.

The use of ternary braze alloy composed of 5% Be - 10% Fe - 85% Zr reduces the brazing temperature to 950 C, and the holding time to one minute. This alloy, however, does not have the corrosion resistance of the 95% Zr - 5% Be eutectic alloy. As a result, a combination of the two alloys presents a temporary solution. The ternary braze alloy is placed on top of the cap. This combination reduces the brazing time by half and still provides a corrosion resistant brazed closure.

Several other alloy systems are being investigated as possible braze alloy candidates; first, from the braze standpoint, then from the corrosion standpoint. Several alloys appear promising but will not be considered as candidates until corrosion data are obtained.

A literature search has shown that only the 95% Zr - 5% Be eutectic alloy has both corrosion resistance and ease of brazing. Over 150 alloy systems were rejected on the basis of corrosion data and nuclear properties.

The equipment for hot heading Zircaloy-2 clad uranium KER outer tubes has been set up in a 400-ton vertical hydraulic press, and four ends of 20-inch long tubes have been successfully hot headed. The heading technique is the same as used to hot head KER inner tubes. The Zircaloy-2 shoulders on the headed end appear sufficiently thick and uniform for the projection welded final closure. However, the narrow shoulders on the hot headed thin walled KER outer tube may limit the projection welded closure to only two projection rings on the closure cap, one on the shoulder each side of the heading extrusion. Several ends will be headed for use in projection welding studies.

An infrared sensing head was used to monitor the temperature of the KER outer tubes during induction heating to insure proper preheating of the uranium into the high alpha range. This method of controlling the tube preheat has the advantage over the timed cycle control method previously used in the KER inner tube preheat in that it allows the coil to be moved over the tube to insure uniform heating of the tube end without altering the desired preheat temperature.

Equipment is now being set up to hot head NPR inner tubes (1.430 inch OD by 0.520 inch ID).

Allied Fuel Studies. The Zircaloy-2 capsules from the in-reactor burst test were given a preliminary examination in the Radiometallurgy cells. In this in-reactor test, tubing simulating fuel element jackets was burst under controlled conditions of temperature and internal pressure. Estimates of the amount of uniform strain in the fractured specimens were made from photographs of the capsules. If these estimates are correct, uniform strain in the 15 percent cold worked specimens has dropped from 17 percent in the ex-reactor control specimens to an average of two or three percent in the in-reactor specimens. There was only a slight reduction in uniform elongation in the annealed specimens. Accurate measurement of uniform elongation in the capsules as well as reduction in area at the fracture will be available soon.

Dies for making plate extrusions at several reduction ratios were installed in the Dynapak. Zircaloy-2 plates were extruded at three reduction ratios and two temperatures as a part of a cooperative effort with Physical Metallurgy Operation to study the effect of extrusion on crystallographic texture. Plates were desired instead of tubes and rounds because mechanical test specimens can be cut from plates at any angle with respect to the extrusion direction. Mechanical properties of specimens cut from

these plates will be correlated with the x-ray crystallographic texture and extrusion parameters. Dynapak extruded rods of a steel alloy (Fe - 7% Al - 5% Cr - 1.7% Nb) could not be further reduced by hot rolling, but plates extruded on the Dynapak were successfully hot and cold rolled to a ductile sheet 0.030 inch thick.

Numerous attempts to measure, with a commercial accelerometer, the force or pressure exerted by the Dynapak were unsuccessful because high frequency high amplitude resonant noise masked the relatively slow deceleration of the Dynapak ram. Direct measurement of the force with resistance strain gages on the punch was successful. Oscillograms of the extrusion force as a function of time are now made routinely with each firing of the Dynapak. The force was measured in numerous shots in which UO_2 sealed in stainless steel capsules was densified with the Dynapak. In some of this work, conical punches, that amplify the force on the ram, were used. Force pulses of about five milliseconds duration reached peaks of over 500,000 pounds acting on about one square inch of capsule.

Two tube charges of dummy fuel elements with two different types of supports were prepared. These are to be flow tested at 100-D to determine the relative resistance to coolant flow offered by a suitcase handle self-support and the flat plate type self-support. Sketches of numerous other types of support designs and shapes were prepared, and an effort to rank these types according to their relative resistance to coolant flow is under way.

Ex-reactor tests show that Zircaloy-2 supports on full size NPR fuel elements severely scratch the autoclaved Zircaloy-2 process tube as the fuel elements are charged and discharged. These scratches may lead to localized corrosion or act as regions of stress concentration. Sheffield steel performs satisfactorily as the bearing surface on a fuel element support down to contact areas between the bearing and autoclaved surfaces of approximately 1/8" diameter. However, by adding a lubricant such as water soluble oil, the contact area can be reduced to a point contact and cause no scratch damage to the autoclave film. No scratching of the autoclaved Zircaloy-2 occurred when ingot iron, a high purity iron, was tested as a possible bearing surface with a point contact area. No lubricant except water was used in this test. However, a method of attaching the ingot iron to the Zircaloy-2 support has yet to be developed.

Of several types of graphite tested, an electrical brush type designated as DTS was found to wear the least. With a contact area of 0.06 in^2 the decrease in thickness is less than 0.003 inch for 120 feet of wear distance. For a contact area of 0.03 in^2, the decrease in thickness is 0.015 inch for the same wear distance. However, the graphite would be subject to additional wear and possible breaking if discontinuities exist along the charging path of the fuel elements. Corrosion test results have yet to be obtained on the ingot iron, but at present this is the only material found that would not require some modifications in the charging procedure, such as the lubricant addition or change in the process tube connection designs. Further wear tests will be made using iron electrolytically deposited on

Zircaloy-2, chromium plated surfaces, and various other oil type lubricants.

Notch fracture bond tests have been made on wafers from two irradiated co-extruded fuel rods which failed in-reactor (2250 and 2400 MWD/T). In both cases, 0.020" and 0.030" clad thickness, the notched wafers fractured through the uranium and clad without peeling the clad from the fuel. This behavior indicates that the clad fuel bond has retained its pre-irradiation strength. The corrosion behavior of the failed rods indicates that bond strength may have deteriorated since the failure propagated readily in the region of the bond line. It is believed that irradiation induced property changes in the uranium fuel have made the uranium and not the U-Zr bond the "weak link".

In-reactor swelling experiments of Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposures are being conducted. Five swelling capsules, GEH-14-97, 14-98, 14-101, 14-103, and 14-105 are presently being irradiated in the MTR to extend the coverage of temperature, exposure, and cladding restraint. Exposures and average center uranium temperatures of these capsules are, respectively, 3000, 330, 1475, 1700, 1810 MWD/T, and 675, 575, 275, 310, 335 C. GEH-14-97 will be discharged at the end of the present cycle. The goal exposure of the remaining capsules has been reduced to the range 2000-2500 MWD/T. Equipment for opening the aluminum capsules irradiated in Hanford reactors has been fabricated and is now being tested. Opening and examination of the capsules should begin early in May.

Facilities and Equipment. Experimental reactor fuel elements should be accurately measured before loading in an irradiation facility. If only a few measurements are made on the fuel element surface, the complete geometry cannot be accurately described. Equipment is being fabricated and methods are being developed to measure inner and outer surfaces of fuel elements. The measurements are continuous and cover a spiral path along the surface of the fuel element. Electromagnetic transducers are used as the sensing element for measuring the outer surface while resistance strain gages are used as the sensing element for measuring the inner surface. The fuel element is rotated in a lathe and the longitudinal screw feed is used to move the sensing element. The measurements are recorded on a Brush Strip Recorder. Successful measurements have been made of the outer surface.

The swage feed (our design) fabricated by Willamette Steel & Iron Company has been set in place at the 8F swage in 314 Bldg. Preliminary tests indicate that the unit performs satisfactorily, particularly from an operator safety standpoint. Some on-site changes are necessary to improve and increase operating convenience.

The roll restrainer (our design) has been received from Harms Tool Co. The unit will attempt to minimize warping in round fuel geometries during air cooling in beta heat treating. Corrections, adjustments, and service connections are being made, and the unit will be operational the first week in May.

The high temperature, high pressure autoclave facility installation, Project CGH-879, was completed and the project closed out. The facility consists of three autoclaves capable of 3500 psi - 425 C operation. Their internal dimensions are: 12" ID x 50" deep, 10" ID x 40" deep, and 6" ID x 20" deep. The two larger vessels are equipped with feed preheaters and may be operated with continuous feed and bleed.

The plastic duct work and fume exhauster, purchased under AR-60-HL5-31, have been installed. This installation provides a facility that is capable of handling corrosive hydrochloric acid fumes created in acid machining of uranium. The facility is located in the electroplating laboratory of the existing 306 Building.

2. REACTOR PROGRAM

Coolant Systems Development

Titanium Galvanic Corrosion. A 14-week exposure of titanium-aluminum couples has been completed in process water at 80 C in the 1706-KE single-pass mockup tubes. Flow rates were three and six feet per second. This testing was performed to measure titanium corrosion characteristics under NPR control rod cooling conditions, since titanium is a candidate material for NPR control rod thimbles. The maximum titanium corrosion rate was 0.012 mil per year. Aluminum corrosion rates, when in contact with titanium range from 0.24 to 0.48 mil per month, with an average of 0.38 mil per month. Measured corrosion rates for uncoupled aluminum at comparable test conditions are in the range from 0.21 to 0.55 mil per month, with an average of 0.34 mil per month. No pitting attack occurred on either the aluminum or titanium.

Heated Slug Rupture Prototype. A second programmed cool-down run was made during the month employing a Zircaloy coextrusion clad uranium fuel tube specimen. The outer jacket on the tube was predefected with a 0.025-inch pinhole. The specimen was exposed in hot water at 300 C, 1650 psi, and 16 fps velocity until the rupture was detected by a resistance-type hydrogen detector. After the NPR prototypical 105-minute cool-down period to reach 100 C, the resulting rupture on the tube consisted of many small mounds, about 1/4 inch in diameter, covering an area about 1-1/2 inches long and 3/4 inch wide and with a maximum height of 0.130 inch. Total weight loss for the tube was 18 grams. This rupture was somewhat less severe than the first tube tested which lost 95 grams, had a ruptured area about 1-1/2 inch by two inches, and had raised about 0.022 inch. Both ruptures exhibited a small amount of swelling on the inside surface of the fuel tube.

Rupture Test of an Irradiated Fuel Rod. A rupture test was conducted using a 30-mil Zircaloy-clad rod from a 7-rod cluster which had been irradiated to an exposure of 1200 MWD/T. The defected rod was exposed in 300 C recirculating water in the IRP (Irradiated Rupture Prototype) for one hour before any sign of activity release was observed, following which it was exposed for an additional 80 minutes. The rate of activity release was somewhat cyclic rather than uniformly increasing, although the rate appeared to be generally increasing with time.

Following the rupture test the loop was decontaminated using peroxide-carbonate, alkaline permanganate and Turco-4518. Although the loop itself decontaminated well, the coupons showed gross contamination with a strong beta emitter. The stainless steel coupons were well defilmed, but the carbon steel coupons were covered with a very black adherent film such as has been experienced previously. It is believed that this is not the original magnetite film but one that is reformed after the magnetite is removed. Decontamination factors on the carbon steel coupons were only about two.

Decontamination Studies. A cyclic single-pass decontamination test was made in the IRP in 242-B Building, using alkaline-permanganate at 100 C and Turco-4512 at 90 C. Each solution was used for two minutes. Three cycles were run with water flushes between. A peroxide-carbonate recirculation rinse was made prior to the single pass test to remove UO_2 from the irradiated uranium wafers. The results appear quite promising with decontamination factors of 200 on carbon steel and 60 on stainless steel. The corrosion rates were about 0.06 mil and 0.01 mil, respectively. In general, the coupons were defilmed including some which had been exposed in the KER-3 mockup tube. The final activities were lower than usual except for an occasional coupon that read high. This was believed to be due to fission product bearing UO_2 particles lodged under the screw heads and not completely dissolved by the peroxide-carbonate rinse. The loop was down for several days to replace tubing, install a flanged carbon steel pipe section, and for general inspection.

The sixth and seventh decontamination cycles were completed in CEP-1 using a Turco-4518 process. This test series was terminated and the loop is being modified slightly in preparation for an eight-cycle test using Turco-4502 and Turco-4518. The total accumulated corrosion calculated in mils after seven weekly cycles of alkaline-permanganate and Turco-4518 with high temperature water operation was as follows: type 304 SS (stainless steel) sensitized, 0.10 to 0.12 mil; type 304 SS nonsensitized, 0.06 to 0.10 mil; A-212 Grade B CS (carbon steel) 0.57 to 0.74; A-212 Grade B CS welded to type 304 SS (1 to 1 ratio), 0.86 to 0.96; Stellite alloy-6, 0.24 to 0.27; Stellite alloy-12, 0.38 to 0.42; mechanically coupled CS with SS screw, 0.60 to 0.74; Zircaloy, coupled and uncoupled, 24 mg/dm^2 (0.04 mil). Stress-crevice coupons discharged after seven cycles in the alkaline permanganate-oxalic acid decontamination process did not exhibit any excessive attack due to the stresses or crevices. Last month, after two cycles, one of the type 304 stainless steel coupons holders had shown galvanic attack where it was coupled to Zircaloy-2 coupons. There was no additional attack of this type up to the completion of the test at seven cycles.

A cyclic Turco-4512 and Turco-4518 run was made in the single pass facility at eight gpm using a present reactor stainless steel pigtail. The decontamination factor was approximately 16 after 24 minutes. A 2.5% sulfamic acid solution was used on a J-1 H-Reactor pigtail. The decontamination factor was approximately 22 after 20 minutes. The average general corrosion loss on polished carbon steel coupons was 0.12 mil for this process.

Galvanic Corrosion. Graphite samples which have been mechanically coupled to Zr-2 coupons were exposed to five cycles of the alkaline permanganate-oxalic acid decontamination test in CEP-1. Other samples were exposed four weeks in 290 C, pH 10 recirculating water (ELMO-5) as controls. Microscopic examination of both sets of samples did not reveal any abnormal attack at the contact points. The Zr-2 coupons were etched prior to exposure and the mechanical couple with the graphite was made on the etched surfaces. After exposure, the Zr-2 was found to have formed a tight black oxide film on all surfaces, including the mechanical joint. Weight change data on the Zr-2 was not applicable because of fretting which occurred between the Zr-2 and the stainless steel coupon holders.

Zirconium Oxide Removal. An attempt to remove ZrO_2 with molten potassium acid fluoride from Zircaloy-2 coupons exposed in high temperature water was successful, but metal weight losses were too high to be of interest for most practical applications. Weight losses of 500 mg/minute were obtained on a two-square-inch sample of Zr-2 in the molten salt.

Structural Materials Development

NPR Process Tubes. The Hanford position on interpretation of the corrosion test specification for NPR process tubes has been clarified in a letter to the vendors. Some confusion and difference of opinion has been apparent in regard to sample preparation, particularly with respect to the amount of metal to be removed from the surface. The thin layer of disturbed metal at the very surface normally does not react favorably in a corrosion test. For this reason about 0.002 inch of metal is normally removed from the tube surface before it is placed in service, and corrosion test samples from the tubes are similarly treated.

Zircaloy Retubing Program. Good progress is being made on the fabrication of the 200 Zircaloy-2 smooth bore tubes for "C" Reactor scheduled for delivery by June 15. Proposals have been received from three vendors for the trial of new fabrication processes for producing these tubes on subsequent large orders. Development cost will be borne by the vendors.

Seventeen Zircaloy-2 BDF internally ribbed tubes meeting all specifications have been fabricated under a development contract. Due to a change in plans and designs, all further development and production work on ribbed replacement tubes has been terminated.

Nonmetallic Materials Development

Hot Test Hole Irradiations. Two CSF graphite "do-nuts" have been irradiated in the 2C test-hole at KE to determine the contraction characteristics of graphite under stress. A graphite plug was inserted into the hole of one "do-nut" with the preferred orientation of the plug rotated 90° from that in the surrounding "do-nut". The transverse thermal expansion is about twice the expansion parallel to the grain at the irradiation temperature (~600 C) so that there was a compressive

force on the plug in the transverse direction during irradiation. A "do-nut" without a plug inserted was also irradiated for comparison.

After 1674 MWD/AT the unstressed "do-nut" had contracted 0.02 percent in the parallel direction with no change measured in the transverse direction. The contractions measured on the stressed "do-nut" were 0.03 percent in both the transverse and parallel directions. The contractions measured for the plug were approximately 0.05 percent in both the transverse and parallel directions. Because of the combined effects of thermal expansion, irradiation contraction, and probably initial irradiation expansion, the stresses are difficult to analyze. However, it is apparent that the contraction rates were altered by the stress-inducing "do-nut" arrangement.

Thermal Hydraulic Studies

Heat Transfer Experiments Pertaining to Present Production Reactors. Hydraulic demand data for BDF geometry were presented in report HW-64560 for steady state operation at tube powers of 50, 100, 200, and 300 KW. The experiments utilized simulated I & E fuel charge heated by d.c. resistance heating and standard BDF process tube and outlet fittings. These data are of value for determining flow requirements to provide adequate fuel cooling during steady state reactor operation at shutdown conditions.

Data have been obtained from the 189-D low pressure heat transfer apparatus to study the time and front header pressures required to recover to single phase flow from a boiling condition caused by a short duration flow stoppage in a BDF process tube channel. The data, obtained at tube powers of 15, 25, and 40 KW, will allow determination of the time which flow can be shut off from a process channel and still prevent boiling or recover from boiling without application of full riser pressure to the process channel. These data will aid in establishing operational procedures during charge-discharge operation.

The experiments were performed in the following manner. Tube powers of 15 KW to 40 KW were examined at header pressures from 40" water to 100" water. The rear header was open to atmosphere. Steady state conditions were established in the tube prior to the adjustment of valves which shut off the header supply and opened the tube inlet to atmosphere. The water was reapplied at various times after boiling commenced in the tube. The tube was considered to have recovered if the heater rod surface temperatures did not exceed 450 C and the initial flow was re-established within 10 minutes after application of the front header pressure. Pressures in the tube were measured to determine pressure buildup during boiling.

Analysis of the data has not been completed but some initial conclusions were apparent. The pressure buildup in the process tube due to the boiling was very small and would not be sufficient to force expulsion of fuel elements. The allowable time for which flow could be stopped and still recover without an increase in front header pressure varied with

tube power. For example, at a tube power of 25 KW the flow could be stopped for 30 seconds after boiling first commenced and still have conditions revert to all-liquid phase after flow blockage was relieved. For 15 KW this was true for flow stoppage times up to three or four minutes after initial boiling. However, in none of the cases could recovery to all-liquid phase be made once the tube had been allowed to boil dry.

Outlet Water Temperature Limits. Transient experiments were initiated on the low pressure heat transfer apparatus to check the validity of the present method of determining BDF outlet water temperature limits for BDF type reactors for cases of high rear header pressures and low Panellit pressures. Data were obtained with initial tube powers of 700, 1250, and 1400 KW for a variety of flow reductions at rear header pressures of 25 and 75 psi and Panellit pressures of 125 psi. Tentative conclusion of the experiments was that the present method of calculating outlet water temperature as specified by A-020 (HW-51659) is applicable to very low Panellit pressures and high rear header pressures.

A mathematical equation was derived to express the outlet water temperature limits based on thermal hydraulic considerations and specifications of A-020. The derivation of the equation was based on concepts developed from laboratory heat transfer data accumulated over the past several years. Compared to the present graphical method of calculating temperature limits, it is expected that the use of the equation will save considerable calculating time for the large variety of variables that exist in the eight production reactors.

Hydraulic Studies. Data were obtained in the Hydraulics Laboratory concerning the effect on pressure drop of attaching "bumpers" to fuel elements. ("Bumpers" are a low profile type of self-support rail which is designed to prevent contact between fuel jacket and process tube due to cocking or misalignment of the fuel piece in a regular ribbed process tube.) For this study, bumpers were attached onto the outside of solid fuel elements and a charge of the solid fuel elements without bumpers was used for data comparison. The data show that the bumpers increased the pressure drop by about 30 percent for this particular size of fuel element-bumper-process tube combination. The pressure drop increase does not check with that which would be predicted using conventional contraction-expansion loss coefficients.

The data are intended to aid fuel element design engineers in selecting proper sizes for bumper fuel elements of I & E type. The data should not be used to imply that increased pressure drop or reduced flow rates will result from eventual use of bumper fuel elements in the ribbed process tubes.

Laboratory Equipment. When operation of the high pressure heat transfer apparatus was resumed upon completion of Phase I of Project CGH-834, excessive leakage occurred through the seals of the recirculating pump. Leak rates of 50 gallons per hour were measured from the inboard seal

which had an operating lifetime of only 100 hours. After replacement of the seals, the leak rate dropped to 0.065 gal/hr. It was concluded that the short seal life was caused by foreign material introduced into the recirculating water during Project 834 or by inadequate care of the seals during the outage.

Engineering discussions on the quick-opening valves to be used for transient experiments on the high pressure heat transfer apparatus were held at the vendor's plant. Although the original quotation was based on the electromagnetic release principle for these quick-acting valves, the vendor proposed a hydraulic system as an alternate. It was the vendor's opinion that simultaneous action of the three valves would be less likely with the electromagnetic method. Other subjects covered included safety, valve body design, assembly design, testing, and inspection.

Test Section for NPR Heat Transfer Experiments. Design was completed of a full-scale, electrically-heated test section to simulate the downstream half of a charge of NPR tube and tube fuel elements. The cosine heat generation along the length is achieved by charging materials with different electrical resistivities.

Installation was completed of a short test section in the high pressure heat transfer apparatus for boiling burnout experiments. The test section is identical in size to the outer annulus of the NPR tube and tube fuel element. This test section is one of a series designed to determine boiling burnout conditions for the NPR fuel elements.

Shielding Studies

Attenuation Measurements. A formal document on "Shielding Properties of Ferrophosphorus Concrete as a Function of Temperature," HW-64774, has been written and will be distributed in May. The measured fast neutron removal cross sections at various temperatures are:

As-cured	0.131 cm^{-1}
100 C	0.121 cm^{-1}
200 C	0.117 cm^{-1}
320 C	0.114 cm^{-1}

By baking the ferrophosphorus concrete at these temperatures, the neutron flux and gamma dose rate values increased by the following factors (based on 48" of ferrophosphorus concrete):

Temp.	Thermal Neutron Flux	Resonance Neutron Flux	Fast Neutron Flux	Gamma Dose Rate
As-cured	1.0	1.0	1.0	1.0
100 C	16.0	17.4	3.3	
200 C	70.0	207.	6.1	
320 C	480.	1960.	8.4	44.0

The measured increase in neutron flux values can be calculated (within a factor of two), using a combination of age and removal theory. The dose rate through 48" of ferrophosphorus concrete in the as-cured condition was primarily due to gamma leakage. After the concrete was baked at 320 C, the primary dose rate was due to the resonance neutron flux. This is because of the water loss that occurs at 320 C. While ferrophosphorus concrete could be used as a biological shield, it should be pointed out that more efficient and cheaper concretes are available.

An interim report on "Effect of High Temperature on Masonite," HW-64868, has been written. There was no appreciable damage to the masonite below 160 C. The kindling point in air was found to be 245-250 C.

Shielding Instrumentation. A single channel gamma ray scintillation spectrometer was completed for foil activation analyses. This will extend the foil activation technique below the fast neutron energy range into the resonance energy spectrum in the shielding evaluation program.

An automatic sample changer and gas flow counter have been ordered for the foil analysis counting room. This equipment is to meet the expected increase in load from the shielding evaluation program.

The electronics associated with the neutron spectrometer, including the multichannel analyzer, are functioning properly, and an initial checkout of the new Perlow Chamber is under way.

Design and Component Testing

NPR Charging Machine. One magazine quick disconnect has been developed and built. Two alternate designs are also being built. A requisition for a prototype magazine tube has been issued. A work order for fabrication of the charging machine carriage has been issued.

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

PRTR Fuel Fabrication. The fuel rods for the first 30 Pu-Al elements for the PRTR are complete with the exception of etching, wrapping, and autoclaving. Considerable difficulty is still being experienced with the etching and autoclaving, and the autoclaved rods show signs of staining. Every effort is being made to determine the source of difficulty, and it is felt that it is a combination of the etching cycle and the condition of the autoclaves. The new etching facility and the large capacity deionizer are being put into service in the 308 Building to help remedy any etching problems which may exist. One of the autoclaves produces satisfactory results whereas the other does not. This one is now being sandblasted again in an effort to remove any contaminants which may be present.

Coincidental with the contamination of the 12-foot autoclaves, the Zircaloy-2 etching process started to produce sub-standard surface finishes. The etching solution removed approximately two mils on the diameter in a seven-minute cycle, and the resultant surface finish was acid stained and coated with a dark film. The slow etching rate was first thought to be due to the presence of "Tygon" tubing used for cooling coils. "Tygon" has been known to inhibit various aqueous corrosion reactions and organic synthesis. The removal of the "Tygon" increased the etching rate slightly. Experiments also indicated that the aluminum core material greatly influenced the rate of etching. A Zircaloy tube without a core etched twice as fast as one with an aluminum core. The core reduces the metal surface temperature during etching. The optimum etching solution for Pu-Al containing fuel rods has the following composition:

HF	7 v/o	(49% grade)
HNO_3	40 v/o	(70% grade)
Deionized H_2O	53 v/o	(3,000,000 ohms)

An etching time of four minutes in a bulk solution temperature of 32-36 C removes about four mils on the diameter.

The stop bath must be kept at room temperature in the temporary etch facility now being used. It was found that at higher temperatures the fume hood would pull aluminum nitrate vapors into the etch bath. During Zircaloy etching the aluminum fluoride complex apparently reacts with nitrous acid to form aluminum nitride which is suspended in the lower section of the statis etch tank.

Final assembly of the Mark I-G Zircaloy end brackets is under way. The first set of brackets completed through autoclaving were quite good. The welding box was not operating satisfactorily, and the welds were discolored in the heat affected zones. However, after grit blasting, etching, and autoclaving, the brackets showed no signs of contaminated metal. While the welding box is being repaired, additional welding fixtures are being fabricated to aid in assembly and alignment of parts.

Design is progressing on a wire wrapping machine, a dual electronic tube gaging machine and PRTR fuel elements. The newest model 19-rod cluster fuel element for the first PRTR power loading will be designated the Mark I-H. This model is essentially the same as the Mark I-G with the exception of 0.495 ID, 35-mil wall Zircaloy-4 tubing.

Fabrication Development. Two injection cast irradiation capsules were found to have flaws in the cladding which were not detected in preliminary radiographs. Ultrasonic tests revealed cracks greater than 0.010 inch deep in the Zr jackets so these capsules were rejected. Three more castings were made in better quality tubing, and additional capsules will be fabricated from this material.

Despite the fact that it is difficult to obtain high density, injection cast PRTR size fuel rods, fuel elements fabricated by this process will be tested in the reactor to evaluate the merits of Zircaloy clad, bonded Pu-Al elements.

Recent development work with a heated reservoir at the top of the bottom-fed fuel tubes has produced castings in which the size of the shrinkage cavities was much smaller and tended more toward a uniformly distributed pin-hole porosity rather than the larger, scattered types of voids.

Fuel Evaluation. An 11-inch long Zircaloy-clad 3-rod cluster containing 1/2-inch diameter Al-Ni-Si-Pu alloy cores has successfully completed 17.5 full power operating days in the GEH-4 loop in the MTR. This element was fabricated by extruding the cores and slipping them into swage sized tubing. There was an average diametral gap between the cores and cladding on two of the rods of 8.7 mils over their 11-inch length with maximum gaps as great as nine mils. The core material used in this element is the same as the corrosion resistant alloy that is being used in the PRTR loading except that it contained 3.2 instead of 1.8 w/o Pu. The Zircaloy cladding used for these rods has cracks emanating from the inside surface that are nine mils deep or greater. A maximum power generation of 75 KW/ft of cluster was calculated for this Pu concentration and flux; however, the element actually generated a maximum of about 60 KW/ft with a surface heat flux of 460,000 BTU/hr-ft^2.

The maximum calculated core temperature, assuming that good thermal contact is made between the core and cladding, is 350 C. One can postulate, however, with average diametral gaps as great as 8.7 mils, that the Pu-Al core would melt before thermal contact, and hence an adequate heat transfer path was provided. This element will be irradiated for another MTR cycle before examination at HAPO.

Examination of the irradiated 19-rod Zircaloy-clad Pu-Al cluster is continuing in the Radiometallurgy facility. Metallographic samples were taken from the center section of the center rod, one from the 6-rod ring and one from the 12-rod ring. Preliminary examination of the samples show them all to be essentially alike. There is evidence of bonding between the core and the Zr-2 cladding. The bonding is not continuous, however, and remains on only about one-third of the circumference. On the other two-thirds of the circumference, intermittent zones where bonding had occurred are visible, but the bond tore away when the element cooled. There is no evidence of an extensive diffusion zone between the core and cladding for these times and temperatures. The element was irradiated for 18 days at full power with a calculated interface temperature of 435 C. Large aluminum grains have formed near the interface whereas the rest of the Pu-Al cross-section consists of smaller ones. Also, there is evidence of some hydriding in the Zircaloy cladding. The concentration of hydrogen, with a maximum estimated to be about 150 ppm, is highest at the Pu-Al Zircaloy interface with little or none being observed near the outside surface. A more thorough metallographic examination is being conducted and hardness determinations will be made.

Examination of 16 irradiated Al-Pu and Al-12 w/o Si-Pu alloy capsules (GEH-14-5 through 12 and GEH-14-42 through 49) is presently being performed in the Radiometallurgy Laboratory. The information on the actual thermal neutron flux and exposure for these capsules was received from R. Neidner.

A brief summary of corrected calculations on the operating conditions for all of the Al-Pu and Al-12 w/o Si-Pu alloy capsules irradiated in the MTR and which have been or are being examined, is shown below:

No.	Alloys	Maximum Core Temperatures* (°F)	% Increase In Core Volumes ± 0.5	Exposures (nvt x 10^{-20})
4	Al-1.65 Pu	322 - 766	0.10 - 1.7	2.6 - 11.6
2	Al-5 Pu	580 - 945	0.13 - 2.0	3.9 - 5.2
2	Al-10 Pu	646 - 696	0.37 - 0.58	1.1 - 2.2
2	Al-15 Pu	678 - 712	0.25 - 0.88	1.4 - 1.9
2	Al-20 Pu	825 - 974	0.18 - 1.8	0.8 - 1.2
4	Al-12 Si-1.65 Pu	392 - 766	0.68 - 1.2	1.9 - 15.3
2	Al-12 Si-5 Pu	604 - 866		2.7 - 3.9
2	Al-12 Si-10 Pu	569 - 797		0.9 - 2.4
2	Al-12 Si-15 Pu	691 -1144		1.1 - 1.7
2	Al-12 Si-20 Pu	706 - 897		0.6 - 1.3

*Calculated values, based on maximum flux as determined by measurements on flux-monitoring wires.

Further examination of the 24 irradiated UO_2-PuO_2 capsules has been delayed since fission gas release measurements must be made before the other evaluation work can proceed. To date, three capsules have been processed through the fission gas collection step.

UO_2 Fuel Development

PRTR Fuel Elements. A swaged UO_2 19-rod cluster PRTR fuel element incorporating special closures in the mid-sections of three fuel rods was designed to contain foils for physics measurements in the PRTR. This element may be disassembled and reassembled as often as necessary to obtain the required measurements. A thermocoupled PRTR fuel assembly is being designed.

Twenty-two swaged, stainless steel clad UO_2 fuel rods, and approximately 400 feet of stainless steel clad, UO_2 pellet fuel rods were fabricated for chemical processing studies to be carried out by Chemical Development Operation.

Fabrication Development. Vibrational compaction studies are continuing. Prototypical PRTR tubular fuel elements have been fabricated. A full size tubular PRTR fuel element will be fabricated by vibrational compaction, using integrally ribbed cladding tubes extruded by NMI. Additional elements, using cladding with Thermatool-welded ribs may be fabricated if the welded ribs are satisfactory. A 7-rod, three-foot long, vibrationally compacted fuel assembly for proposed irradiation in a high temperature loop has been fabricated. Two of the rods have Zircaloy-4 cladding; the remaining five have Zircaloy-2 cladding. The two Zircaloy-4 clad rods and two of the Zircaloy-2 clad rods have intentional defects.

The Magnetic Force Resistance Butt Welder was received and is being installed for fabrication of fuel element and closures.

Improved equipment is being fabricated for welding spiral ribs on tubing with the Thermatool Rib Welder. Roller contacts are being incorporated as a possible solution to the problem of excessive contamination of the Zircaloy tubes by the sliding controls heretofore used. More reliable control of welding pressure also is expected. The new equipment will permit welding of ribs tc within two inches of each end of a cladding tube.

A special inert gas tungsten arc welding torch was built for welding Zircaloy without requiring the conventional evacuable, helium atmosphere chamber. A fine mesh screen is used to provide a uniformly dispersed inert gas blanket on the hot metal.

The Sutton 30 SI swage is being adapted to hot swaging. The reworked spindle, hammerblocks, and adjusting wedges were received. All swaging dies also are now on hand. Assembly of the swage awaits receipt of Garlock oil seals.

Fuel rods, composed of various UO_2 powders contained in various cladding materials, were successfully hot swaged at cladding temperatures to 1000 C. Significant improvement in swaged density over that obtained by room temperature swaging was achieved in some instances. For example, -100 mesh sintered and crushed UO_2, contained in Inconel-X tubes, was swaged at room temperature to ~81 percent T.D., and at 100 C to ~92 percent T.D. Powdered material of the same type and particle sizes vibrationally compacted to 71 percent T.D. The fuel rods were resistance heated through silver-graphite contacts contacting the cladding just prior to entry of the rods into the swage. Local melting of silver from the contacts caused minor contamination of the fuel rods surfaces at the highest swaging temperatures and necessitated replacement of the silver-graphite contacts with graphite contacts. Tungsten carbide and tungsten-platinum contacts have been ordered and will be evaluated.

Installation of the 25 KW, 200 KC induction heater is complete and hot swaging experimentation utilizing this heating equipment is under way.

Stainless steel tubes containing sintered and crushed, depleted UO_2 were swaged to 0.906 inch OD. The wall thickness of the swaged cladding was 0.033 inch, and the swaged UO_2 density was 85 - 85.5 percent T.D. These large diameter swaged rods will be assembled into 7-rod cluster for irradiation testing.

A radiant energy sensing device was designed and fabricated by personnel of Chemical Research Operation and Instrument Research and Development Operation for use in conjunction with a precision temperature controller to control fuel rod temperatures during hot swaging.

A radiographic method for accurately determining thermocouple locations in UO_2 fuel elements was developed by Radiographic Testing Operation. This development will result in more accurate determination of UO_2 and cladding temperatures during hot swaging of UO_2 fuel elements.

Corrosion Studies

Fretting Corrosion. A magnadash stirring autoclave has been modified so that the erosion effect of a loaded Zircaloy-2 rod on a rotating Zircaloy-2 disc may be quantitatively determined under various conditions of temperature, atmosphere, and contact pressure. The only atmosphere investigated to date has been deionized water at 1500 psi, and the rotational speed of the disc has been fixed at 75 rpm. The Zircaloy-2 disc was run as etched.

Disc penetration and rod wear both decreased markedly as temperature was reduced from 300 C to 250, 200, and 100 C at constant loading. Increase of the contact pressure at 300 C also considerably increases disc and rod wear.

Fretting corrosion of Zircaloy-2 is also being evaluated under flowing conditions in CEP-2 at 316 C, pH 10.0 (adjusted with LiOH). The system

simulates the PRTR process tube and fuel element arrangement on a miniature scale. Velocities of 15 and 30 fps have been studied. After one week of testing, the specimens were examined. Where the PRTR-type end support contacted the "process tube," fretting had taken place. This fretting had removed the corrosion product film and some of the metal. Original clearances between the supports and tube had been about five mils - a value selected as the minimum allowed for the PRTR. The specimens had been etched but not autoclaved prior to exposure. Examination after two weeks disclosed slightly increased penetration. The total penetration after two weeks was in the range of one mil.

Varied degrees of clearances will be evaluated with and without autoclaving. Also, vibration of the specimens at selected frequencies will be performed to determine the importance of this variable.

Effect of Metal Purity on Al-Fe-Ni Alloys. The base metal purity range employed in making 1.8% Fe, 1.2% Ni alloy has now been extended to cover 99.999%, 99.995%, 99.95%, 99.70%, and 99.45%. The first three purities all produced alloys which corroded the same. The 99.70% aluminum base alloy exhibited a penetration in 10 days which was 50% higher than penetrations measured for the higher purity alloys (0.3 mil as compared with 0.2 mil), while the 10-day penetration of the 99.45% base aluminum alloy was 0.50 mil. From these data the threshold purity of the aluminum required for the best corrosion resistance is between approximately 99.95% and 99.70%.

Columbia National Sponge. Two sets of Zircaloy coupons fabricated from Columbia National Sponge have been received from KAPL and corrosion tested as part of a "round robin" test. The first set of samples consisted entirely of Zircaloy-2 fabricated from Columbia National Sponge. The second set of samples consisted of Zircaloy-2 and Zircaloy-4 fabricated from Columbia National Sponge but with added amounts of silicon. Both sets of samples contained coupons fabricated from plate and sheet stock.

Except for the material with added silicon, coupons machined from plate stock showed unacceptable weight gains after 14 days in 400 C, 1500 psi steam. All of the Zircaloy-2 and Zircaloy-4 coupons which contained added silicon and most of the coupons fabricated from sheet stock showed acceptable weight gains. Although the silicon addition appears to have reduced the corrosion rate, the surfaces of these coupons still exhibit a gray, mottled appearance, as did the previous coupons fabricated from plate stock.

The unacceptably high corrosion rates occur during the first 72 hours of exposure to 400 C, 1500 psi steam. After this initial exposure, the corrosion rates assume approximately the same slope as the standard reference Zircaloy-2 material.

Structural Materials Development

Metallurgical Properties of Zircaloy-2. PRTR-type process tube sections of various percent cold work have been burst tested at 300 C, and the corresponding hoop stresses have been calculated. These data were reported in HW-62172 Rev. Longitudinal tensile specimens were cut from the same tube samples and tested at 300 C.

The hoop strengths of the annealed tubular specimens were about 25% greater than the tensile strength of the annealed tensile specimens. However, the percent increase in strength of the tubular specimens decreased to about 10% as the percent cold work increased to 17.8%. Part of the strength increase in the burst tests may be attributed to the presence of a biaxial stress condition in the tubes versus a uniaxial stress condition in the tensile test. The preferred orientation resulting from the fabrication procedure also contributes to the higher strength in the transverse direction.

Zircaloy Sheath Tube Evaluation. Two short samples of Zircaloy-2 tubing obtained from the Heraeus Company of Hanau, Germany, exhibited outstanding capability to withstand a free-sink swage test without wrinkling or cracking on the inside surface. This behavior was much superior to the domestic tubing used as a control. Metallographically, the most striking difference between the German tubing and the domestic tubing was the grain size: Heraeus tubing is about 0.005 mm average grain diameter, while the grain size of the best domestic tubing ranges from 0.019 mm to 0.065 mm average grain diameter.

In an attempt to investigate the metallurgical properties of and methods for producing fine grained Zircaloy-2, a series of grain refining experiments have been initiated.

Samples of 40% and 70% cold worked Zircaloy-2 have been sealed in evacuated Vycor tubes and annealed at temperatures ranging from 550 to 825 C for various times. To date, the smallest grains (0.014 mm) were produced by annealing for two hours at 550 C.

Zircaloy-4 PRTR Cladding Order. The vendor's (Wolverine Tube Co.) first efforts to produce the 0.680-inch ID size tubes on this order resulted in a severe cracking problem. The first problems occurred when attempts were made to extrude the tubes at a 27:1 extrusion ratio. The steel cladding stripped and reduced in thickness permitting the external copper jacket to contact the Zircaloy, resulting in local alloying between the two. However, subsequent reductions in extrusion ratio coupled with a heavier steel cladding on the billets resulted in successful extrusions. It was also reported verbally by the vendor that the Zr-4 apparently does not "work" like the Zr-2.

The vendor also experienced difficulties with some tubes cracking all the way through the wall during the second and third pass on the tube reducer. The cracking, apparently caused by local alloying on the inside

surface, should be alleviated by the reduced extrusion ratio coupled with only two passes on the tube reducer. Preliminary results now appear promising.

The majority of the 0.505-inch size tubing on this order has been changed from 0.505-inch ID x 0.030-inch wall to 0.495-inch ID x 0.035-inch wall, and the ID tolerance has been changed from +0.005-inch - 0 inch to 0.002-inch - 0 inch. To date the vendor has not fabricated the smaller diameter tubing. He has fabricated a few pieces of the 0.505-inch size and reports destructive tests reveal freedom from cracks and good surface finish. This tubing will be fabricated from a small extrusion requiring only two passes on the tube reducer. Changes in tooling design to hold the closer tolerance on the ID and prevent ringing have been completed. The vendor's most recent schedule of delivery of the two sizes on this order is 100 tubes per week for the 0.680 size by 5/9/60, and 100 tubes per week for the smaller diameter by 5/23/60.

PRTR Process Tube Monitoring. The Mark I prototype monitor will incorporate means for visual examination and diameter measurement of PRTR pressure tubes before startup of the PRTR. This unit is not intended to be serviceable in a gamma radiation environment.

For visual examination, closed circuit TV is being given primary attention. Successful application of closed circuit TV techniques would provide simultaneously direct viewing and a permanent record by means of video tape recording. To provide an early start in the development of TV inspection techniques, a camera has been rented until a suitable camera can be purchased. Experience with the rental camera shows that the type and position of lighting is fully as critical as with an optical borescope. Experiments with a 12.5 mm focal length wide angle lens indicate a need for a shorter focal length lens. (Wide angle lenses with a focal length of 7.5 mm are commercially available.) Right angle viewing also appears promising and offers a potential advantage of optical magnification. A conical mirror arrangement which would permit right angle viewing through a 360° arc is under consideration.

Purchase specifications for a closed circuit TV camera have been revised to assure better construction and performance. Bids under this specification are due April 29. Orders have been placed for the electric components needed for ID measurement by means of differential transformers.

Design of the Mark I drive and positioning mechanism is about 70 percent complete. The Mark II Monitoring Probe will be designed to operate in the intense gamma flux to be encountered in the PRTR process tubes. In addition to a TV camera and diameter measuring device, sensing probes to measure the wall thickness, the insulating gas gap, the hydrogen concentration, and the depth of any flaws will be added as they are developed.

KER Loop No. 1 Tube. The KER Loop No. 1 Zircaloy-2 process tube was discharged during the month. This tube contains four defect areas (two pits, two small protrusions, and two areas of scratches). Examination of these

defects in Radiometallurgy will be started in early May. In addition, five samples of the tube from the front and rear edge of the moderator, and the 1/4, 1/2, and 3/4 positions in the moderator will be subjected to flattening tests, metallographic examination for grain structure and hydride needles and burst tests. Additional samples will be available for tensile tests and other measurements, if desired.

Radiometallurgy Laboratory Studies

Examination of a 3.1 w/o U-235 enriched and swaged UO_2 fuel element (24" long, 0.568" OD, and clad in Zr-2) with a five-mil defect through the cladding was started this month. Sectioning through the hole and metallographic examination revealed that hydriding of the cladding had occurred to a maximum concentration of 50 ppm H_2. A three-foot long, 1.77 inch OD, Zr-2 clad, tube and rod UO_2 fuel element, that had ruptured in the ETR as GEH-10-5, was received for examination. The outer cladding of the tube had parted in a six-inch longitudinal split at six inches upstream from the center. The surface of the cladding surrounding the crack appears to have been overheated. The tube was sectioned through the rupture area and there was no evidence of washing out of the fuel.

A fission gas sample was removed from a low density UO_2-PuO_2 capsules, GEH-14-21, and submitted to Analytical Operation for mass spectrometer analysis. A volume of 11.3 cc of gas was removed which is equivalent to three atmospheres pressure in the capsule.

The results and conclusions from these tests will be reported in connection with the respective development programs of Ceramic Fuels and Plutonium Metallurgy Operations.

Thermal Hydraulic Studies

Problems of a Small Leak Downstream of the Orifice in a PRTR Process Tube. The flow out of a small leak downstream of the orifice of a PRTR process tube would come partially from an increase in flow through the supply piping and partially from a robbing of the flow through the tube. Studies have revealed that the flow increase through the supply piping is so small as to make impractical the use of a high flow trip to guard against leaks which would reduce the flow through the tube to a flow less than that required to prevent film boiling. A decision has been made to make use of the pressurization of spaces outside the tube which small leaks would cause to guard against such leaks. An alternate method of protection against such leaks would be to decrease the ring header to ring header pressure and to provide less pressure drop across the tube orifices. A study was made of this alternate to provide the necessary information for its application, should it be deemed necessary. The study resulted in a relationship between the high flow trip setting necessary to protect against flows resulting in burnout and the ring header to ring header pressure drop:

$$F_{HT} = \left(\frac{\Delta P - 18.2}{\Delta P - 16.1}\right)^{1/2} \times 100$$

F_{HT} = percent of normal flow at which the high trip has to function

ΔP = ring header to ring header pressure drop.

Entering this at a high flow trip at 110% of normal flow reveals that the ring header to ring header pressure drop must be 28.2 psi. The tube orifices would then have to be resized to provide a 12.1 psi pressure drop from bottom ring header to tube inlet.

Wire Wrap Orientation. Experiments were performed in the high pressure heat transfer apparatus to investigate the effects of wire wrap orientation on the coolant temperatures throughout a cross-section of the 19-rod PRTR fuel element. The test section was full size in cross-section, but 24 inches long, and had uniform heat generation. Two series of tests were run at flows of 127 and 86 gpm, inlet water temperatures of 478, 500, 510, and 250 F, and specific powers of 0, 75, 150, and 225 KW/ft.

The first series of tests was run with a wire wrap orientation similar to that being used on the Pu-Al fuel elements. For the second series of tests, the wire wraps were shifted to give different orientation of the wires.

An initial analysis of the results of the experiments indicates that a change in orientation of the wraps does not greatly change the mixing efficiency.

PRTR Project Management and Design

Phase III PRTR Contract. The Phase III contractor is estimated to be about 79% completed versus a scheduled 90%, based on the official AEC schedule. Over-all PRTR Project is estimated to be 86% completed versus a scheduled 88%.

Repairs to the calandria weld seams which showed leaks during the contractor ATP's were completed. The reflector vessel was helium leak tested with the exception of the vent line and found to be sound. Installation of the calandria is being delayed by procurement of the spiral tubes for the refelctor vent line installation by the contractor. The iron shot was installed in the bottom primary shield and the shot filling holes plugged and seal welded. Leak testing of these seal welds has been completed. Satisfactory shot density was achieved in the bottom shield, and deflection of the shield as a result of placing the shot was negligible. The shot has been installed in the core region of the top primary shield. The annular region will not be filled until the shield has been installed.

Assembly of the fuel handler in the reactor building is about completed. Rail stops and limit switch brackets are being made for the floor rails. It has been necessary to raise the cask to permit travel across the reactor hall floor which is out of tolerance in a number of locations.

The ATP on bow measurement, hydrostatic and leak testing of process tubes continued during the month. Bow measurements and assembly of tubes and nozzles were completed.

Process Piping. Primary coolant piping flexibility analysis reports covering inlet and outlet jumper stresses and the effect of overbalancing the normal operating weight of the steam generator were received from Electric Boat Division of General Dynamics Corporation. Thus far, all piping stresses are shown to be below allowable limits.

Instrumentation and Control. The PRTR moderator level gas balance system is being modified to reduce the maximum possible rates of reactivity increase at levels between 3.5 and 7.5 feet while maintaining previously existing rates in the operating range. This is being accomplished by adding a fifth valve which bypasses the gas balance compressor in the same way as the other level control valves. The valve is operated by the pressure differential between the moderator storage tank and the top of the calandria. The valve is open at low pressure differentials (moderator levels) and closes as the pressure differential (moderator level) increases. The result of this valve action is to lower the rate of moderator level increase which can be obtained at low moderator levels. The valve is closed above 7.5 feet and therefore does not affect the previously existing rates in the operating range. The PRTR control system is being studied to determine whether any changes must be made in it to compensate for the changes made in the gas balance system.

All submittal data has been received and reviewed on the rupture monitor electronics system. Delivery was originally scheduled for 4/19/60, but all submittal data had not been received by that date. A revised delivery schedule has not been received to date.

The Keithley amplifiers for use in the containment system were received during the month. The safety system bypass panel had previously been shipped less these amplifiers. Upon inspection, a number of discrepancies between the amplifiers, the panels, and the specifications were observed which will make installation of the amplifiers difficult. Also, the amplifiers as delivered will require the provision of a separate 24-volt DC power supply for their operation. A claim for backcharge against the vendor has been forwarded for processing.

Fuel Element Examination Facility. The joints between the various shielding sections have been seam welded. The vertical shield and the viewer support plate have been installed in the cell. The ventilation and services are currently being installed.

The W. F. and John Barnes Company was unsuccessful in getting a satisfactory finish on the aluminum castings for the primary manipulator. An attempt is now being made to obtain a satisfactory finish by metallizing and repolishing.

The air duct with movable outlet (zipper), which is to operate at approximately two psig, failed to pass the initial pressure test due to excessive spreading of the track on which the carriage travels. The duct has since been strengthened and is now satisfactory for use at a pressure of three psig.

The testing of the wide angle viewer has been completed, and the viewer is ready for installation. The profilometer is still undergoing tests.

Load-Out Cask. A visit was made to the vendor's plant to discuss the changes which have been requested. The vendor's quotation for additional charges was subsequently approved.

Helium Gas System. The possible relocation of one or more of the diaphragm helium compressors is being studied. The operations group has requested the change as a means to facilitate maintenance on the unit.

PRP Critical Facility (Project CAH-842). Project funds totaling $360,000 were approved April 14, 1960. The Design Criteria, HW-62117, has been published.

Purchase specifications for the fuel transfer lock were prepared and placed for bid on a design and fabricate basis.

Rough draft specifications for the reactor instrumentation system were issued for comment.

Development of a drop-type safety rod and a shutter-type control rod has been initiated by MEDO.

Fuel Element Rupture Test Facility (Project CAH-867). The text of the design criteria has been completed and is being routed for approval. All scope drawings for the facility are completed and are ready for approval except water plant, equipment annex, and effluent holdup tank drawings. It is expected that these drawings will be completed by April 29, 1960.

High pressure-high temperature bellows, for use as expansion joints in the Test Section "B" backup tube-pressure tube complex, are being procured for evaluation.

Transient studies are being conducted by RTDO personnel. To date, the thermal shock to equipment after the failure of normal electric power and after a regenerative heat exchanger bypass valve malfunction has been computed. The data obtained were used to set design maximum rates

of temperature change (350 F/hr) and design temperatures for piping and equipment downstream of the regenerative heat exchanger (250 to 450 F). Further analyses are being conducted to establish the required test section outlet temperature control system characteristics (proportional band, reset frequency, and rate action) and to determine the effectiveness of convective circulation in cooling the test section after a total electric power failure.

Design and Component Testing

Design Test PR-1 - Discharge Operation Mockup. The PRTR fueling vehicle was removed from the 314 Building by the Phase III contractor. A report (HW-64687) has been completed.

Charge-discharge data from a process tube with a maximum bow of 0.12"/length are summarized below:

> The end brackets of the element chattered against the tube wall during each charge-discharge trial from the tube. The UO_2 element was charged and discharged from the tube with the discharge hook offset 0.25" east from the centerline of the nozzle and 0.32" west of the nozzle. It was possible to discharge but not charge the element with the hook 0.38" west and 0.32" east of the nozzle. Ten charge-discharge trials were made with the centerline of the hook positioned on the east-west centerline of the nozzle and offset 0.06" south. The metal particles formed by the abrasion between the element and tube were collected at the bottom of the tube and weighed less than one milligram.
>
> It was possible to charge and discharge the Pu-Al element with the centerline of the hook offset 0.10" east from the centerline of the nozzle and 0.24" west from the centerline of the nozzle. The hook was offset 0.05" west and 0.06" south and the element charged and discharged ten times. Total weight of the metal particles collected during the ten trials was 2.97 milligrams. Measurements of the fuel element at the completion of the charge-discharge trials revealed a bow of 0.15" at the center.

PR-10 - Primary Loop Mockup. The second of the three PRTR primary pumps (#352472), which had 1.4 mils maximum vibration, was disassembled on March 27, 1960, after 129 hours of operation. The rotating mechanical seal face was heat checked at the outside diameter of the graphite face. The raised face on the graphite member (0.093") instead of the standard (0.063") is thought to have been a contributing factor to the overheating observed. The wear pattern indicated that the higher raised face had deformed. This malfunction had been observed on earlier tests which resulted in the adaption of a lower raised face on all replacement seals. Retesting of the pump previously run during March 1960 (#352473), revealed the same excess vibration of six mils maximum after careful alignment with both the original impeller and a rebalanced impeller returned

from the factory. Recordings were made to show pump speed and magnitude and direction of vibration.

The third pump (#352471) was installed and operated on April 18, 1960, with the rebalanced impeller. The vibration level was found to be six mils on the pump case. The critical resonance frequency of the assembled pump and support was found to be 29 CPS. This frequency corresponds closely to the pump speed. Stiffening the pump supports moved the critical frequency from 29 to 34 CPS and reduced the pump vibration to 1.4 mils. A vibration element mounted directly on the coupling hub above the flywheel showed a maximum vibration of the rotating assembly of eight mils. The pump case vibration was reduced to 0.3 mil, and the vibration at the coupling hub reduced to 2.8 mils, by the addition of 52 oz-in to the flywheel. This is an alarming amount of imbalance.

Further corrections are being planned to eliminate excess play found in the upper radial bearing. The vibration imparted by the impeller will also be reduced by increasing the clearance between the pump case and impeller.

The weight addition to the flywheels has been ordered and will be assembled and balanced as a unit at the factory.

The high pressure seal of the prototype pump continues to operate satisfactorily after 3685 hours of operation and 64 pump starts. The leak rate is still approximately 0.1 gph at equilibrium conditions.

Packing tests were resumed in the small capacity Aldrich pump on April 11, 1960, using R/M Vee-Flex Packing rings, Style #R/M 1204. The packing has operated approximately 85 hours without measurable leakage.

During the past month the single tube prototype has operated 447 hours with 15 thermal cycles. The fuel element and the process tube were removed on April 20 for inspection. The process tube No. 6063, has now operated for 2000 hours at simulated reactor conditions. A boroscope inspection revealed only small burnished spots where the fuel element contacts the wall of the tube. It is proposed that this process tube be operated at least an additional 1000 hours.

The nozzle-to-process tube (NTPT) connection of the single tube prototype operated without shim 447 hours this past month with an average leakage rate of 0.2 ml/hr. This particular seal had operated for 632 hours when it was broken April 20 for tube inspection.

The special nozzle-to-process tube test piece was operated for 500 hours with 37 temperature cycles to 500 F. The shimmed end of this test piece has been leaking excessively throughout this period. Leakage while heating and when hot has been from five to 20 ml/hr with leakage slightly higher during the heating portion of the cycle. Leakage at the non-shimmed end has been consistently low with average collection less than 0.2 ml/hr.

Cap seal leakage on the single tube prototype has been excessive all month. The nozzle gasket seat has been lapped twice to remove surface roughness, and the cap gasket groove has been remachined twice in efforts to reduce leakage. The lowest sustained leakage rate averaged about six ml/hr. Impingement of the inner gasket metal ring between the metal seating surfaces has still been observed.

Similar experience was observed with the cap seal being tested on the jumper flexure test loop. This cap has now been modified in an attempt to prevent impingement of the gasket between the metal gasket retainer and seat. Preliminary leak data during the first three thermal cycles has shown leakage to be less than one ml/hr.

Continuous testing and analysis of the nozzle cap seal, which is physically limited to a very narrow gasket, is being emphasized with new and modified seal designs being prepared for evaluation.

PR-20 - Calandria Characteristics. The maximum rate of rise attainable in the 189-D mockup was 0.019 ft/second under test conditions with 3-1/2 feet of water in the storage tank. A theoretical rate of rise of 0.027 to 0.021 ft/second was reported in HW-61236 (Safeguards Analysis Report).

PR-40 - Shim Control Mockup. Operation of the prototype corrosion test mockup was started during the month.

Two motors were received from the vendor for testing. One motor exhibited uneven winding resistance and was returned to the vendor. The second motor is undergoing electrical and mechanical tests.

PR-70 - Helium Compressor Test. Three check valves of 17-4 PH stainless have been fabricated for the Hofer high pressure compressor.

Rebuilding of oil pumps for the high pressure compressors is being continued. Test evaluation of the oil pumps is also being continued.

PR-80 - Air Cooling Duct Test. The high pressure duct has been modified to prevent deformation of the carriage rail section. Delivery of the compressor to the reactor contractor has made it necessary to install a temporary portable compressor for testing. Final tests of air flow, leakage, and carriage operability have started.

Special Tools. The horizontal jumper wrench for the reactor has been completed and tested. It is capable of retaining and positioning the nut for starting. The nut can be run into position and the initial 25 foot-pounds of torque applied. The final 500 foot-pounds is applied with an extended open end type wrench.

Tongs to remove and retain the shim control electrical connection have been completed and tested.

The design of the load-out cask pin and hanger remover has been completed and is in the shop for fabrication.

Electrical Structural Opening Sealers. Two sealants, epoxy cement and 3M sealer EC 1291, have proved to be acceptable for sealing the structural openings and the wire ends. The silicone rubber material which was specified did not provide an acceptable seal.

The two acceptable sealants were used to fill the top inch of an opening with sand used as a filler base. A report has been completed.

PRTR Process Instruments. An acceptable bid was received from a vendor for the fuel element temperature detector probe of Hanford design for the Fuel Examination Facility. After completing the accumulated dose of 10^9 R on the arsenic trisulfide windows, it was discovered that the loss in transmission efficiency was due to surface etching and not to radiation darkening. When the surfaces were polished to remove the etching, the transmission efficiency was found to be identical to that measured before the windows were irradiated. Silicon and germanium lens, both coated with silicon monoxide to favor transmission at the six-micron wavelength, are on order.

A radiation exposure test has been authorized for a commercial temperature detector utilizing small amounts of mineral oxides as a eutectic salt. The detector is a small (0.088 inch) stainless steel sheathed cable capable of operating up to 900 F. It is a potential candidate for an in-pile monitor on the Gas Loop in the PRTR.

Design Analysis

PRTR Safeguards Analyses. Analysis and writing for the PRP Critical Facility preliminary hazards report were continued.

A summary of hazards and restrictions for the PRTR critical tests was written, discussed with the Physics Sub-Council of the Startup Council, and submitted to the Council. The write-up covered special hazards associated with the tests, procedural restrictions, and special process specifications.

ACRS Review of PRTR. Comments of the Advisory Committee on Reactor Safeguards resulting from their review of the PRTR on January 28, 1960, were received. Two recommendations of the Division of Licensing and Regulation, U. S. Atomic Energy Commission are as follows:

1. "The following conditions be positively required by revisions in the facility, installation of appropriate interlocks, etc:

   a. Shim rods and moderator level should not move simultaneously.

   b. It should be impossible to increase reactivity through the increase of moderator level at the maximum rate except when the high level flux trip is set at about one-tenth full power.

c. There should be a warning signal if the voltage across any ionization chamber deviates appreciably from the specified value.

d. Startup without a positive signal from startup or period channel should be prohibited.

Procedures should be adopted to insure that:

a. The rate of reactivity increase will be restricted to levels substantially below the maximum until after extended operating experience has been gained.

b. Manual operation should be employed during initial startup tests and initial full power tests. Automatic control should be used only after initial tests."

2. "Prior to startup of the reactor, the following information should be submitted:

a. Analyses should be made of the consequences of a pressure tube rupture, including the effects of possible moderator level changes in the calandria, which might occur under unfavorable operating conditions, e.g., during startup while reactivity is being added at a maximum rate.

b. Indication of conditions under which positive void coefficients might exist in the PRTR and the effect these coefficients would have on the accidents that have been analyzed.

c. The actual values of void coefficients are of considerable importance in the safety evaluation of this reactor. It is requested therefore that the procedures be described by which these, and other physics parameters, will be measured in later critical experiments with the initially loaded reactor."

A document, HW-61236, SUP1, which provides information and describes actions taken with respect to the above items has been issued and transmitted to the AEC in preparation for a further review early in May.

All of the recommendations, with one exception, were adopted by making revisions in the equipment or establishing procedural practices. This exception is concerned with interlocking the shim rods and moderator level to prevent simultaneous movement. Installation of a moderator level rate control valve will substantially reduce the maximum possible reactivity changes caused by moderator level changes in the range of 2.5 to 7.5 feet, and it is believed will permit simultaneous movement of a shim rod and moderator level without compromising reactor safety. At the minimum critical moderator level of six feet, the maximum rate

of reactivity addition by simultaneous movement of a shim rod and moderator level could increase reactivity from delayed to prompt critical in about 21 seconds.

Further analyses of the consequences of process tube failure are presented. Process tube ruptures when the primary coolant is hot result in formation of such large moderator voids that there is no net positive reactivity addition. Only in the case of a process tube leak occurring when the primary coolant is cold and pressurized is there a net positive reactivity effect, and this is very small, 0.25 mk.

Analyses of void coefficients for PRTR show that only loss of coolant will give a positive void coefficient, and this coefficient is low, resulting in a maximum reactivity increase of about four mk upon total loss of coolant for anticipated core loadings.

The opportunity afforded by this communication was taken to request consideration of new limits for the exhaust air activity trip and a new limit for reactor thermal power. The new limits are:

Exhaust air activity:	Alarm	4.5×10^{-6} μc/cc
	Containment trip	4.5×10^{-5} μc/cc
Reactor thermal power:	Nominal maximum	70 MW
	Actual maximum	75 MW.

Small PRTR Process Tube Leak. The pressurizer liquid volume transient was calculated following a process tube rupture of 0.286" equivalent diameter. With the reactor operating at 70 MW the initial leak rate is 50 gpm or 5.95 lb/sec. The leak rate increases in 30 seconds to about 7.0 lbs/sec. Five minutes following the incident the heat exchanger and primary coolant system are depressurized linearly in 10 minutes. The leak rate drops sharply to 1.81 lb/sec at five minutes as a result of the depressurization of the pressurizer, but then the decrease is gradual to 1.67 lb/sec at 15 minutes. The make-up feed pumps supply 23.3 gpm for the initial minute, and then the flowrate increases to 32.0 gpm or 4.45 lb/sec. Therefore, after five minutes the feed rate exceeds the leak rate; however, not until after 18 minutes does the pressurizer begin to refill. The lag is due to contraction of the D_2O primary coolant from temperature changes. The maximum D_2O volume change was 57.8 ft^3 or 432 gal. At no time during the transient do fuel element temperatures exceed 15 F above normal.

Moderator Level Transients. The moderator level transient following process tube ruptures during high pressure-high temperature reactor operation and during high pressure-low temperature reactor operation were calculated.

In the low temperature study the process tube was assumed to be completely parted. The resulting flow rate was 190 lb/sec which was assumed constant for the entire transient. A scram was assumed after 0.1 second. Initially the moderator was at 6.0 feet.

The calculation indicated the moderator level increases to a maximum of about 6.02 feet as the result of such a rupture. The level will drop, however, to the original 6.0 feet after about 0.22 second.

For the high temperature study, two process tube failures were examined. First, the rupture which provides 18.75 lb/sec flow rate (the flow necessary to rupture the shroud tube) and, second, a complete parting of the process tube which provides a flowrate of 140 lb/sec. In each case the flowrates were assumed constant during the entire transient.

In the 18.75 lb/sec case it was assumed that 50 percent of the steam formed in flashing to atmospheric pressure was condensed, yielding a quality of 20 percent. The volumetric steam flowrate was thus 89 ft^3/sec. Calculations were made for initial moderator levels of 4, 6.5, 8.0, and 8.83 feet. In each case a scram was assumed at 0.1 second.

With the moderator initially at four feet, the liquid level continued to rise during the entire transient. However, it is believed the assumption of trapping all the steam below the surface of the moderator is not valid, and thus a liquid level change of about 1.5 feet would be about the maximum value. The corresponding steam void will occupy about 3.3 feet of the calandria.

In the remaining cases examined the moderator level was calculated to peak before the calandria becomes filled with 20 percent quality steam. The maximum liquid level increases were 1.08, 0.453, and 0.40 feet which corresponded to steam voids of 1.05, 0.776, and 0.658 feet. The initial moderator levels were 6.5, 8.0, and 8.83 feet, respectively.

In the 140 lb/sec case it was assumed that none of the steam in the steam-water mixture was condensed. The quality was 40 percent and the flowrate was 1330 ft^3/sec. Because the steam flowrate was high, the rate of liquid level rise was equal to the rate of steam void formation until the moderator level reached 9.40 feet. From this time on the liquid level remained constant while the steam void increased and filled the calandria. The time to completely void the calandria was estimated to be less than 0.2 second.

PRTR Rupture Loop Transient. The effects of completely bypassing the cold leg flow to the regenerator upon the outlet primary coolant temperature from the cooler was determined. The calculation was made with an 1800 KW fuel element and assuming the reactor is not scrammed.

The results indicated that the temperature of the primary coolant at the inlet of the cooler would increase from its normal 180 F to about 445 F, but the outlet temperature would increase only from its normal 130 F to about 220 F. The outlet temperature would remain in excess of 200 F for about 1.8 minutes.

PRTR Physics Analyses. Additional calculations have been carried out to determine moderator and coolant void effects on reactivity for anticipated operating conditions. It was found that the initial moderator void coefficient utilized for the safeguards analysis is conservative for voids larger than 10 percent. This is of importance in compensating the reactivity introduced by a transient increase in moderator level if caused by a major pressure tube failure.

Loss of primary coolant has a more complex effect and the calculated separate effects are summarized in the following table:

SUMMARY, D_2O COOLANT LOSS EFFECTS

	UO_2	Pu-Al	Uniform Enrichment
$\Delta\eta/\eta$	0.000	0.000	0.000
$\Delta f/f$	+0.002	+0.002	+0.002
$\Delta p/p$	-0.003	0.000	-0.002
$\Delta\epsilon/\epsilon$	+0.010	0.000	+0.010
$\Delta k_\infty/k_\infty$	+0.009	+0.002	+0.010
$\Delta k_{eff}/k_{eff}$	+0.003	-0.004	+0.004

The largest positive contribution to the coolant void coefficient appears to be the increase in the fast fission factor, while increased leakage represents the largest negative effect.

Two dimensional calculations of PRTR flux and power distributions have been initiated. A test case has been run successfully on the IBM-709 code, ANGIE, which is being utilized for this study. The problem is being set up for three neutron groups incorporating a two-region core, top, bottom and side reflectors, and the dump chamber.

A study of the mean neutron lifetime in the PRTR is currently under way, and results will be reported in the near future.

PRP Shielding Analysis. Calculations of sky shine from the air in the fuel element storage pit when the fueling vehicle passes over were made. Since this will be a transient source, no additional shielding is required.

A list of potential sources of radiation compiled by the PRTR operating group is currently being reviewed and a document will be issued in the near future.

Radiation through the hole in the containment vessel for the 14" steam line could present a hazard to persons outside. Calculations of dose rates for this situation are under way.

Computer Codes. The North American S-4 One Group Transport Cylindrical Cell Code has been successfully adapted to the Hanford 709 Fortran Monitor System. This code has provision for 200 regions and 400 mesh points and requires as input the macroscopic total cross section, the macroscopic scattering cross section, and the source value of each region. A document will be published shortly.

The SNG Code is now complete and ready to run. The code is a combination of the ANL SNG and the North American SNG, with modifications to decrease running time. A document on this code will be published in the near future.

PRTR Xenon Tables. The basis for the PRTR Xenon Tables was published as HW-64503, "The General Xenon Equation and Their Application to the PRTR," April 1, 1960, and the tables themselves have been published as HW-64453, "The PRTR Xenon Tables," April 1, 1960.

Critical Facility Physics Analyses. Calculation of critical loadings for the PRCF have been completed for the case of operation with heavy water as moderator. The general scheme of fuel distribution was restricted to an eight-inch hexagonal lattice composed of a central test region, a buffer region composed of MK-I UO_2 cells, a peripheral driver ring of MI-I Pu-Al cells, and a heavy water reflector. Critical loadings varied between combinations of 19 UO_2 cells with eight Pu-Al cells and 37 UO_2 cells with 12 Pu-Al cells. These calculations were made using the FLUX-WEIGHT Code, a one-dimensional multi-group diffusion theory model.

Results in addition to an effective multiplication for each loading were also obtained. These include the normalized radial flux distribution, fission density distribution, and multi-group importance function distributions. This flux description of the reactor is sufficient to permit calculation of the relative radial effect of any reactivity perturbation introduced in the core or reflector.

Plutonium Fabrication Pilot Plant

Construction is estimated to be 92% complete at month end.

The oxide preparation line (Room 131) and the zirconium etch facility (Room 221) were completed and accepted from construction during the month. The plastering subcontractor completed construction of the second floor partitions at the end of the month.

Leak tests were made on the ammonia, nitrogen, and hydrogen piping at the sintering furnace installation. A representative of Sargeant and Wilbur Company assisted in startup and acceptance testing of the ammonia dissociator and nitrogen generator systems.

Work on the sintering furnaces was completed with the exception of operational adjustments. A claim for on-site completion of these units is in process of negotiation at month end. Operational acceptance tests were started during the last week of the month. Preparations for floor painting in Room 125 were under way.

A larger water demineralizer unit was purchased and delivered during the month. It was installed in time for startup of the zirconium etch facility.

The cryolite reduction furnace hood installation is scheduled for completion May 20. The 20-inch rolling mill is scheduled to arrive the first week in May; construction personnel are organized to complete its installation soon after receipt.

PRTR Operations Planning

Pre-Startup Activities. Sixteen operating procedures were issued during the month. Copies of the procedures were distributed to the PRTR Startup Council for review and approval.

The Electrical Manual was completed at month end. Copies of this manual will be issued early in May.

A report, "PRTR Data Processing Program," HW-64631, was issued. This document, designed primarily for EDPM Operation use, gives definitions for data input, calculations required, reports requirements, and an estimate of data volume.

The "PRTR Valve List," which identifies each valve, including the function and a print reference for each, was issued to all interested personnel.

A meeting was held with the "Third Party Inspector" to discuss procedures for assuring that all PRTR vessels and piping meet code requirements where applicable.

Spare parts were ordered for the injection pumps, primary pumps, process water pumps, and the de-aerator during the month. A review of spare parts requirements for bearings, solenoid valves, relays, contactors, and switchgear is under way.

A list of 35 maintenance procedures which must be prepared prior to reactor startup has been assembled. FPD Maintenance has been requested to write these procedures. The first procedure, "Repair of the Primary Pumps," is presently being circulated for comment.

The helium compressors must be relocated to allow adequate maintenance access, as well as eliminate vibration problems in the supporting structure. A study to determine suitable alternate locations is being made. Consideration is being given to a relocation as suggested by PRTR Operation.

Results of a noise-level analysis made by Industrial Medical indicate ear protection devices are required for personnel working near the diesels when they are running under load. "Ear muff" type protectors will be ordered.

Members of Operations Research and Synthesis Operation met with PRTR Operation personnel to discuss heavy water systems measurements and accountability problems.

In meetings with Analytical Laboratory Operation personnel, the PRTR Sampling Program was discussed to determine the effect this program will have on future work loads of various ALO components.

PRTR Training Program. A tentative schedule for the PRTR Qualification Test was prepared. The test, to be given to all personnel who will operate the reactor, will include a general written examination about the reactor and its systems. In addition, a written examination on the reactor automatic controller, reactor safety systems, and other operational features of the reactor, an oral examination, and a demonstration will be included.

Classroom training sessions were conducted to instruct all Engineering Assistants with the automatic controller theory and operation.

Design Tests. Final operational and design review was completed for 18 tests during the month. Design Test No. 39, "Flux Monitoring System," was reviewed by the PRTR Startup Council. Procurement of special equipment for performing the design tests continued. Meetings with REDO personnel were held to discuss detailed scheduling of the tests.

Power Tests. Detailed scheduling for the proposed power tests were prepared. The outlines of proposed tests were reviewed by the PRTR Startup Council.

Critical Tests. All portions of the PRTR Critical Test document were presented to the Startup Council. The "Instrumentation" and "Hazards and Restrictions" summaries are presently being reviewed by the Council. The document will be issued when this review is complete.

Design and Construction Liaison. Scanning circuit prints from the vendor of the rupture monitor electronic components were reviewed and comments were issued.

Information meetings were conducted to acquaint PRTR Operations and FPD Maintenance personnel with the objectives and design features of the PRTR Gas Loop and the Critical Facility.

Extra Activities. A paper entitled "Status of the Plutonium Recycle Program at Hanford" was presented at the 1960 Nuclear Congress by R. E. Dunn.

2. PLUTONIUM CERAMIC RESEARCH

The UO_2-40 w/o PuO_2 and the pure PuO_2 compositions of a series of pellets which appeared to have "flowed" during a hydrogen sintering treatment of approximately 75 hours between 1300 and 1500 C were examined by x-ray diffraction and metallography. The pellets were sectioned so that the bottom portion which rested on the molybdenum boat and the top portion which was exposed only to the hydrogen atmosphere were analyzed independently. Diffraction patterns of the areas which were in contact with the Mo presented many lines which were not successfully indexed. This is presently attributed to a Mo-Pu-U interaction. The upper portion of the UO_2-40 w/o PuO_2 pellet was of the cubic solid solution structure as expected. The lattice parameter was 5.439 ± 0.003 Å as compared to the theoretical of 5.440 Å. There was one plane, however, with a spacing of 2.656 Å which was not indexed. This spacing falls near that of the alpha-Pu_2O_3 (411) plane, but intensity considerations seem to rule out this possibility.

The top of the pure plutonium dioxide sample, unfortunately, was very small. In addition, the spinner on the diffractometer goniometer head was out of order so the intensity of all reflections was rather low. The (531), (600), and (620) planes could be resolved very well, however, and the average lattice constant was 5.395 ± 0.002 Å as compared to 5.3960 Å for pure PuO_2. Again, no trace of a Pu_2O_3 phase was present.

Metallographic examination of the top of the PuO_2 sample with polarized light showed a coarse, mottled matrix which had the appearance of a solidified eutectic alloy. A few small islands were noted which appeared to be a second phase. These were somewhat segregated and occupied only a small fraction of the total sample area.

X-ray diffraction studies have been completed on ZrO_2-PuO_2 mixtures sintered at 1500 C for eight hours. As little as one mole percent PuO_2 in ZrO_2 stabilized a small amount of ZrO_2 to the tetragonal phase and made the pellet stable dimensionally to the thermal stresses encountered during sintering and cooling. Pure ZrO_2 pellets crumbled under the same conditions. X-ray diffraction shows a two-phase region of monoclinic plus tetragonal ZrO_2-PuO_2 solid solutions extending from less than one mole percent PuO_2 to about 25 mole percent PuO_2. Beyond this point a single tetragonal ZrO_2-PuO_2 solid solution is encountered. The tetragonal 'c' axis approaches the 'a' axis with increasing PuO_2 content until at about 50 mole percent PuO_2 the two axes are equal and the solid solution becomes face-centered cubic. Several points on the liquidus curve of the ZrO_2-PuO_2 system have been determined using the tungsten-ribbon melting-point furnace. Further experiments are under way to complete the determination of the liquidus curve.

A pellet containing the stoichiometric ratic of Al_2O_3 and PuO_2 (66 M/o PuO_2) required to obtain $PuAlO_3$ was pressed and sintered at 1500 C for eight hours in hydrogen. X-ray diffraction showed a single phase, $PuAlO_3$, to be present. Another pellet of the same composition was

sintered at 1100 C for eight hours in hydrogen; x-ray diffraction showed Al_2O_3, PuO_2, and $PuAlO_3$, indicating that the reaction starts at a relatively low temperature. The melting point of $PuAlO_3$ was observed in the tungsten-ribbon furnace at 1810 C.

Al_2O_3 pellets containing two and eight w/o PuO_2 have been sintered at 1500 C for eight hours in hydrogen. X-ray diffraction shows a reaction taking place which has not yet been identified or indexed.

More heating runs have been made with mixtures of PuO_2 and graphite. The percentage of graphite added and the reaction temperature were varied in an effort to obtain pure PuC. In all cases, though, when the temperature was raised high enough to reduce the oxide, the predominant carbide formed was Pu_2C_3.

When four to six weight percent graphite was added to plutonium hydride, however, the predominant carbide was PuC. This reaction was carried out at 1400 C for four hours. The chief difficulty with this method of making the monocarbide is the fact that liquid Pu is formed. Before the Pu-C reaction temperature (approximately 900 C) is reached, the Pu attacks the crucibles. Tantalum crucibles have proved to be reasonably resistant to this attack.

The a_0 of the PuC formed by this technique is 4.968 Å. This agrees well with the values Mulford et al report of 4.959 to 4.973 Å. These samples were at the carbon-rich end of this region; however, the monocarbide appears over a rather wide composition range. More precise lattice parameter measurements are being made.

Chemical analysis of two "PuC" samples showed 3.2 w/o C. This is lower than the 4.2 w/o which was added. Duplicate samples will be sent to the Analytical Laboratory in an attempt to resolve this discrepancy.

The present gamma absorptometer is being modified to determine densities of full length oxide fuel rods. A uranium colliminator has been designed and built to give a more accurate value for the I/I_0 ratio which is proportional to the density. Work is also continuing on the thermal conductivity apparatus.

3. URANIUM DIOXIDE FUELS RESEARCH

Fuel Evaluation

Continued post-irradiation examination of the second, purposely defected Zircaloy-2 clad, swaged UO_2 rod revealed long stringers of zirconium hydride, in excess of the original 50 ppm concentration. A hydride concentration gradient across the 0.030-inch thick cladding was observed opposite the defect. The concentration was greatest at the cooler, outside surface of the Zircaloy-2. Quantitative analysis has not been completed. The examination is continuing. A third defect test, employing Zircaloy-4 cladding has just been completed in the MTR.

Irradiation of a vibrationally compacted, Zircaloy-2 clad fuel assembly in an ETR loop started April 28. The assembly contains seven rods, three feet long.

Swaged UO_2 capsules attained an estimated exposure greater than 15,000 MWD/T in MTR-ETR. One sintered and two swaged UO_2 capsules were successfully irradiated to 2750 MWD/T at a surface heat flux in excess of 1,250,000 BTU/hr/ft^2. No failure of swaged UO_2 fuel elements has yet occurred during any irradiations.

Basic Studies

Detailed discussions were conducted with personnel of BMI regarding the proposed continuation of the UO_2 thermal conductivity cooperative research program. Goals being considered include: (1) completion of thermal conductivity measurements to 600 C of the series of irradiated UO_2 specimens, (2) evaluation of effects of fabrication methods and component grain size and orientation on thermal conductivity (to 600 C), and (3) measurement of thermal conductivity of one nonirradiated UO_2 specimen (to 2000 C) using equipment to become available at BMI in about six months.

The two models of electron microscopes meeting CFDO requirements were examined, operated, and evaluated at BMI and at the United Aircraft Laboratories. Each has advantages not offered by the other, but both appear to be capable of meeting basic performance specifications. Evaluation of operational design, reputation in technical circles, and demonstrated capabilities of basic instruments and accessories will be completed prior to final selection.

Micronized UO_2 was compacted to 10.90 g/cc (99.4 percent T.D.) in the Dynapak equipment, using a modified, ultra-high pressure die. "PWR-type" UO_2 was compacted to 97.5 percent T.D. under similar conditions. The stainless steel capsules containing the UO_2 were heated to 1200 C before they were transferred into the die. The temperature of the UO_2 at the time of compaction was estimated to be 500-800 C.

Another study, using a standard Dynapak die, revealed that the density of compacted, micronized UO_2 increased with increasing starting temperature to 1100 C. Further increase in temperature, e.g., to 1200 C, resulted in a decrease in the density of the compacted UO_2.

4. BASIC SWELLING STUDIES

Irradiation Program

Two types of capsules for irradiating unrestrained uranium at a constant temperature are currently being constructed: a metallographic specimen swelling capsule for insertion into either the MTR or the ETR and a general swelling capsule for insertion into HAPO reactors. Four metallographic specimen capsules and five general swelling capsules have now been fabricated.

Of the four metallographic specimen swelling capsules thus far assembled, three contain carefully precharacterized uranium specimens while the fourth contains a dummy specimen. The fourth capsule has been used to establish the validity of the heat transfer calculations and to determine the operational characteristics. These were determined by testing the capsule to destruction and then applying an appropriate safety factor to establish the optimum in-reactor operating conditions. The three capsules containing precharacterized specimens are scheduled for operation at the ETR: two to be irradiated and the third to be used as a control for the irradiations in order to evaluate the influence of the environment and the thermal history on the specimens.

The initial tests on the capsule with the dummy specimen revealed that large ($\pm$ 50 C) random temperature fluctuations were occurring within the capsule. Additional tests indicated that these severe thermal fluctuations were the result of the refluxing of the NaK in the highly evacuated inner chamber. Above about 250 C the vapor pressure of the NaK exceeded the total pressure of the system sufficiently to create a rapid cycle of boiling and condensing. The condensate dripping from the cold top of the chamber causes the temperature to drop suddenly. Thermal cycling was completely eliminated by removing the cooling fins from that portion of the chamber extending above the heaters, and hence, allowing this section to more nearly attain the same temperature as the bulk of the NaK.

The laboratory tests and calculations have now demonstrated that the capsule will operate over the range: 450 to 630 C in a neutron flux, 3 to 9 x 10^{13} n/cm^2sec; with gamma heating of 0.5 to 1.0 watt/gram. Temperature control in the order of $\pm$ 3 C on the surface of the specimen can be expected.

General swelling capsule No. 5 containing three uranium spheres of two enrichments has successfully undergone bench testing and has been shipped to the reactor site for insertion in the reactor at the earliest opportunity. The necessary control and monitoring instrumentation has also been completely assembled and calibrated and shipped to the reactor site.

Fabrication of components for ten additional general swelling capsules of the same design as the first five has begun. These capsules will contain uranium specimens in the form of split, hollow cylinders instead of spheres. This change in specimen geometry is intended to reduce the temperature gradient across the samples to values less than 10 C when the reactor is at full power.

Design effort is also under way to entrain two or more capsules so that better utilization of the irradiation test facilities may be realized. This requires shortening the over-all length of the capsules to about nine inches.

The general swelling capsule containing four, one centimeter diameter, uranium spheres that is being irradiated is continuing to perform according to design expectations. Recalibration of the control

instrumentation has improved the temperature control when the reactor is at full power from ± 5 C to ± 2 C. This is well within the accuracy of the chromel-alumel thermocouples and the precision temperature controller. The total burnup that has thus far been accumulated with the specimens in this capsule is about 0.03 a/o.

Fission Product Mobility

Diffusion of rare gases in uranium is being studied by introducing xenon and krypton into a uranium surface by glow discharge (sputtering) and ion bombardment and then determining the gas distribution as a function of temperature, time, and system conditions. A portable, CEC type 21-620 mass spectrometer has been received to facilitate this investigation and is currently being incorporated into a glow discharge system. Work for the next few months will be involved with setting up, calibrating, and establishing the limitations of the equipment.

5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

This program has been initiated to determine the mechanical properties of structural materials during irradiation. Currently, the study of in-reactor creep properties of Zircaloy-2 is in progress. The specimen is annealed Zircaloy-2, and a duplicate specimen is being tested in the laboratory to provide a direct comparison with the in-reactor test. The test temperatures for both specimens have been changed since the last measured creep rates from 500 F (260 C) to 550 F (287 C) at a stress level of 30,000 psi. An increase rate in the creep of the ex-reactor specimen was observed, the rate increased from 1.5×10^{-7} in/in/hr to 1.5×10^{-6} in/in/hr. However, technical difficulties with the associated strain measuring system for the in-reactor test precluded the measurement of the in-reactor rate with any statistical certainty. No rate can be stated for the in-reactor specimen at this time. The carrier current generator in the creep monitor for the in-reactor creep sensors slowly lost its output causing the readings to become erratic. The condition of the monitor was analyzed and corrected, but insufficient time has elapsed since the repair to obtain significant creep data.

A progress report from the vendor revealed that the order for four more second generation capsules is proceeding on schedule, and delivery should be made by the middle of June. These capsules are expected to be more reliable than the prototype now being irradiated.

6. GAS-GRAPHITE STUDIES

Gas Capsule Irradiations.

Four CO_2-filled capsules containing graphite were discharged from the reactor after ten months of exposure. The irradiation temperature was approximately 500 C and the CO_2 pressures were 200, 300, 400, and 500 psia at temperature. Five new capsules are ready to charge into the reactor at 500 C. Four are filled with CO at 85, 185, 270, and 280 psia, and one is filled with H_2 at 14 psia.

CO_2 Oxidation. Slabs of CSF graphite (3" long, 3/4" wide, 1/16" thick) are being oxidized in flowing CO_2 at 650 to 850 C. Preliminary data show weight loss rates and the activation energy are identical to those observed in earlier work on solid cylinders, hollow cylinders, and spheres. Thus, none of the experiments show evidence of diffusion controlled oxidation since no effect of surface to volume ratios is observed.

Oxidation Studies in Co-60 Irradiation Facility

The radiation-induced reaction of carbon dioxide with graphite in a 10^6 R/hr gamma flux was measured at temperatures of 520 C, 650 C, and 700 C with a constant gas flow rate of 20 cc/min. In the absence of radiation the thermally-induced reaction of graphite with CO_2 is not observed below temperatures of about 600 C. A reaction rate on the order of 10^{-6} g/g-hr was measured at 520 C in the cobalt-60 gamma facility. At 650 C and 700 C the reaction rates were higher but, because of the low weight losses, are somewhat uncertain. An automatic balance which will re-zero three times an hour is being installed and should increase the accuracy of the measurements.

Graphite Burning Experiments

Graphite burning experiments are being conducted to aid in evaluation of potential hazards to the EGCR. In the preliminary work, 1/2" diameter graphite samples in a one inch ID quartz tube are being utilized. The graphite is not heated except by the gas and the combustion.

Graphite was found to ignite at 750 C in an oxygen stream of 2.0 cfh and burn with a blue flame. Oxygen flow and temperature were varied to determine the effect on the combustion. Combustion continued unless the oxygen flow dropped to 0.2 cfs. The reaction was very flow sensitive but was insensitive to oxygen temperature variation over the range from 500 to 800 C.

EGCR Lattice Prototype

The full-scale prototype EGCR lattice unit in which the final burning experiments are to be conducted is nearing completion. Instrumentation has been installed, and essentially all equipment including the needle-coke graphite is on site.

Radiation Damage Annealing

Samples which had contracted in the transverse direction during high temperature (600 to 1200 C) irradiation continued to contract during annealing at temperatures of 1500 to 1800 C. Changes in C_o were small both during irradiation and annealing; however, the L_c crystallite dimension decreased significantly during irradiation but recovered during annealing.

These property changes are consistent with the observation reported last month that the contraction in the parallel direction is essentially removed (re-expanded) during annealing. All of the data indicate a removal of high activation energy lattice defects. Parallel contraction under irradiation is apparently explained by shrinkage of the crystallites in the A_o direction, whereas transverse contraction is counteracted by the accompanying C_o expansion and must result from some other mechanism.

EGCR Graphite Irradiation

Construction of the EGCR graphite irradiation capsule has started. Mockup tests for the assembly configuration and calculation of predicted sample temperatures have been completed. These temperatures are estimated to vary between 300 and 700 C along the length of the capsule. The temperatures were confirmed within 10 percent by the mockup tests.

Based on the mockup test, a configuration similar to the GETR H-1 capsule will be used. Four one-quarter cylindrical samples, one inch in diameter and 3-7/8 inches long, fit into graphite sample holders which are screwed tightly into molybdenum centering discs attached to the aluminum cooling rings. The cooling rings are swaged into the aluminum can. A cooling tab has been added to the center of each of the support rods, and flux monitors of nickel, iron, and cobalt-aluminum are located in holes in the cooling rings.

Gas Loop Project Management and Design (Project CAH-842). Drawings and specifications for the Phase "C" portion of the gas loop project (installation of services) were completed and approved during the month. Negotiations are under way for the performance of this work by J. A. Jones.

Additional specifications for Phase "D" - installation of the loop equipment proper - are in preparation.

Fabrication of the main loop package by Struthers-Wells is continuing. Struthers-Wells has indicated they intend to start testing of the package on or about May 10. The first primary gas blower is still under test by Bristol-Siddeley Engines, Ltd. Delivery on or shortly after May 1 is hoped for; the second blower should follow about one week later. Delivery of the third blower has been deferred; it will be shipped directly to HAPO during June.

Design of the sample cask is complete, and the drawings have been issued for comment.

Gas Loop Component Testing

The gimbal bellows type expansion joint was installed and cycled in the furnace at 1500 F and 500 psi. Failure of the furnace after several hours of testing has delayed the test.

An inlet nozzle of Hastelloy "X" has been completed and is being used to test closures. A platinum gasket sealed at 1500 psi cold, but leaked when heated to 1500 F. The platinum gasket welded to the Hastelloy face even though parting dust was applied. Spiral wound type gaskets of Hastelloy and asbestos have been ordered.

The dome seal nozzle closure was revised to provide additional clearance for the stainless steel parts. Initial tests showed a leak tight assembly while cold but excessive leakage after heating to 1500 F. The assembly was removed and the seal faces were lapped. The assembly has been operating at a temperature of 1500 F for 24 hours. Leakage of 0.075 cubic foot per day has been recorded.

Gas Loop Design Analysis

Transient temperature calculations were made for the gas loop following a total loss of helium shroud coolant. These calculations assumed graphite specimens were being tested. In order to achieve the most rapid cool-down of the loop with only the CO_2 primary coolant, it was assumed that the CO_2 flow rate was increased from the nominal 4500 lb/hr flow rate for non-fission specimen irradiation to the maximum 15,000 lb/hr flow rate and that the regenerator was fully bypassed. Both the increase in flow and bypassing of the regenerator were assumed to occur instantaneously on loss of helium shroud coolant.

Under these conditions the maximum shroud tube temperature was calculated to be 805 F, about seven minutes following the incident. The shroud tube temperature would remain in excess of 600 F for about 12 minutes.

An investigation of possible nuclear hazards for the final hazards evaluation of the gas loop was completed. Calculations indicate that the U-238 displaced by the gas loop will not significantly reduce the effective negative fuel coefficient of the core.

Irradiation Effects on Nickel-base Alloys for Gas Cooled Loop Facility

Nickel-base alloys are being considered for use as in-reactor structural materials for the gas cooled loop. Samples of the candidate gaseous materials are being irradiated in contact with a typical reactor environment. Comparison of mechanical properties of the irradiated specimens with those of unirradiated control pieces will yield data on the behavior of these alloys under anticipated loop operating conditions. A graphite capsule containing thin washer specimens of candidate materials was opened at the Radiometallurgy facility during the month. This capsule had been exposed 30 days to reactor atmosphere with the specimens reaching 500 C in the high neutron flux. No extreme deterioration of any of the specimens was observed; consequently, they have been transferred to the Physical Metallurgy laboratories for weight and gain and hardness measurements. Two graphite capsules containing tensile specimens of inconel, inconel-702, Hasteloy X, and Hasteloy R-235 have accumulated approximately one month of their respective three and six-month irradiations.

D. RADIATION EFFECTS OF 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 475 to 575 C for molybdenum, zirconium, and high purity nickel; from 150 to 275 C for titanium; and from 150 to 225 C for iron and copper. Molybdenum specimens irradiated to 4.4×10^{18} and 1.5×10^{20} nvt underwent linear recovery with temperatures between 350 and 550 C, and exhibited a sharp decrease in hardness between 450 and 500 C. A corresponding decrease in hardness of the unirradiated molybdenum specimen suggests overaging and may be related to the same process which caused hardening around 250 C in the same three specimens. The electrical resistance of irradiated zirconium showed no further decrease above 425 C for the 4.7×10^{18} nvt specimen and 500 C for the 1.5×10^{20} nvt specimen indicating that recovery of electrical properties is completed at these respective temperatures. Over-all resistance recovery was greater than 100 percent for both exposures; the lower exposure specimen exhibiting the greater departure from pre-irradiation resistance. The 1.5×10^{20} nvt specimen softened sharply at approximately 525 C, but nearly linear recovery in hardness with temperature had occurred to this point. A second recovery region above room temperature for the electrical resistance of irradiated nickel was observed at approximately 475 C which coincided with the first region of hardness recovery observed.

The electrical resistance of irradiated titanium underwent continuous recovery between 150 and 275 C except for a small plateau near 200 C. The separation of the two resistance curves for the two exposures was constant with temperature. A discontinuous softening occurred for the 1.5×10^{20} nvt specimen at 150 C followed by little additional change in hardness above 175 C. On the other hand, a slight continuous softening of the 1.1×10^{19} nvt specimen occurred from 150 to 275 C.

Significant recovery in the properties of irradiated iron below 225 C was observed only for the 1.3×10^{20} nvt specimen which exhibited a coinciding decrease in electrical resistance and hardness at approximately 175 C. No significant changes in either the electrical resistance or hardness of irradiated copper was observed below 225 C.

The iron specimens provided for the program were fabricated from three ingots which varied over wide limits in carbon, nitrogen, and oxygen contents. Consequently, tensile tests have been initiated to determine the influence of radiation damage on the plastic yielding characteristics of iron which are peculiar to these constitutents. As a check on the methods to be employed, an unirradiated specimen from ingot 3 containing approximately 0.0013 N was solution treated for 2000 minutes at 200 C, prestrained four percent at room temperature and aged 24 hours at 600 C. Upon subsequent straining the yield stress increased 4550 psi, the flow stress at 1.5 percent strain increased

3000 psi, and a 0.86 percent Luders strain resulted. These results are in excellent agreement with published results of studies of strain aging in low carbon steels caused by the diffusion of interstitial nitrogen atoms to free dislocations. It seems certain that this phenomenon contributed to the brittleness of ingot 3 specimens after high neutron exposures. In comparison, ingot 1 and 2 specimens which had extremely low nitrogen contents were relatively ductile.

E. CUSTOMER WORK

Radiometallurgical Examinations

1.47% Enriched I & E Fuel Elements (RM-404). Two self-supported elements that were irradiated under PT-IP-247-A for approximately 800 MWD/T were received for examination. The entire outside surface of both pieces was covered at the time of discharge with a heavy black scale that is usually found associated with hot-spot type corrosion. The black scale had been largely removed by a chemical treatment after discharge which left a rough orange peel surface in the aluminum can wall. There was no evidence of any accelerated attack on the aluminum such as was found on the two non-supported elements examined previously. Transverse sections have been made through one of the elements to determine the amount of can wall lost during irradiation.

The bonding layer on both the outside can wall and the inner spire have been found to be cracked and separated in many places. Micro cracks in the uranium emanating radially from the inner bore were found.

Severely Corroded Process Tube From 105-DR (RM-401). A sample from a 2S aluminum process tube which failed in 1265-B seven months after it had replaced an original tube was submitted to Radiometallurgy for examination. The tube had been attacked on the upper side of the portion containing the downstream end of the charge.

Visual examination disclosed "groove pitting" attack which penetrated the tube wall in two locations in the four-inch long sample. The attack included about two inches of the circumference of the tube. The tube had been cleaned after discharge to remove the scale and some of the metal was removed in the process. The damage incurred during the cleaning operation made it impossible to make a metallurgical evaluation of the mechanism of the original attack. No heat effects were noted, and the metal quality was consistent with commercial grade 2S aluminum.

Examination of Cracked Process Tubes (RM-406). Three process tubes in H Reactor were discharged because of leaks. Examination showed the failures appeared as fine cracks running in the transverse direction. Samples of two of the failed tubes were submitted to the Radiometallurgy Laboratory for examination to determine, if possible, what caused the failures and the mechanism by which they failed.

The internal surface of one of the samples contained six transverse cracks in a one and three-quarter inch length, and three of these penetrated through

the tube wall to the outside surface. There was no corrosion or reduction of wall thickness at the cracks. The second sample which had not been descaled, contained a single crack that penetrated the tube wall. The samples were divided at the crack, and the fracture surface was examined visually with binocular viewers and photographed. The crack progressed through the tube wall at an angle of 45°. No reduction in tube wall thickness was observed, and no corrosion was evident.

High Level Examination and Cut-off Cell. Examination work accomplished in the High Level Examination and Cut-Off Cell during April is listed below:

Samples into Cell	32
Conveyor Transfers	22
Photographs	17
Length Measurements	9
Diameter Measurements	21
Plastic Mountings	0
Samples Ground	1
Samples Sectioned	23
Number of Cuts*	39

*1 Standard Cut = 1 transverse section on a solid 1-1/2" diameter uranium element.

Metallography Laboratories

Further testing of the lapping surface plate for the Syntron vibratory polishers which was described in last month's report has shown that it is not feasible to use with abrasive particles as large as 600 mesh size (approximately 25 microns). The particles were discovered to cause splitting and chipping of brittle inclusions or phases in the metallographic specimens and also to become embedded in soft metals, particularly aluminum. Further work along this line will be dropped since there would be no advantage in using a finer abrasive than 600 grit as an intermediate step between fine grinding and polishing of specimens.

A metallographic study is in progress to determine the nature of inclusions and minute foreign material found at the uranium-Zircaloy interface in co-extruded fuel specimens. This work is in support of FPD and Fuels Development Operation studies to evaluate the effect of these inclusions on the bond resistance to corrosion and resulting fuel performance. Optical and electron micrographs completed during the month have characterized the size of the inclusions in a bond rated "No. 2 (Poor-Minus)" to be about five microns in diameter. This characterization work is continuing.

Samples Processed During the Month.

Total Samples	380
Carbon Replicas	48

Photographs.

Micrographs	290
Macrographs	99
Electron Micrographs	216
	605

Special Fabrications

Coextruded fuel rods containing Al-7.35 w/o Pu alloy cores and clad with aluminum (X-8001 alloy) are being fabricated for irradiation in the Savannah River reactors. To date, 144 fuel rods have been shipped to the Savannah River Laboratory. At the present time there are 443 pieces in the process stream which are distributed as follows:

159	Cast fuel cores
24	Coextrusion billets
79	Extruded and straightened rods
15	Machined rods
98	Completed rods - reach for final etching
68	Rods - ready for shipment
443	Fuel Elements - Total

Two-hundred and eighty-nine Al-7.35 w/o Pu billets were cast during the month for coextrusion cladding into high exposure plutonium fuel elements. Thirty-nine billets were remelted because of gas pockets. All billets were cast with both end configurations, thus eliminating machining and scrap generation with the exception of saw chips generated in cutting-off one end. The cut-off operation was reduced substantially by closer control of the mold tolerances. It was necessary to cut off one end of about one-tenth of the billets, the others were assembled as cast. The end-thickening problem was eliminated by removing the abrupt change of contour of the billets.

The ultrasonic bond test results for 335 rods indicate that 87 percent of the pieces were satisfactory. A test rod with non-bond defects which had cross-sectional areas of 1/40, 1/8, and 1/5 square inches was fabricated and used to evaluate the sensitivity of the bond tester. All defects were readily detected. The current process specification allows non-bond areas up to 1/8 square inch.

During final etching operations on finished fuel rods, six pieces were found to show indications of mercury contamination. Inspection of the processing areas disclosed that a thermometer had been broken in the room adjacent to the etching room. It is believed that gloves were brought from the contaminated room into the etching room and came in contact with two of the six rods. The investigation is continuing.

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

APRIL 1960

FISSIONABLE MATERIALS - 2000 PROGRAM

STUDIES RELATED TO PRESENT PRODUCTION REACTORS

Neutron Temperature Studies

The program ACE has been used to generate the total cross sections of Lu-175 and Lu-176 and the fission cross section of Pu-239. The resonance parameters for the twelve resonances which contribute the most to the thermal cross section were used in the calculations. The parameters for the Pu-239 cross section were the same as those used by C. H. Westcott. The cross sections were calculated up to 0.75 ev and agree with the available experimental information. The Pu-239 calculation reproduces the curve in BNL-325 and the Lu-176 calculation agrees with the measurement by V. L. Sailor at BNL.

A Lu-176m source was obtained from an irradiation of Lu_2O_3 at F reactor. The momentum distribution of the electrons emitted by the source were measured with the beta-ray spectrometer. An investigation of the spectrum three days after the 3.7 hr activity had decayed showed that the cadmium capsule in which the source was irradiated had limited the amount of Lu-177 produced to a negligible amount. The intensity of the Lu-177 activity was less than 0.5% of that of the Lu-176m activity. In addition to an electron distribution of continuous energies two lines from electrons with discrete energies were observed. These lines were caused by L and M electrons from internal conversion of the 88-kev transition which occurs in the decay of Lu-176m. The L electrons have been observed by other experimenters. However, no evidence for the M electrons has been reported previously.

An analysis of the continuous distribution is being conducted using the program FERMI PLOT. This program was written by K. R. Birney for the IBM 709 and does many of the tedious and time consuming calculations which otherwise would be done by hand.

Multimaxwellian Group Analysis

The computer code FIT-1 has been used to obtain a satisfactory fit of calculated fluxes to the room temperature flux traverse data from the rethermalization experiments. This was done by systematically adjusting the various neutron diffusion parameters until the residual, or the sum of the squares of the differences between experimental and calculated flux values, was minimized for both the thermal and epithermal data. With these adjusted values used in the calculations, the maximum difference between experiment and theory is less than 1.6% in either energy group. The fast-to-thermal ratio is now being adjusted in an effort to improve the agreement between measured and calculated cadmium ratios.

Slowing Down Spectrum Program

Work has been started on adapting two codes from General Atomics to local use. Combined, these two programs will compute the infinite medium flux spectrum using a free gas model. The first code calculates the scattering kernel for the moderator between each pair of energies, assuming isotropic scattering, the kernel being normalized to the free-atom scattering cross section. These values of the kernel are input to the second code which computes the infinite medium flux spectrum for a medium consisting of this single moderator and up to 20 absorbers.

Neutron Rethermalization

The analysis of the rethermalization experiments on graphite in cylindrical geometry has continued through this month. The primary effort has been spent on fitting the fast and thermal traverses of the activity of Au and Cu for the room temperature experiment (no temperature discontinuity). This work has been done to provide the best diffusion parameters for use in the analysis of experiments with temperature discontinuities. This work has been completed satisfactorily and preparations are being made to analyze the experiments with temperature discontinuities.

The emphasis in the analysis of lutetium data has shifted from the determination of effective neutron temperatures to comparison of computed and observed traverses of the activity of Lu-176. The cross section of Lu-176 is non-1/v in the region of thermal neutron energies. This comparison will be made upon the completion of the analysis of the "1/v" copper traverses.

Instrumentation and Systems Studies

New circuits are being developed and evaluated for the study on scintillation pulse shape methods of discriminating fast neutrons from gamma rays.

A new method of reactor in-core neutron detection was suggested. This method is based on the use of microwaves to measure the free electron density in an ionized gas. Briefly, a small chamber of neutron sensitive gas is placed at the end of a waveguide, and the resulting ionization is measured with microwaves. Preliminary calculations indicate this method may be practical for high-flux reactors. More extensive survey work and more detailed calculations will be done.

An analog computer study of lithium buildup in the old reactors has been started. This study will be similar to the previous one but will be covered in more detail.

A recommendation for additional instrumentation on the 1706 KER test loops, made by IPD, was reviewed. The changes and additions to the existing installation are extensive and are aimed at providing a "two-out-of-three" logic for all safety circuit instrumentation. A comment letter was sent to Instrumentation Design, CE&U0, in which several suggestions for possible improvements of the proposed alterations were made. It appeared that development work on the following items would be advisable: (1) An improved trip indicator or scanning system, (2) an improved boiling point suppression instrument, and (3) system reliability evaluation.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Exponential Pile Measurements of Large Diameter Fuel Elements

Final buckling values have been determined for a lattice with tube-and-rod and I and E fuel elements. The results are shown in Table I.

TABLE I

Fuel Element	Lattice Spacing (in.)	Buckling (10^{-6} cm^{-2})	λ (inches)	Volume Ratios Al/U	H_2O/U	C/U
2.5 x 1.6 with 1.17 solid	10 3/8 wet	+ 7	1.7	0.309	0.628	25.03
2.5 x 1.6 I α E	10 3/8 wet	-34	1.8	0.378	1.286	34.41

λ is the measured side-to-side extrapolation length. A front-to-rear λ of 1.03 inches was used. Both measurements were taken in 4-foot exponential piles.

An 8 x 8-foot exponential pile with tube-in-tube fuel elements has been built and measurements have been started.

Measurements in the 6 x 8-foot pile with the sources clustered close to the axis as they are in 4-foot piles have been completed. The results of the side-side horizontal traverses are shown in Table II and compared with results previously reported for the sources placed at ($\pm$ a/4, 0) and (0, $\pm$ b/4); where a is the effective width and b is the effective depth of the pile.

TABLE II

Cell Position	Source Position	Number of Points	λ (inches)
Edge	Clustered	14	1.63 $\pm$ .2
Edge	Clustered	13	1.38 $\pm$ .1
Edge	Split	14*	1.02 $\pm$ .1*
Edge	Split	13*	1.14 $\pm$ .2*

* Previously reported.

It appears that the measured side-side extrapolation length is a function of the source position. Analysis of the front-rear horizontal traverses taken in the 6 x 8-foot pile is not complete.

The IBM-709 buckling program has been corrected for the errors in the calculation of the harmonic corrections to the vertical traverses. The difficulty in obtaining these corrections for the horizontal traverses turned out to be an error in the data input. There still appears to be a programming error in the special sub-routine used for calculating the harmonic corrections for a split source dis-

tribution. The machine program can be used, however, by by-passing this special sub-routine, even though the machine time is slightly increased.

PCTR Measurements of Lattice Parameters of Large Diameter Fuel Elements

The analysis of the data from the 2.5 x 2.0, 1.66 x 1.12 tube-in-tube experiment in the 10.5-inch graphite lattice has given the following values for the lattice parameters.

	Wet	Dry
k_∞	.982 ± .003	1.041 ± .003
f	.831 ± .003	.923 ± .003
p	.867 ± .006	.815 ± .006
ϵ	1.025 ± .002	1.036 ± .002
η (inferred)	1.330 ± .009	1.335 ± .009

The p and ϵ analysis follows the method outlined by W. E. Niemuth and R. Nilson.

Final values have been deduced for the same tube-in-tube element in an 8 3/8" graphite lattice with water coolant. The results are compared in the table below with corresponding values calculated with the IDIOT-IBM 709 machine code.

	Experiment	IDIOT
1/v-thermal utilization	0.858 ± 0.005	0.856
k_∞ (PCTR)	0.978 ± 0.002	0.999
k_∞ (exponential)	0.979	

The result referred to as k_∞ (exponential) was calculated using a value $(-64 \pm 6) \times 10^{-6} cm^{-2}$ for the material buckling as measured in a small exponential pile and a value of 334 cm^2 for the migration area obtained from the IDIOT code. The error in this k_∞ is ± 0.002 if the migration area is assumed to have no error.

The k_∞ results from PCTR and exponential measurements are seen to be in excellent agreement. Also, the utilization calculated from the code agrees well with the experimental result. (In making the comparison, one should overlook the experimental error quoted, which is predominantly due to uncertainty in the hydrogen absorbtion cross section.)

The 2% discrepancy between experimental and calculated values of k_∞ is indicative of the difficulty of calculating p for the tube-in-tube geometry.

Lutetium foils were irradiated in the PCTR during the 8 3/8" and 10 1/2" lattice experiments to obtain effective neutron temperatures. A program has been

written which will process this data.

A program for fitting a polynomial, f(x), up to ninth order to a sequence of points has been written. It contains a testing sequence which calculates the function f(x) at intervals Δx as desired.

Data Correlation and Analysis

The exponential measurements on tube-and-tube elements were analyzed to determine η by plotting ln (k_∞/f) versus the uranium to moderator ratio. The intercept (ln $\eta\epsilon$) and the ϵ from the PCTR measurement were combined to find $\eta = 1.29$. This is considerably different than the value 1.33 derived from PCTR measurements of k_∞, f, p, and ϵ. This discrepancy has appeared several times before, indicating a fundamental difficulty of one of the methods. The difference is almost entirely due to the difference in resonance integrals, derived from the slope of the exponential plot and from the p measurements.

P_3 calculations for the fluxes are slightly high in the graphite, so the calculated f is low by 0.5 to 1.0%. A neutron temperature correction may give better agreement.

Rod Replacement Analysis

A small source theory procedure has recently been developed for calculating the effect of rod replacement on the criticality condition in an infinite lattice of supercells. At the present time this procedure requires a series of digital computer calculations with several intermediate steps being carried out by hand. To improve the application of this small source theory procedure, a computer code is being written to eliminate these intermediate steps. To date, a portion of this code has been completed and checked out satisfactorily.

A Program for Analyzing PCTR Data

APDAC-I continued in limited production use. Fifty or sixty traverses and cadmium ratios were satisfactorily analyzed. The three errors mentioned last month correspond to three cases which have consistently refused to run. In one of these cases it was discovered that the input was not in the correct order. The causes of the other errors apparently lie in the code; they have not yet been located.

Instrumentation and Systems Studies

The initial phase of a study of reactor control systems was started with a study of reactor equations. The functions which relate the kinetic equations of one region in the reactor to those in another region are to be determined in a manner suitable for control studies. Eventually, it will be necessary to verify the relationships in terms of actual behavior of the production reactors. Attempts will be made to develop suitable methods for this experimental verification.

The analog study of pressure buildup in the NPR confiner following various types of incidents is 85 percent completed. The study is being conducted to determine the number of rupture vents needed in the reactor building to keep the pressure below a preset level.

Considerable time has been spent this month obtaining computer solutions to the reactor kinetic equations for sinusoidal variations in reactivity of various amplitudes and frequencies. Some difficulty was encountered in obtaining results in the region of variables where the results are of particular interest in demonstrating the validity of the theoretical solutions. This region is for low amplitudes, approximately $\pm 2 \times 10^{-5}$ δK, and low frequencies--around $0.01/2\pi$ cps. It appears that in this combination of variables the amplitude and time scaling of the program must be such that the effects of noise and accuracy of the potentiometer settings and multiplier do not mask the small effects being studied. The results obtained are currently being evaluated.

Fabrication of the detailed fast-slow scan mechanical mockup for the proposed NPR Fuel Element Rupture Detection System is proceeding rapidly at the Minor Construction (White Bluffs) shop. After fabrication, the mechanical unit will be moved to the outdoor experimental platform of the 329 Building for testing. Satisfactory circuit development continues for the fast-scan portion, directed toward refinement of the prototype circuits. Additional investigative work is being done concerning possible automatic circuitry compensation related to sample water flow changes. Other work on this project included the design and start of fabrication of a slip-ring assembly to be used for the mockup tests. The detector shielding assembly was designed for the fast-scan portion and is being fabricated. The shielding was designed for simple adjustment to provide an optimum shielding-sensitivity ratio. In addition, an indicator lamp circuit was devised using transistor switches, and initial tests indicated good applicability to the rupture monitor identification circuitry. Work to date was reported in an interim status report, HW-64639.

Tests continued on the prototype NPR Logarithmic (5 mr/hr to 5 r/hr) Scintillation Remote Area Monitor. In an effort to reduce the cost of the unit, a new high voltage supply system will be incorporated. This, if proven satisfactory, will reduce the cost per unit by $250. In addition, a more stable RCA 6655-A phototube will be used in place of the original DuMont 6363. The DuMont 6363's in use are not stable, and the RCA 6655-A tubes have proven to be much more stable. The use of the RCA tube will also lower the instrument cost (tube and mu-metal shield) by an additional $100; thus, the total cost reduction will amount to at least $350 per unit.

The prototype Linear Scintillation Area Monitor for the NPR project is presently being fabricated. All development work is completed.

Various portions of the circuitry are being tested for the prototype NPR Beta-Gamma Transistorized Air Monitor. In an effort to insure reliability, the circuits are designed, and are being tested, to be stable from +25°F to +150°F. Machining work is being completed on the detector head assembly after a faulty lead pouring job which left voids in the shielding. The voids are being filled and finish-up machining done.

Mechanism of Graphite Damage

Actual assembly of the beam sweep circuitry for the electron Van de Graaff is now ready to start. The high voltage power supply and a few other minor components have not yet been received, but are expected in the very near future.

The beam current stabilizer for the electron accelerator was received. It will be installed at the same time as the beam sweep.

A new calorimeter for measuring energy loss in thin sections of materials was fabricated. Installation of calibration and control equipment is in progress.

STUDIES RELATED TO SEPARATIONS PLANTS

Plutonium Critical Mass Facility

The current status of the project, as reported by the Construction Engineering Operation at the end of the month, is as follows: the total facility is 84 percent complete versus a currently scheduled 82 percent; the work covered by the fixed price contractor is on schedule, being 98 percent complete.

The significant development during the month was the delivery, on April 8, of the instrumentation and control system. Installation has proceeded during the month, but still remains a major part of the work yet to be done by the contractor. Other construction and installation work is essentially complete with the work of placing equipment in service, and performing acceptance tests remaining.

The primary part of the project not covered by the fixed price contractor is concerned with the in-hood reactor or critical assembly components and their installation by plant forces. The outside vendor-fabricator of these components for the initial experiments has indicated a probable delay of three weeks in their completion, originally scheduled for June 1. Such a delay will directly affect the startup date but will have little effect on completion of the contractor's work and its acceptance.

During the month, in addition to continued liaison in following the facility's progress, work was devoted to scoping some aspects of the future Stage II design.

The design of the split half machine for use in the critical mass facility was continued. A meeting was held with H. Radow and R. C. Ingersoll of Facilities Engineering on April 14, 1960, to discuss the control and safety rod design. The drawings of the mechanical part of the table are being prepared by drafting.

A safety review was made of the Thymotrol control unit for the DC motor for the movable table drive. Several other plants use similar control units and drives for the operation of split half machines in critical experiments. In the case of a partial field loss a significant increase in motor speed results.

It was found that a field loss relay could be installed as a safety against a "run-a-way" because of field loss; also, a tachometer generator relay could be used to shut off the power in case of excessive speed.

The decision was made to use the Thymotrol control unit with the DC motor drive. The motor will be equipped with a field loss relay. A combination or shunt motor, whichever is least likely of uncontrolled speed increases, will be used.

Measurement of k_∞ in the PCTR for Aqueous Pu Solution

Experiments to determine the limiting concentration for which $k_\infty = 1$ for solutions containing Pu-239, U-235 and U-233 compounds have been proposed for the PCTR. The value of η for these materials will also be determined from these experiments.

The measurements with Pu-239 are presently underway; the vessels were filled with Pu solution and the experiments were begun in the PCTR during the last week of April.

The vessels consist of a large annular buffer tank, which has an O.D. of 19 3/8", and an I.D. of 6 7/8", and is 33" in length; the end buffers have a 6 1/4" diameter and are 6 1/2" long, and the core tank is 6 1/4" in diameter and is 20" long. All vessels are constructed out of corrosion tested stainless steel of at least 1/8" thickness. All vessels are jacketed in 1/16" thick or greater polyethylene and are completely sealed in this jacket when filled. For transportation these vessels are contained in a second stainless steel vessel at least 1/8" thick.

The initial solution concentration was a nominal 6.5 gm Pu/liter in the buffer tanks; concentrations of Pu in the core tanks were nominally, 6.5 gm/liter, 7.5 gm/liter and 8.5 gm/liter. From the initial measurements, a prediction of the concentration for which $k_\infty = 1$ will be obtained. The buffer tanks will then be refilled with this concentration and the experiments repeated to obtain the final results.

Exponential Experiments with One Percent Enriched Uranium Rods in Boron Poisoned Moderator

A series of measurements were completed for determining the amounts of neutron absorber to "safe" a heterogeneous system of 1.007 percent enriched uranium rods. This information can be used for determining the amount of poison needed in dissolver batches as a secondary safety control against criticality.

The fuel rods were 0.925 inch in diameter, and 44 inches in length. They were encased in aluminum tubes having a wall thickness of 0.032 inch. Eighty-five of the fuel rods were loaded into a stainless steel tank having a 1/16" wall thickness. The lattice and moderator which contained the poison was separated from the light water reflector by this stainless steel tank. Increments of boric acid, H_3BO_3 were added to the moderator until the buckling became negative.

The following table lists the results of all measurements made in this series, because the final analysis of the data has resulted in some changes from the previously reported values. The values used for the extrapolation length, λ, were taken from BNL-C-7592 (multiplied by 0.91λ to correct for the effect of the stainless steel tank on the extrapolation length).

BUCKLINGS OF 1.007 PERCENT ENRICHED URANIUM WITH POISONED MODERATOR

Lattice Spacing (inches)	H_2O/U (volume)	H_3BO_3 in Moderator (gm/L)	Boron Moderator (gm/L)	λ (cm)	Buckling ($10^{-6}cm^{-2}$)	Quantity of H_3BO_3 (Boric Acid) to reduce Buckling to zero
1.40	1.37	0	0	6.92	2794	4.0 ± 0.3 gm/L
		1.5*	0.26		1643*	
		3.0*	0.53		663*	
		4.5*	0.79		-269*	
1.50	1.74	0	0	6.65	3294	3.4 ± 0.5 gm/L
		1.5	0.26		1502	
		3.0	0.53		97	
		6.0	1.06		-2303	
1.60	2.15	0	0	6.43	3341	3.2 ± 0.5 gm/L
		1.5	0.26		2061	
		3.0	0.53		-313	
		4.5	0.79		-1162	

* These measurements were made this month.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

A set of 18-group cross sections has been prepared for the Zoom code for the 709 and several trial cases are being readied from P-11 data. The cross section set is also being adapted to SNG and AIM-5 and AIM-6 inputs.

The cross section set is presently for specific use with plutonium-H_2O systems; future expansion of the set will make it more appropriate to other systems.

The IDIOT code is now in what may be termed a trial production period. The code is being used on a variety of different problems.

An apparent limitation in the code has now been overcome. The limitation was due to the fact that the products of some of the terms in the P_3 determinant exceeded the ± 38 exponent limit for the 709. This was bypassed by changing the order of magnitude of some of the columns in the determinant.

The Monte Carlo code for the homogeneous system has been compiled for debugging purposes. The work on the hundred group cross sections is continuing.

The SNG code obtained from Atomics International Division of NAA has been converted to the Hanford Monitor system and a sample case given in the writeup has been successfully run.

Critical Hazards Specifications

Nuclear Safety in HLO

The nuclear safety specifications for Hanford Laboratories, which are being prepared in accordance with HLO Nuclear Safety Bulletin No. 1, are about 64 percent complete. A summary of the status is given below:

Component Suffix	Component	Approx. No. of Specifications Required	% Complete
A	Reactor Lattice Physics	2	50
B	Experimental Reactor Operation	1	100
C	Critical Mass Physics	7	60
D	Chemical Engineering Development	1	75
E	Chemical Research Operation	1	75
F	Fuels Design and Fuels Fabrication	1	50
G	Ceramic Fuels Development	1	90
H	Radiometallurgy Operation	3	50
I	Calibration Operation	1	100
J	Plutonium Metallurgy Operation	6	30
K	PRTR Operation	1	20

Comments concerning the effect of a plutonium neutron source on criticality were submitted to Process Control Development.

Nuclear Safety in CPD

Section 11.0 of HW-62847, concerning the nuclear safety of the proposed mechanical processing cell (CG-830), was reviewed and comments submitted to CPD. Concentration control of UO_2 fines in the shear basin was emphasized.

The nuclear safety of an aluminum bird cage design, proposed for shipping 4.5 kg units of plutonium metal off-site, was reviewed. This new bird cage is cubical in shape with dimensions of at least 20 inches on a side. The plutonium metal in this bird cage will be enclosed inside of three containers of which at least two will be water tight. The critical volume for 4.5 kg of plutonium at optimum moderation and full reflection is about eight liters (homogeneous system). It was pointed out, therefore, that further nuclear safety assurance could be obtained by limiting the volume of plutonium metal and air space in the central container to six liters or less by the use of non-hydrogenous inserts such as aluminum. In a six-liter volume, 4.5 kg of plutonium could not be made critical, even if flooding with water were to occur.

Nuclear Safety Off-Site

At the request of the AEC, a review was made of the Bridgeport Brass Company operating procedures for handling enriched uranium. Comments were given to the AEC for further transmittal to this Company in Adrian, Michigan.

The review was concerned with the fabrication of fuel elements with enrichments of 0.95%, 1.0%, and 1.6% for experimental use at Hanford.

Safety and Education

A talk was presented to the Plant Facilities Operation, FPD, on the subjects of Criticality Accidents and Nuclear Safety in FPD; about 35 persons attended.

Annual Meeting of Nuclear Safety Committee

The annual meeting of the Nuclear Safety Committee was held at Livermore on April 12, 13, and 14 with several personnel from HLO and CPD in attendance. Those persons from Hanford were: J. E. Faulkner, C. L. Brown, E. D. Clayton, and R. L. Stevenson.

Reviews were made of nuclear safety work at the various sites and of the proposed experiments for the coming year. The revision of TID-7016, "Nuclear Safety Guide", was reviewed. The preparation of a supplement to TID-7016, "Critical Data for Nuclear Safety Guidance", was discussed. Members of Nuclear Physics Research are participating in both the revision of TID-7016 and the preparation of the proposed supplement.

Comments were made on the proposed regulations of the AEC applicable to shipment of irradiated fuel elements.

The proposed standard, "Safety Code for Fissionable Materials", by Subcommittee No. 8 of the ASA Sectional Committee N6, Reactor Safety Standards, was reviewed.

Mass Spectrometry

The mass spectrometer for this program has encountered continual difficulty from high voltage breakdown in the source region. A partial redesign of the electrical lead through system has only partially alleviated the problem and further work will be necessary to obtain the reliability of performance which is expected.

One important advance has been made in the performance of this single stage, single filament mass spectrometer. A new sample filament shape was developed which consistently yields a metal ion to oxide ion ratio greater than 100. This development will permit the analysis of uranium and plutonium samples without the necessity of troublesome and uncertain corrections of O^{18} in the metallic oxide ion mass spectra. The new filament shape which achieves the large yield of metal ions is a short open ended trough 0.125 inches long, 0.020 inches deep and 0.004 inches wide at the open end. A die which presses this shape from rhenium metal strip 0.04 inches wide by 0.001 inches thick was designed and successfully fabricated. The trough shaped sample filament yields a high metal ion to oxide ion ratio basically because the sample is concentrated in the trough region where the filament temperature is uniformly highest.

Critical Mass Theory Development

Kinetics with Time Dependent Reactivity

A copy of the reactor kinetics code, AIREK, has recently been obtained from Atomics International. This code has been assembled on the Hanford monitor system and run using the same test cases employed in debugging RKE, the reactor kinetics code which has been under development here for some time. With the analytic test case, the AIREK calculations were found to be accurate to within the convergence limits chosen. Subsequent runs with more typical test cases have shown AIREK to be superior to RKE in calculational speed. In view of these tests, work on RKE has been suspended in favor of further adapting AIREK to Hanford use.

To further this adaptation, two new subroutines for AIREK have been written and compiled. One of these subroutines calculates the reactivity under the condition that the geometrical buckling changes with time. At present the code is being tested using this subroutine and input corresponding to the case of a cylinder containing a plutonium solution, the height of which changes linearly with time. The second subroutine, which provides an alternative output format, has not yet been checked out. In addition, reference material is also being assembled on transient effects which influence the reactivity, since AIREK has provision for including a large number of such effects as feedback equations.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Scattering Cross Sections

An attempt was made to grow an aluminum crystal in an aluminum oxide crucible at a very high growth rate. The attempt resulted in an aluminum ingot of many grains, none suitable for neutron diffraction studies. The results of the studies of single crystal growth in aluminum were compiled for publication in the Nuclear Physics Research Quarterly Report.

Additional crystal reflectivity measurements were made on one aluminum ingot which shows some promise as a neutron monochromator in order to determine the best way to cut the ingot. Reflectivity measurements were also made on three lead (220) crystals. One crystal warrants further measurements after it has been sawed. The results of crystal reflectivity studies obtained to date were reviewed for publication in the Nuclear Physics Research Quarterly Report.

Subthreshold Fission

Measurements have been made on the fission component of the lowest neutron energy resonances of U^{236} and U^{238}. The observed fission cross section in the vicinity of the 5.5 ev resonance in U^{236} is indistinguishable from that expected from the 3.85 percent U^{235} impurity. Analysis indicates that the amount of fission in U^{236} is less than about one-hundredth of that expected from the simple Hill-Wheeler barrier model. No fission was seen in the vicinity of the 6.68 ev resonance in U^{238}. The upper limit established for the peak fission cross section in this resonance was 0.3 barns which is about one-half of that calculated from simple theory.

Fast Neutron Spectra

The new chamber for the analyzing magnet of the Van de Graaff has been completed. The chamber and drift tubes have undergone outgassing prior to installation at a pressure of 10^{-7} mm Hg. Design of the associated beam locating slit assemblies has been completed.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Low Exposure Plutonium Lattices

Some preliminary values of k_∞ and f for the 8 3/8 and 10 1/2 inch graphite lattices have been computed. The lattices were fueled with 19-rod clusters of PuAl. The rods were 0.5-inch in diameter and contained 1.8 w/o Pu. Assuming 2200 meter/sec cross sections and 1/v fluxes throughout and neglecting the change in effective fuel cross section upon removing the copper poison.

$$10\ 1/2 \text{ inch} - k_\infty = 1.55,\ f = 0.86$$

$$8\ 3/8 \text{ inch} - k_\infty = 1.62,\ f = 0.88$$

These values will change considerably when the true absorption rates are factored into the k_∞ computation. Analysis of the fission foil traverse is continuing to obtain these actual absorption rates.

Longitudinal adjoint traverses were made in the moderator, 3 3/4 inches from the central cell axis, outside of the copper poison position. The ratio (m_1/m_2) was constant to within 5% over the test cell region. The ratio had the same value of 0.91 to within 1% for each lattice. A decrease of about 50% in the adjoint ratios was observed upon removing the poison from the lattices.

The Critical Facility of the PRP

The content of an experimental program for the Critical Facility was presented at a Technical Progress meeting. The long range goals of the program were outlined. The short range goals which must be attained in order to solve some of the problems connected with the long-range goals were discussed also.

Some of the initial experiments were outlined at a PRTRO Information Meeting. This was done in order to indicate to the PRTRO personnel the techniques which will be used in the Critical Facility.

Experimental Studies on PuAl-Water Systems

Additional critical approach and exponential experiments were conducted with Pu-Al alloy fuel rods containing 5 wt. % Pu. Measurements were made this month with hexagonal lattice spacings of 0.85, 1.20 and 1.30 inches. The fuel elements were 0.506 inch in diameter and 24 inches in length; the cladding was Zircaloy-2 with a wall thickness of 0.03 inch.

The 1.2-inch lattice was measured previously, however, since there was some question concerning air bubble formation on the Lucite tubing in the first experiment, a re-measurement was made; the results are in exact agreement with the previous measurement. In the case of the 0.85-inch lattice, a 7% increase in the critical mass was observed because of bubble formation over an approximately 20-hour period. Steps were taken to minimize the bubble formation on all other lattices.

Preliminary values obtained from measurements on these lattices are reported below:

Lattice Spacing (inches)	H/Pu* (atom ratio)	$\frac{V_{H_2O}}{V_{Pu\text{-}Al\ Alloy}}$	Extrapolation Length (λ)	Critical No. of 24-inch Rods (Cyl. Geometry)	Estimated Critical Mass (Spherical Geometry)	Buckling ($10^{-6}cm^{-2}$)
0.85	354.7	1.86	7.92 cm.	230.2(2.54 Kg Pu*)	2.07 Kg Pu*	10,838
1.20	944.0	4.95	7.03 cm.	181.1(1.99 Kg Pu*)	1.73 Kg Pu*	8,840
1.30	1149.3	6.03	6.04 cm.	215.5(2.37 Kg Pu*)	2.12 Kg Pu*	7,681

* Pu-240 isotopes $\sim$ 5.3 percent.

Measurements have now been made at eight different lattice spacings with H/Pu ratios in the range of 218 to 2422. The maximum buckling for these fuel elements in light water is $\sim 11{,}250 \times 10^{-6} cm^{-2}$ which occurs at an H/Pu ratio of $\sim$430. The minimum critical mass for spherical geometry is estimated to be 1.5 Kg of Pu (including Pu-240) which occurs for an H/Pu ratio of $\sim$ 660.

Instrumentation and Systems Studies

The PRTR Gas Loop analysis program has been started on the EASE computer. At present the controller settings are being optimized.

In the Neutron Lifetime Study, preliminary tests were made to determine the frequency spectrum of a Zener diode noise generator, using a newly acquired low frequency bandpass filter. The tests indicated that special filters may be required to limit the necessary amplifier dynamic range on low frequency measurements. Further laboratory tests are planned to compare the bandpass filter method of analysis to methods employing autocorrelation techniques. A magnetic tape system was developed to record data directly from the neutron detectors. The system has a linearity of ± 0.25 percent and frequency response of dc to 3,000 cps. Use of the tape as an information storage medium will allow the analog computers to be used directly for determining the autocorrelation functions of the measured neutron activity.

Plans are being made to develop part of the instrumentation for a probe for the in-reactor inspection of PRTR process tubes. A system of linear variable differential transformers was purchased for inside diameter measurements. Eddy current methods are being studied for application to the measurement of the gas gap spacing between the process tube and shroud tube.

NONDESTRUCTIVE TESTING RESEARCH

The signal-to-noise ratio in the broadband electromagnetic testing system being developed for measuring jacket thickness and jacket-to-core gap variations in an unbonded fuel element has been improved to the extent that these two variables are now being resolved. When displayed on an oscilloscope connected to display the direct current output of one channel along the vertical axis and the output of the other channel along the horizontal axis, air gap variations from 1 to 2 mils generate beam spot loci whose direction is approximately in quadrature with that due to jacket thickness change over a range of 4 mils. The loci due to gap variation for different jacket thicknesses are not parallel, but some control over their direction is obtained by adjustment of the time domain sampling times. The oscilloscope display can now be calibrated for jacket thickness and air gap thickness. Data are being obtained which will be used in designing read-out circuitry to read jacket thickness only on one meter and gap thickness only on a second meter. The present equipment reads jacket thickness in the range of 27 to 33 mils and gap thickness 0 to 2 mils. It is desired to extend the jacket thickness range downward to 15 mils, and to determine the amount of interaction at the output caused by the two variables over this wider range.

Tests were made with a model TD-1 Radiation Electronics Corporation radiation thermometer, on loan from the manufacturer, to determine how applicable this type of instrument would be to the thermal bond testing program. This instrument, used in conjunction with an induction heater, was capable of detecting 3/8-inch-diameter mica-produced voids in the braze layer of aluminum clad uranium fuel elements. No difference in heat transfer through 1/2-inch-square aquadag-produced non-wets compared to that through the surrounding well bonded cladding could be detected with this equipment. Although the tests on the model TD-1 unit were very promising, this type of instrument would have to be modified to give optimum performance for thermally bond testing fuel elements by non-steady state heat flow measurements. The present standard TD-1 is designed to focus on a spot at least 5/16 inch in diameter, and the chopper operates at 600 cps. Such a low chopping frequency leads to severe interference with detection of small hot spots at the high scanning rates required to prevent overheating of test pieces at high power inputs.

The spot on the surface of the test piece observed by the detector should have a diameter less than 1/8 inch to permit resolution of hot spots comparable to this size. Noise in the output of the standard TD-1, during wide band operation to permit good high frequency response, is equivalent to temperature variations of about 10°C on the surface of the test pieces.

During the tests, aluminum clad uranium fuel elements containing mica-produced voids 1/2, 3/8, 1/4, and 1/8 inch in diameter in the braze layer were heated at 1/2 KW in a 1/4-inch-wide circumferential zone of the cladding. The TD-1 unit was placed so that it measured the temperature variation within a 5/16-inch-diameter spot partially within the heated zone. Hot spots on the aluminum surface due to differences in heat transfer were mapped by correlating the record from a Minneapolis-Honeywell "Visicorder" with position on the test piece surfaces.

The average surface temperature indicated over 1/2-inch-diameter circular and 0.4 x 0.8-inch-rectangular voids was about 40°C higher than that of the surrounding well bonded cladding, circular voids 3/8 inch in diameter gave an increase of about 19°C, and 1/4-inch-diameter voids could not be detected above background noise. Time-temperature transients recorded over a 1/2-inch circular mica void showed that the equilibrium temperature differences of 40°C was reached in 3/5 second during heating, and that it drops below a detectable value within about 1/5 second after removal of the heating power. This cooling rate agrees quite well with an earlier estimate.

Surface emissivities of X-8001 aluminum alloy samples, which had been etched in nitric acid and oxidized by autoclaving 20 hours, were determined with the model TD-1 radiometer. Values varied between 0.3 and 0.6. Emissivities of autoclaved 2-S and C-64 aluminum, and vapor blasted X-8004, 2-S, and C-64 aluminum were also within this range.

A comparator-difference amplifier for a prototype inductive thermometry instrument was returned from fabrication, and evaluation tests indicated that it will adequately perform its function. The amplifier has a nominal gain of 200 and a linear frequency response from 500 cps to 15 KC, and will accept a maximum input variation of 2V p-p. Variation of the reference voltage allows triggering to be set at any practical value.

GAS COOLED REACTOR PROGRAM

Lattice Parameter Measurements

The PCTR measurement of k_∞ and f for the EGCR lattice with 2.6 w/o UO_2 fuel has been completed. A preliminary rough estimate of k_∞ based upon the experimental data indicates that k_∞ is in the neighborhood of 1.25 for this lattice.

The reactivity effects of substituting graphite spiders and end caps for those of stainless steel were measured along with the flux peaking in the graphite spiders. The substitution of the graphite components resulted in a reactivity increase, as expected.

The r,θ power distribution was measured, but the resulting data have not been analyzed at the present time. In addition, a flux traverse was taken along two rods in the cluster to determine the flux depression which results from the presence of stainless steel spacers.

The analysis of the data taken during the EGCR stainless steel loop experiment is continuing. The corrections for resonance absorptions in the copper foils remain to be derived. The required cadmium ratios are currently being determined using APDAC-I.

A report has been prepared on the PCTR measurement of the total control rod worth in the EGCR lattice, and will appear in Nuclear Physics Research Quarterly Report-January, February, March, 1960.

The report for Allis-Chalmers on the measurement of k_∞, p, f, and ϵ for the 1.8 w/o UO_2 fuel has been distributed to the customer.

Variation of Doppler Coefficient with S/M Ratio

PCTR experiments on the 1.92-inch-diameter solid natural uranium fuel element in a dry 8 3/8-inch graphite lattice were completed. Data for the computation of the fuel temperature coefficient, p and ϵ, and revised values of k_∞ and f were obtained. The foil activation data have been processed using APDAC-I and await examination. The temperature coefficient data are being analyzed.

Preparations are continuing for the measurement of k_∞, f, p, ϵ and the fuel temperature coefficient of an 0.926-inch-diameter solid natural uranium slug in a 6-1/2-inch graphite lattice with air coolant. An attempt will be made to handle the temperature coefficient assembly remotely, enabling the insertion of the heated slug into the reactor while at power level, and increasing the range of the measurements to $\sim 900^{\circ}C$.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Calibration continued on the Tri-Carb equipment for assaying the amount of zinc sulfide on the membrane filters exposed during the Summer - 1959 diffusion and transport experiments. The procedure involves preparation of samples containing known masses of zinc sulfide over a concentration range of some six orders of magnitude. The calibration method is designed to provide data from which a complete analysis of variance can be made and sources of drift or variation identified.

One additional early morning field experiment was completed during the month over the 3200 meter sampling grid. The vertical density distribution in the lower atmosphere was nearly neutral with moderate wind speeds. A preliminary analysis of dosage data indicated that the experiment may have been classical in the sense that the crosswind distributions were essentially normally distributed and peak concentration decreased with the inverse -1.75 power of the distance. Final analysis of the data was deferred until after calibration of the assaying equipment.

Work continued on data compilations and preparation of individual chapters for the Geophysical Research papers, according to agreement with the Air Force. Additional stability ratios from the portable mast data were completed and transmitted to the Air Force for correlation with the dispersion data. Edited and corrected summaries of all of the portable mast data were transmitted to the Air Force for direct reproduction in the final reports. Revision of the format for presentation of the Pacific Northwest meso-scale analyses and forecast verifications for each experiment was started. Rough drafts of other sections of the report were reviewed.

Work progressed in the engineering study of facilities to house the Atmospheric Physics Operation. At month end, design criteria were being formulated for use in making cost estimates. Preparation of a new sampling grid to the Northeast of the Meteorology Tower for use in studying diffusion patterns from elevated sources continued.

DOSIMETRY

Several people exposed to radioisotopes were counted in the whole body counter. One showed traces of fission products, one showed traces of the isotopes present in reactor effluent water, one contained plutonium in a wound which required surgery.

A new, more substantial chair was fabricated for the counter. There was difficulty in finding a padding material which was not radioactive. A removable bed was made for the iron room and a screw drive was installed on the holder of the counter. These will permit studies aimed at a scanning method for routine counting.

A third debug run was completed of the IBM system for storing data and calculating results for the whole body counter. Everything is now judged to be working properly and ready to accept the counter data on a routine basis.

The cooperative experiment with Dr. C. L. Finch of the University of Washington continued. Two more people were given intravenous injections of Fe^{59} and counted at the whole body counter.

As a result of the realignment reported last month the positive ion Van de Graaff is now operating better than it ever has before. The alignment methods that were developed permit definition of the direction of the undeflected beam to within 0.01°. It appears probable that shifts in the foundation of the building will prevent keeping the beam aligned within these limits.

Three precision long counters made independently by three different shops are now available for intercomparison. One discrepancy that appeared was traced to different neutron absorption in geometrically similar metal tubes in the different counters. Presumably the metals differ slightly in composition or contain traces of different neutron-absorbing impurities. The tubes are being replaced with some more of a metal having low neutron absorption.

Equipment for developing a helium ion source was assembled. A beam of roughly 10 microamp of helium ions was produced.

The first attempts at fabricating tissue-equivalent chambers for neutron measurements were made.

The Manager, Radiological Physics spent two weeks at Geneva, Switzerland attending meetings of the Ad Hoc Committee on Quantities and Units of the International Commission on Radiological Units and Measurements (ICRU). The committee prepared a report containing new and/or improved definitions of the concepts, quantities, and units that are fundamental to radiology, radiobiology, radiation protection, etc. The ICRU is now examining the report. They will distribute it when they have approved it.

A new control system was put on the water bath of the gamma ray calorimeter. It operates like damping in a mechanical system. Without it there was a $0.001^{\circ}C$ overshoot in the bath; now the temperature cycle has a maximum range of $0.0002^{\circ}C$. The effect of this improved control on the calorimeter is being evaluated.

INSTRUMENTATION

Excellent developmental progress was obtained on the personally-carried selectable-level alarming dosimeter. A complete bench-model circuit was assembled and satisfactorily tested during the month. The circuit comprised all necessary parts including ion chamber, detector, amplifier, and the dose-level alarm circuit. In addition, it was determined that the circuitry could be simplified from the bench model. Leakage tests were conducted with the 10 cc ion chamber both with and without the triggered illuminating light. The flashing light caused no increase in leakage. It appears that the final complete unit will not exceed 2 by 1 by 3 inches in size. This development work is being accelerated with the aim of having a final prototype unit in operation within two months.

Development continued on a data entry system for the Body Monitor operated by the Radiological Physics Operation. The component parts were received and fabrication begun on the keyboard for manual entry of data into the multichannel analyzer.

Final adjustment and developmental modification work was done on the alpha air monitor using completely transistorized circuitry and using coincidence counting techniques to eliminate radon-thoron background effects. Testing of the portions of the unit already fabricated continues simultaneously.

Fabrication continues on the experimental beta-gamma scintillation dose-rate meter using all transistorized circuitry. All development work for this particular prototype is completed.

One of the previously developed and fabricated scintillation transistorized portable gamma energy analyzers was experimentally modified using a thin NaI crystal, and it performed satisfactorily for gamma energy analysis work from 10 Kev to 150 Kev over the full span of the base-line control. The 17 Kev Pu^{239} photopeak and the 60 Kev Am^{241} photopeak were easily resolved in a mixed source. Thus, by using a thin NaI detector, the 10 Kev to 150 Kev range can be covered; and by using the 2 by 2-inch NaI crystal, the 150 Kev to 2.0 Mev range can be covered for gamma energy analysis.

Investigative work continued concerning the new tunnel diode circuitry with several experimental oscillators, multivibrators, and amplifiers experimentally fabricated and tested. The diodes seem to be a bit unpredictable in operation to date.

The P-N junction detector work promises a rather fascinating range of application possibilities for alpha, beta, and neutron work. A purchased high-resistivity ingot of silicon is scheduled for delivery in May. With this, a large number of P-N junctions can be prepared for all types of experimental work. A visit is being made to ORNL for first-hand observation of the techniques for preparing P-N junction detectors.

Experiments are continuing into the possibilities of plastic casting of the probe housings for the developmental non-gamma sensitive alpha scintillation probes. Initial casting work was successful.

The experimental prototype transistorized alpha monitor (110 VAC-operated) which uses either, as desired, an air proportional probe or the new non-gamma sensitive (to 10 r/hr) scintillation probe continues to perform satisfactorily in demonstration use at the 308 Building.

The large 5-inch by 9-inch NaI crystal, using four matched phototube detectors, for the Biology Total Body Monitor was received and tested. One phototube was bad, and it was replaced by the manufacturer. Using a Cs^{137} source, the system resolution for the 661 Kev photopeak was found to be nine percent. This is quite acceptable, and the detector head is ready for installation.

After rather extensive multiplier phototube investigations (similar work was done over the past two years on other tube types) concerning noise level versus high voltage, signal-to-noise ratios, stability with time of operation, and stability versus temperature changes, it is quite apparent that RCA phototubes (6199, 6342, and 6655-A) are quite superior in all measured respects to DuMont tubes such as 6291, 6292, and 6363. Some selected DuMont tubes perform satisfactorily; however, in general and considering lots of 10 tubes or more, the RCA tubes were found to be superior in all stated measurements. The DuMont tubes are exceptionally poor from the time stability (drift) standpoint and from the signal-to-noise ratio standpoint. For any application requiring long-term stability and a good signal-to-noise ratio the RCA tubes are preferable.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Research and Development

Five days of mass spectrometer operation were devoted to the accumulation of data on experiments designed to study possible causes of mass discrimination induced by the ion source focusing conditions.

Three operating days were lost because of the failure of the diffusion pump water cooling system. Sand in the 326 Building water supply plugged various instrument valves and fittings. A filter and trap were installed to help prevent future clogging of the water lines and valves.

Two days were used to try a trough-shaped filament of the new design used in the other mass spectrometer. The resulting efficiency of the ion source, which was designed for triple filament operation, was too low to make practical use of this filament design in the source assembly of this spectrometer.

The spectrometer operated routinely during the month on the isotopic analysis of program samples.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month on a one- and two-shift basis. There were three unscheduled shutdowns; two were caused by electronic failure and one by faulty bypassing technique.

The 1.92-inch O.D. natural uranium experiment to determine p, ϵ, and $\frac{1}{p}\frac{dp}{dT}$ and the EGCR experiment with 2.6 percent enriched fuel for k_∞ and power distribution were completed.

The aqueous Pu-k_∞ = 1 experiment was started during the month.

TTR

The critical mass experiments utilized the TTR facilities during the month.

One foil calibration irradiation was made for PRTR experiments during off-shift hours.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

The second in the series of three scheduled reports on prospective 1960 crests of the Columbia River flow at Hanford Works was issued on April 15. The water content of snow cover in the Columbia River watershed above Hanford Works remained substantially below normal and the runoff far above normal as anticipated. Therefore, the 1960 forecast remains unchanged from that given in the earlier report dated February 23.

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	84.9
24-Hour General	60	83.7
Special	135	90.4

Although there was a week-long warm spell early in the month, a series of cold front passages beginning on the 8th kept most of the remainder of the month quite normal. Precipitation, most of which occurred in a single storm on the 22nd and 23rd, totaled 0.53 inch. This was about 50% greater than normal. Although there were a number of windy days, the over-all monthly average speed (8.8 mph) was exactly equal to the sixteen-year average for April.

Instrumentation

Further field tests were conducted on the Scintillation Detector Mask Monitor designed and fabricated for the Laundry Operation. Satisfactory operation was achieved in all tests, and the unit is scheduled to be placed in routine service.

Advice and help was rendered to RMU at Purex concerning adjustment procedure for the Aural Alpha-Beta-Gamma Monitors. After adjustment, the units performed satisfactorily.

A second completed Scintillation Transistorized Alpha Hand Counter, built to our specifications by a Seattle firm, was received, tested satisfactorily, and placed in service in the 308 Building. Two more units are being fabricated.

Advice and help was rendered to the Drafting Operation concerning the drawings being made for the Scintillation Transistorized Combined Alpha, Beta, Gamma Hand and Shoe Counter. The mechanical layout drawings are completed, and the electronic circuit drawings are partly done. From a received letter, it appears

that Dr. Wakefield of Radiation Counter Laboratories, Inc., is quite interested in this instrument and is contemplating the commercial manufacture and selling of it. His estimated commercial price was stated to be less than $4,000. He proposes building and selling the unit based directly on our drawings with no changes.

A battery-operated alarming scintillation dose-rate meter was designed, fabricated, and delivered to IPD for use as a stand-in monitor for reactor elevator use. The unit employs a transistor high-voltage supply, phototube, NE-102 detector, a meter-relay, and alarming circuits. The unit has two ranges of 0-1 r/hr and 0-10 r/hr with selectable, stable alarming at any point from about 50 mr/hr to 10 r/hr considering both ranges. Continuous battery life is 150 hours and rechargeable-type batteries may be used if desired. The unit is both beta and gamma sensitive and its response is essentially independent of gamma energies from 90 Kev to 5 Mev. It has provisions for both an external cable-connected meter and an external alarm. By high-voltage changes and/or by using a different phototube, ranges of 0-20 mr/hr up to 0-20 r/hr can be easily incorporated in other models as desired. The complete unit weighs about 3-1/2 pounds. In lots of 20, the cost per unit will be less than $250.

An in-cell monitoring system and a special airfilter monitor are being fabricated for the HLO Chemical Research Operation. The cell monitor uses several beta-gamma probes of different types for dose-rate measurements in hot cells. The air filter monitor uses a gamma scintillation detector and alarming dose-rate circuits.

The modified 614 Building Monitors (10) just completed (0-200 mr/hr single range linear units) were calibrated after employing a long-term aging of the phototubes in a 100 mr/hr field. It is apparent from the tests that the DuMont 6363 phototubes drift excessively; if they fail, these tubes should be replaced with proven stability RCA 6655-A tubes. The next lot of 10 such units now being fabricated will employ the RCA 6655-A tubes.

A Model LE-1 Victoreen Electrometer line-operated instrument was evaluated at the request of IPD, and it was found to have excessive drift even after a five-day warmup. The drift exceeded 18 percent per day after the warmup.

Acceptance tests were completed on nine CP-TP portable dose-rate instruments built offsite to plant specifications.

Eleven Model I Scintran transistorized scintillation CRM and loudspeaker alpha monitors were received and passed calibration tests. Several minor electromechanical changes are being incorporated before they are placed in service. These units (four more to come) were built offsite to our specifications.

Equipment costs were compiled for an instrument to measure and indicate the precise position of PCTR movable face. The compilation was forwarded to Experimental Reactors Operation (HLO) as Systems Research Memorandum 60-16.

FPD requested a summary of the studies made to date on the Autoclave Temperature Control problem, for use in conferences with several autoclave vendors. The work has been summarized in Systems Research Memorandum 60-12, "Temperature Control Characteristics of Autoclave Vessels". The computer studies planned

for this problem were delayed due to higher priority work scheduled for the computer. The problem is now programmed into the Goodyear Analog Computer, however, and the computer runs should be completed in a few days. FPD has requested assistance in preparing the instrumentation portion of the criteria for a new autoclave installation in the 333 Building, based on the above studies. The computer study will be completed before these recommendations are made.

Materials Engineering Operation, FPD, requested assistance in measuring the hydraulic pressure and ram velocity versus ram position on the large extrusion press in the 333 Building. Systems Research Memorandum 60-14, "Extrusion Press Instrumentation" was prepared describing the problem. It was determined later that Systems Research could not accept the assignment because the work had to be completed in a short time and manpower was not available.

The results of the Dynapak Extrusion Press acceleration tests made to date were summarized in Systems Research Memorandum 60-13, "Acceleration Measurements on the Dynapak Press", and sent to the customer. Further work on this problem is not expected in the near future.

Authorization was received from the HLO Fuels Development Operation to proceed with calibration and evaluation of a Shaevitz linear motion transducer, indicating, and recording system intended for ultimate use in in-reactor creep measurements. Preliminary designs of apparatus to be used in testing have been sketched. It is believed that the apparatus will permit measurements of displacement accurate to ± 5 micro-inches or less. The apparatus is expected to incorporate a mechanical amplification of motion of between 20X and 100X after which the motion will be read by use of a traveling microscope accurate to ± 80 micro-inches. An alternative method employs an autocollimator to read the rotation of a mirror. Tests will be performed at room temperature and at other temperatures up to 400°C.

Optics

Radiation Ratio Pyrometer - The pyrometer as first installed demonstrated its ability to measure temperatures in the range 500°C to 1000°C on Zircaloy and steel specimens. The temperature of specimens in the hot stage of the metallograph was controlled to within ± 25°C by using the signal output of the pyrometer as the input to the existing controller.

Drift of the lead sulphide detector makes it necessary to recalibrate the pyrometer every ten minutes. The pyrometer is quite sensitive to positioning with respect to the metallograph. A supplemental work order has been received to provide for automatic recalibration or elimination of the drift and for elimination of the position sensitivity.

Scratch Depth Microscope, 105-C - The 105-C Fuel Examination Facility variable power stereomicroscope was converted for use as a scratch depth microscope. The conversion consisted of providing a monocular filar micrometer eyepiece which is interchangeable with the stereoscopic eyepiece normally used. The scratch depth illuminator, designed by the Optical Shop, is expected to be on site from the fabricator by the end of April. Installation of this unit will make possible the measurement of the depths of surface defects in irradiated fuel elements. Optics for this unit have been fabricated in the Optical Shop.

PRTR Calandria Displacement Measurement Equipment - Assistance has been given in completing the design of a camera for use in keeping track of the displacement of the calandria with respect to the shielding in the PRTR reactor. Another method of displacement measurement employing a traveling microscope has also been discussed.

During the four-week period (April 3 to May 1) a total of 480 manhours optics shop work was done, of which 14.5% was for Stores (Spare Parts), 11% for IPD, 17% for CPD, 50.5% for HLO, and 7% for CEO.

Three borescopes were repaired for Irradiation Testing Operation, IPD.

Two plastic cylinders were machined and polished.

Four pump seal faces were lapped for Mechanical Development Operation, HLO.

Twenty glass bearings were fabricated for CPD and Stores.

The diameter measurement unit was mounted in the upper housing of the PRTR profilometer.

Five hemispheres of Mylar were formed and coated with aluminum until light tight for Radiological Instruments.

Twelve alundum "O" rings were ground to size for Wiley Cole of HLO.

Analog Computer Facility Operations

The major problems on the analog computers this month included studies of the reactor kinetic equations, the PRTR gas loop, and an autoclave control system.

The EASE was placed in use on April 11, and out of 88 hours of possible use time, the unscheduled down time was four hours, or about 4.5 percent. Out of 168 hours of possible operating time for the GEDA, there were four hours of scheduled down time, and 52 hours of unscheduled down time, or 31 percent due to unscheduled down time.

The EASE acceptance tests were essentially completed, except for minor tests which will be completed when the computer is not in use. There is still trouble with the digital voltmeter, the printer or scanner, the potentiometer servo-setting mechanism, and four of the time delay units. Resolution of these difficulties is being discussed with the vendor.

The shielded wire to be used for trunk lines between the two computers has been received. Making the necessary patchbay connections to the GEDA computer will require a major shutdown. This has been scheduled for early in May.

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Chemical Research & Development

RESEARCH AND ENGINEERING

FISSIONABLE MATERIAL - 2000 PROGRAM

IRRADIATION PROCESSES

Uranium Oxidation & Fission Product Volatilization Studies

Revisions to the shielded cell for fission product release experiments with highly irradiated uranium were completed. Six tests with unirradiated uranium at 1215°C for 24 minutes in air gave a mean degree of oxidation of 68.7% ± 3.6% standard deviation. One test with slightly irradiated uranium was made to evaluate the performance of the equipment. The test facility is considered ready for higher level experiments.

NPR Effluents

Laboratory research concentrated on a study of the scavenging of cobalt and zinc from reactor decontamination waste. The presence of certain constituents in the waste mixture appears to prevent scavenging of cobalt isotopes by the precipitates from permanganate reduction. Mixtures of solutions from the use of three-step decontamination methods give poor cobalt scavenging; such solutions contain the peroxide-carbonate-E.D.T.A. mixture used for a preliminary decontamination. In addition, two-step decontamination systems utilizing an ammonium citrate-E.D.T.A. mixture for a second step result in poor cobalt scavenging. The work indicated that the E.D.T.A. is partly responsible for this poor scavenging but both peroxide and citrate contribute to it. It is postulated that strong complexing agents and strong oxidizing agents may prevent cobalt scavenging because of the high stability of cobalt (III) complexes. The scavenging of zinc was not affected by the presence of these agents.

Reactor Effluent Treatment

Design of the test facility for studying reactor effluent decontamination with aluminum beds was essentially completed and estimates were made for its construction and installation at 100-KW. The facility will consist of a steel tank some 32' long, 7' deep and 3' wide. Provision is made for passing up to 2000 gal/min hot reactor effluent through the tank in which aluminum turnings will be supported.

The specification for initial aluminum turning configuration was revised to permit a greater surface area per unit volume of bed. This reduces the length of bed required materially but likewise reduces the bed life to 4 - 5 years, rather than the 10 years earlier specified. Estimates received for milling bar stock into turnings appears to be favorable for full scale installations.

SEPARATION PROCESSES

Observation Wells

The question of adequately monitoring the water in an aquifer by sampling the contents of a perforated well was studied. As monitoring wells generally are

perforated throughout their depth below the water table they may form low resistance flow paths between aquifers having different piezometric heads. The probability of such differences occurring in regions of ground water recharge, such as the vicinity of swamps, is quite high. An effort was made to estimate the conditions limiting the flow into a well from a specific zone having rather typical Hanford aquifer characteristics. These estimates indicate that a piezometric head difference of only a few thousandths of an inch between aquifers penetrated by a completely perforated well will prevent water from the low-head aquifer from entering the well. It is planned to study methods of identifying aquifer zones that cannot be monitored by means of well samples because of such head differences.

There were no significant changes in ground water contamination patterns in the vicinity of the 200 Areas over the past month.

Recent reductions in the volume of waste and quantity of radioactive material discharged to the Purex tank-farm condensate crib are quite evident in wells monitoring this site. Samples from only two of the thirteen wells in the vicinity now contain concentrations of radioisotopes exceeding 10^{-4} ucB/cc. One year ago, twelve of the thirteen wells contained concentrations of radioactive material exceeding 10^{-4} ucB/cc.

Ten feet of well 299W-22-2 monitoring the abandoned 216-S-1 and 2 Redox process condensate cribs was reperforated. Samples from this well have contained a low but fairly constant concentration of Sr^{90} for the past three years. Over the years two nearby wells became completely filled and this well partially filled (in the ground water zone) with sand and silt. Analyses of liquid and mud samples obtained prior to and following reperforation and bailing, along with future environmental monitoring sample results should provide a basis for determining if Sr^{90} is still draining from the crib into the ground water. An increase in the gross beta activity by a factor of twenty following reconditioning was an indication that previous samples from this well may not have been representative of the ground water under this disposal facility.

Processing Nickel-Coated Aluminum-Clad Fuels

Decladding and core dissolution studies were made on full size non-irradiated I and E fuel pieces with and without nickel coating on both surfaces of the aluminum cladding. The nickel-coated fuel had been heated at 590 C for 45 seconds at one step during fabrication. These studies confirmed earlier observations on small sections of fuel pieces. The outer nickel coating dissolved rapidly in 1.5 M UNH - 1.5 M HNO_3. The inner nickel coating was not dissolved during dissolution of aluminum cladding in NaOH-$NaNO_3$ solutions. It was undercut slowly during prolonged digestion in the decladding solution. During core dissolution, the nickel coating (and underlying Al-Si layer) left on the fuel after jacket removal was not readily dissolved by hot 13 M HNO_3. It did undercut and flake away. The resulting dissolver solution had more solid residue present than do dissolver solutions prepared similarly from non-nickel-coated fuels.

Purex C-Column Studies

Additional studies in the three-inch 1C test column confirmed that Purex Plant demineralized water used as ICX (0.02 M HNO_3 added) seriously decreased the

instability threshold of this column. At the standard test conditions (1270 gal/hr-sq.ft., one inch pulse amplitude, 60 C), the following instability thresholds were obtained:

Source of Water for 1CX Makeup	Instability Frequency Cycles/Min.
Distilled water	57 ± 4
Effluent water from cation and anion demineralization immediately after cation resin regeneration	<26
Water from the cation exchanger one day after regeneration	ca. 45

For comparison, the use of very pure demineralized water from KE Area (10^7 ohm-cm specific resistance compared to 10^5 ohm-cm for Purex water) as 1CX gave an instability threshold frequency of 46 ± 5 cycles/min., about the same as with Purex demineralized water at its best.

Tests were made to determine if Purex cation exchanger water taken right after resin regeneration could be improved in quality by passing it through a strong-base resin, Amberlite 1RA-401. The initial water from this bed produced an instability threshold of 47 ± 4 cycles/min.; but after 13 resin-bed throughputs the instability threshold decreased to ca. 30 cycles/min., about the same as untreated cation-bed water.

Additional pilot plant tests have indicated that each of the following materials added in moderate amounts decreased the instability threshold of distilled water 1CX by 5 to 10 cycles/min.:

1. Silica added at 5 to 20 ppm as sodium silicate.
2. A dilute suspension ($\leq$10 ppm) of finely ground Dowex 50W resin.
3. Purex cation regenerant sulfuric acid, either filtered and added directly to the 1CX at 0.01 M, or used at 1 M concentration to treat cation resin which was then eluted with the distilled water used as 1CX.

Disengaging time studies with Purex demineralized water indicated the presence of an impurity which decreased the disengaging time. In this test, the Purex water adjusted to 0.02 M HNO_3 was passed through an agitated vessel containing 60 ml of 30 percent TBP and the disengaging time periodically measured. The disengaging time decreased from 50 seconds initially to 38 seconds after two liters of water had passed through the vessel. A control experiment with distilled water (0.02 M HNO_3) gave a consistent disengaging time of 66 ± 4 seconds.

These pilot plant and laboratory studies seem to indicate that there are at least three impurities in Purex demineralized water that affect column performance:

One which should have a tendency to increase the instability threshold (perhaps an insoluble silicate such as talc), one which consistently lowers the instability threshold by about 10 cycles/min. (perhaps silica), and one which shows up only after the cation resin bed has been regenerated (perhaps resin fines or residual impurities from the sulfuric acid) and which reduces the instability threshold by 30 cycles/min. or more.

Preparation of Uranium(IV) Nitrate

Several schemes for the preparation of uranium(IV) nitrate for use as partitioning agent in the Purex process were investigated. These involved reduction of uranium(VI) in sulfate or nitrate solution with amalgamated aluminum or zinc. Separation of the uranium(IV) from unwanted cations or anions was by precipitation or solvent extraction. In the currently most promising procedure, uranium(VI) oxide is dissolved in sulfuric acid. Uranium(VI) is reduced to uranium(IV) with amalgamated zinc. The solution is made alkaline with sodium hydroxide to precipitate uranium(IV) hydroxide. Zinc remains in solution. After washing with dilute sodium hydroxide and water, the uranium(IV) hydroxide is dissolved in nitric acid containing sulfamic acid or hydrazine to prevent reoxidation of uranium. Product solutions containing as high as 275 g/l U(IV) (total uranium 335 g/l) have been prepared and have remained stable toward oxidation of uranium for over three weeks. The calculated heat of reaction for reduction of uranium(VI) to uranium(IV) in sulfuric acid solution is 67.27 Kcal/mole of uranium reduced with zinc and 116.5 Kcal/mole with aluminum.

WASTE TREATMENT

Semiworks Waste Calciner Prototype

Eight runs were completed during the month utilizing a simulated high acid Purex waste as feed. These studies were directed towards testing of additional feed nozzle designs which would hopefully hold nozzle agglomerates to an acceptable low level while maintaining adequate bed particle size control.

Two commercially available nozzles (Spraying Systems Company Set-ups F4B and 30) both internal-mixing types, were tested and found less suitable than the standard nozzle. (Previously, only external mixing nozzles had been tested.) Use of the internal-mixing nozzles resulted in severe agglomeration at the nozzle and a rapid build-up in the bed of excessively large particles with a subsequent loss of fluidization.

The effect of bed temperature on nozzle agglomeration with simulated high-acid Purex feed was tested at 400 C and 500 C. Little, if any significant difference was noted. (Similar results were previously reported for formaldehyde-treated, three-fold concentrated feed.)

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Promethium Purification

Installation of ion exchange equipment in A-Cell was completed, and a series of cold runs have been initiated prior to introduction of radioactive feed. Purpose of the cold runs is to better define flowsheet parameters, test the equipment,

and train operators (both with respect to the equipment and the process). Start-up was singularly uneventful and free of difficulties with all equipment functioning perfectly. The first run was completed at month end after two weeks of round-the-clock operation. A synthetic mixture of rare earths (less promethium) in the same ratio they occur in fission was used as feed. The columns were filled with 40-60 mesh Dowex 50W-X8 resin in the mixed copper-hydrogen cycle. The columns were operated at 60 C, and the elutriant solution contained 4.5 g/l EDTA buffered to pH 8.83 with ammonium hydroxide. Flow rate was 3.5 ml/min,cm^2. Numbers are not yet available, but purification achieved appeared visually to be excellent.

Strontium Recovery

There is much current interest in the composition of the boiling supernate in the Purex 103-A waste storage tank since the contents of this tank might serve as a convenient source of well-aged cesium-137 and strontium-90. A one gallon sample was accordingly obtained for analysis and process studies. Cesium-137 content in the filtered supernate was found to be 13.3 curies/gal; however, the strontium-90 content was only 0.02 curies/gal, too low to be of practical importance from a recovery standpoint. Major components included nitrate (2.6 M), nitrite (4.2 M), phosphate (0.02 M), and carbonate (1.0 M). Failure to find a large fraction of the strontium in the supernate is accordingly not surprising.

In other work, in support of a recent plant test, autoclaving cerium-rare earth double sulfate precipitates at temperatures of 100 to 300 C was found to have only a small effect on ease of dissolution in dilute nitric acid, in contradiction to the results of a preliminary experiment. Nitrite, a product of radiolysis, was found to depress pH in the peroxy-acetate process (as do iron, aluminum, chromium, and excess sulfate). If nitrite is the cause of failure to obtain a cerium peroxy acetate precipitate in the plant, its effect can probably be overcome by use of a nitrite suppressor, such as urea.

Excellent one inch diameter, high-density strontium titanate pellets were finally produced, after solving certain temperature measurement and control problems and automating the furnace. Attempts are now being made to produce 2-1/2 inch pellets. A homogeneous strontium titanate process, which eliminates ball milling, also shows promise. Solutions of titanous sulfate (commercially available) and strontium nitrate are used as starting materials. The product exhibits an X-ray diffraction pattern identical to that of commercial strontium titanate. A sufficient quantity is being made for pellet pressing tests.

Technetium Recovery

Work continues on the development of analytical methods for the determination of technetium in Hanford separations process solutions and waste streams. A sample of Purex K-6 solution (final uranium stream) was found to contain 2.06 ppm technetium. This is equivalent to 4 ppm in the uranium shipped and implies that about 20 percent of the technetium initially present is leaving the plant by this route.

Purex 3A-3B Column Studies

Analytical results are now complete on the two 3A column entrainment runs reported last month. In the first of these runs, at a scrub section volume velocity of 900 gph/sq.ft., the aqueous entrainment in the product was 0.25 volume percent and the sodium tracer decontamination factor was 4400. The second run, at a scrub section velocity of 1850 gal/hr.-sq.ft. resulted in 0.22 percent entrainment and a sodium D.F. of 2100. Virtually all of the sodium tracer was removed from the organic phase in a glass wool coalescer-separator.

The 3B columns studies which are now underway have indicated the necessity of a graded cartridge to obtain a uniform dispersion throughout. The flowsheet for this column is similar to that of the 1C column except the low aqueous flow ratio limits uranium transfer into the aqueous phase to less than 50 percent of the uranium in the organic feed. The ensuing "pinch" effect seems to result in greatly increased stability in the lower two-thirds of the column. Tentatively, the use of 23 percent free area nozzle plates (3/16-inch holes) in the top three to five feet and 10 percent area nozzle plates (1/8-inch holes) in the remainder, all on four-inch spacing, appears to give a reasonably uniform dispersion profile together with an adequate capacity of 1200 to 1500 gal/hr.sq.ft. The optimum pulse amplitude and plate spacing must still be established.

Fission Product Packaging Prototype

The tests on the conversion of $Cs_2ZnFe(CN)_6$ to the mixed oxides in the hydrolyzer were completed. The results showed that to make the process practical, ferric oxide needs to be added to the feed slurry in excess of 0.3 pound Fe_2O_3 per pound $Cs_2ZnFe(CN)_6$ (a 1:1 mol ratio). Tests with excess Fe_2O_3 (up to 1.32 pounds per pound $Cs_2ZnFe(CN)_6$) showed no deleterious effects.

The completion of the hydrolysis studies defined the characteristics of the solid products discharged from the hydrolyzer for subsequent leaching and filtering cesium isolation operations. Filtration studies were completed with the conclusion that Fe_2O_3 added to the hydrolyzer feed significantly improved filterability. These tests indicated that the present leaching and filtering equipment is inadequate. From the filtration studies sufficient basic design information was obtained to permit specification of a firm workable leach-filtration system.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Determination of Al, B, Ca, Fe, Si, Ti, and V in Reactor Graphite

An emission spectrographic method was established to determine aluminim, boron, calcium, iron, silicon, titanium, and vanadium in reactor grade graphite. All except boron were determined by direct-current arcing a mixture of sample and copper fluoride. Limits of detection were 1 to 10 ppm except for a 50 ppm calcium limit. A boron limit of 0.02 ppm was needed. It was met by analyzing (as above) the residue from the ignition of 1 gram of sample mixed with copper carbonate. All measurements were subject to 50 percent error which was permissible.

Colorimetric Determination of Molybdenum in Uranium Alloy

A dithiol (toluene-3,4-dithiol) colorimetric method was placed in regular use for the determination of molybdenum in nitric acid solutions of uranium-molybdenum alloy. The green dithiol complex was read at 680 mμ in 5 cm cells by means of a Du spectrophotometer. Interfering nitrate was removed by double evaporation

with hydrochloric acid. The method, subject to about 5 percent error, was twice as fast as the alpha-benzoin oxime gravimetric method which had yielded low results.

Improved Mass Spectrometer Molecular Leak

A new molecular leak constructed of a brass housing with a demountable gold foil having a 2 mil orifice was installed in the low mass spectrometer for analysis of low pressure gas samples such as vacuum fusion gas evolutions. The new leak was unit-designed and fabricated here. Repeated plugging of the orifice on the all-glass molecular leak, installed two years ago, had caused many lost analyses.

EQUIPMENT AND MATERIALS

Purex Organic Treatment Pump Mixer

HW-64733 entitled "Improved Method of Organic-Aqueous Contact During Treatment of Purex 1CW Stream," was issued. This document describes the studies associated with the modified Purex G-1 Tank system in which organic is introduced (along with aqueous treatment solutions) directly into the suction of a deepwell turbine pump.

Canned Motor Pump Development

On the basic premise that particulate matter in the solution fed to canned-motor pump bearings is the major contributor to their premature failure in our plant applications, studies have been made with a hydroclone installed in the bearing lubrication line of a canned motor pump. Clear overflow from the hydroclone is fed to the pump bearings while the "muddy" underflow is fed back to the pump suction.

With an available 1-1/2 inch diameter hydroclone coupled with an available chempump and employing 20 to 40 micron diameter glass beads (specific gravity of 2.3) as simulated abrasive dirt 97.5 percent of the beads were carried out in the hydroclone underflow. Further improvement is expected with an optimized design. The hydroclone would ne more efficient on larger particulate which would be more damaging to pump bearings.

Metering Pump Development

Assistance has been given the Engineering Operation of FPD in the development and selection of process equipment for use in an experimental plating bath system. A metering pump has been designed for delivering small flows (approximately 10 cc/min) of three different makeup chemicals to the plating bath. Basically, the pump consists of three Archimedes screws (bent tubes) which dip into three constant level reservoirs and deliver fixed increments of solution with each rotation. The speed of rotation of the pump is controlled by a pH control system installed in the plating bath.

Corrosion Studies

Comparison of 309 SCb and 309-L Stainless Steels - Corrosion behavior of weldments fabricated from 309 SCb stainless steel welded with 309 SCb was compared

with that of weldments fabricated from 309-L stainless steel welded with 309-L. Samples of each type of weldment in the as-welded condition and heat treated at 1300, 1500, 1800, 1900, 2000, 2100 and 2150 F were used. In the standard Huey test, all samples had corrosion rates less than one mil/mo; maximum rates were obtained for both types of weldments when heat treated at 1300 and 1500 F. When the test time was extended, rates for samples heat treated at these temperatures approached three mils/mo. In boiling 13 M HNO_3-0.25 M HF, corrosion rates for all samples were about 100 mils/mo. However, the 309 SCb weld metal was attacked preferentially at rates as high as 1000 mils/mo. The 309-L samples showed severe end-grain attack; those heat treated at 1300 and 1500 F showed heat-affected zone attack and sensitization. Interpretation of these data should be tempered by the fact that only one heat of each metal is represented by the samples. Coupons of 309 SCb welded with 309-L will be tested in HNO_3-HF solutions.

Corrosion in the Purex E-H4 Back-Cycle Concentrator - Corrosion rates of 304-L stainless steel in boiling synthetic E-H4 solution were significantly reduced by keeping the chromium present in the reduced, or tervalent, oxidation state. Chromium(VI) initially present was reduced by the addition of sodium nitrite. To prevent oxidation of chromium during the test, sodium nitrite was added at a rate of 0.001 moles/hr.-liter. Corrosion rates for 304-L in this solution were a factor of four lower than in a control solution to which sodium nitrate rather than sodium nitrite was added.

Corrosion of 304-L Stainless Steel by Alkaline Purex IWW - Coupons of 304-L stainless steel showed no detectable weight loss or pitting attack during 400 hours exposure (vapor and liquid phases) to boiling synthetic alkaline (pH 10.5) Purex IWW. The test is continuing to accumulate longer exposure times.

234-5 Hood Rod Seal

A "low-friction" seal has been developed for use with a 234-5 automatic weighing and recording device. The scale pan is installed in a 234-5 hood and the attached pan rod extends through the bottom of a hood to the connected weighing mechanism. A low friction seal was required for the rod to effectively seal the "contaminated" hood environment from the clean outside area. When seals of thin rubber sheeting were found to adversely affect the weighing sensitivity, a special double liquid seal was developed which had essentially no affect on weighing sensitivity even with expected fluctuations in the hood vacuum.

PROCESS CONTROL DEVELOPMENT

C Column Studies and Facility

A scope document describing the research program to be pursued in developing a model of the C-column was issued this month, HW-64623.

Operating conditions and procedures for preliminary runs on the C-column have been established. The Data Reduction code was rewritten in FORTRAN-MONITOR language and is presently being debugged and refined. It will be usable with the printed output obtained from either the new or present data scanner.

The 1CX, 1CF, and five mid-column temperature indicating thermohms, the 1CX pH recorder-controller, the pulser speed recorder-controller, and the cartridge position indicator have been calibrated. Data obtained from these instrument calibrations were reduced by least squares techniques for use in the Data Reduction code.

A 1/2-in. ball valve was installed on the upper section of the column. The valve will be used to test the feasibility of this type device for inserting 3/8-in. diameter probes into the column for various mid-column analyses.

Quick disconnect type sample ports were also added to the 1CX and 1CU streams to permit calibration of the mid-column photometer and analysis of the 1CU for uranium concentration.

Polyvinyltoluene Phosphors for Counting Plutonium Alpha Particles in Solution

Recently completed decontamination tests on a terphenyl-in-polyvinyltoluene phosphor indicate that its usefulness for alpha monitoring of plutonium solutions is limited to solutions having a plutonium concentration greater than about 0.1 g/liter. This is due primarily to the buildup of plutonium on the phosphor surface. For example, after exposure to a 0.56 gram/liter plutonium solution the background could not be reduced below the equivalent of 0.06 gram/liter.

Ion Chamber for Purex HSP Jumper Installation

Design and drawings have been completed for an ion chamber for installation on the Purex HSP stream jumper.

Tantalum, stainless steel and fluorothene were evaluated as materials for fabricating the section of the jumper that the ion chamber "sees." Test specimens exposed to plant HSP solutions exhibited increasing fission product buildup from fluorothene to stainless steel to tantalum in the ratio 1:3:9. Linear polyethylene shows similar properties to fluorothene in this respect and is more stable to radiation. Consideration is presently being given to lining a section of stainless steel with linear polyethylene.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

Shear Studies - Interim Report - An interim report, HW-62842, "Shear Studies for the Non-production Fuels Processing Program," has been issued in rough draft form to fill current design needs. The report is being prepared as a formal document for off-site distribution.

Shear Basin Cleanup Studies - Fabrication has been completed for a shear basin system designed to demonstrate the current concept of an effective system for shear dust control in the NPF mechanical cell. The concept includes a cylindrical product bucket positioned beneath the shear to form a water-tight (or low-leakage) seal with the shear discharge chute for wet shearing. First tests show that the bucket-shear juncture leakage is less than five gal/min, a leakage considered acceptable for the system.

Yankee Atomic Fuel Disassembly - Feasibility studies of methods of disassembling the Yankee Atomic fuel were concluded following tests of alternate methods of removing the hardware and cutting the bands which hold the subassemblies together.

Hardware removal by hacksawing through the ends of unsupported fuel rods was demonstrated; however, an unpredictable probability of damaging the blade and/or

the fuel rod exists. Rod shimming is recommended to remove this hazard. Positioning of shims between the fuel rods using a manipulator has been demonstrated.

Band removal by various methods (e.g., slow-speed milling cutter, high-speed abrasive or friction wheel, pull-knife) is feasible. The pull-knife is the simplest of the methods explored. A simple knife could be easily handled by the mechanical cell manipulator.

The actual selection of a disassembly technique may well depend on the as-received condition of the Yankee fuels and the difficulties encountered in inserting both shims and knives into the fuel bundle.

NPF Mechanical Cell NaK Disposal - Tests continued on the underwater (shallow depth, 1 to 6 inches of water) disposal of NaK with the subsequent removal of the fume (sodium and potassium oxides) by a Peabody scrubber. NaK charges as large as 6 to 7 grams were reacted under a slightly submerged lucite hood which was placed in a pan of water. No damage to the lucite (1/2 thick) was observed, although a charge this large reacted violently with the water (vigorous generation of hydrogen and a sharp crack of the hydrogen shock wave). The fume and hydrogen trapped under the submerged hood was vented through a one inch seal of water. Samples of the water in the pan and the scrubber off-gases show that 99.2 percent of the NaK remained in the pan water and less than 0.1 percent penetrated the scrubber (i.e., greater than 99.9 percent of the NaK was captured). From these tests it is concluded that the NaK can be safely reacted when the NaK exposure rate is carefully controlled by the hacksaw blade feed rate.

Feed Preparation

Zirflex Process - Further tests were made in an attempt to define the dependence of Zircaloy-2 dissolution rate on hydrogen ion concentration (pH) during decladding by the Zirflex process. So far, no fully satisfactory method of measuring pH in Zirflex decladding solutions has been found. Reproducibility of measurements made with a glass electrode and with a tungsten oxide electrode was poor. Special plastic electrodes for use in fluoride solutions have been ordered but not received. Interpretation of data so far obtained indicates the dissolution rate to be dependent on $(H^+)^{0.58}$ in initial Zirflex decladding solutions (5.5 M NH_4F-0.5 M NH_4NO_3) for dissolution rates between 10 and 150 mils/hr. Further increase in hydrogen ion concentration does not increase the dissolution rate. Because of the previously noted difficulty in measuring pH, it is not possible to assign accurately a pH for any given dissolution rate.

Acid Fluoride Decladding of Zircaloy-2 Clad Fuels - Nitrite inhibitors such as sulfamic acid and urea reduce the attack on uranium dioxide cores by terminal acid fluoride decladding solutions (0.25 M HNO_3-2 M HF-0.44 M Zr). However, when these agents are present during the decladding step, uranium losses are increased. The use of agents to reduce uranium(VI) to uranium(IV) following decladding as a means of reducing uranium loss is under study. Oxide films on Zircaloy which had been exposed to high temperature water were penetrated more slowly by acid fluoride decladding solution (0.25 M HNO_3-3 M HF, 25 C) than by boiling Zirflex decladding solution.

Dissolution of Uranium-Molybdenum Alloy - The use of boric acid as a soluble nuclear poison during dissolution of uranium-molybdenum fuels in HNO_3-$Fe(NO_3)_3$

solutions has been suggested. Dissolution of uranium-molybdenum alloy in HNO_3-$Fe(NO_3)_3$-H_3BO_3 solutions under conditions to precipitate deliberately uranyl molybdate were made to determine the path of boron. The terminal dissolver solutions would have been 1 M UNH - 0.3 M H_3BO_3 if no precipitation had occurred. The uranyl molybdate obtained had a boron to uranium weight ratio one-third to one-fourth that in 1 M UNH-0.3 M H_3BO_3.

The molybdic oxide precipitated when uranium-molybdenum alloy is dissolved in concentrated (>11 M) nitric acid carries some plutonium with it if plutonium(IV) is present during the dissolution. About the same amount of plutonium was carried on the oxide when plutonium(IV) was added after dissolution was complete. These results indicate that surface adsorption can account for the observed coprecipitation of plutonium.

Sulfex Process - Preliminary studies indicate that Nicrobraz-10 on the surface of stainless steels (types 304L and 347) causes the steels to be difficult if not impossible to passivate to Sulfex reagent. For this effect to be reproducible, it appears that stainless steel surface must be covered to the extent of about 10 percent with braze metal. Further studies are planned.

Formaldehyde has been demonstrated to react with nitrate ion at low nitrate and acid concentrations. A solution 1 M H_2SO_4, 0.5 M HNO_3, and 0.5 M HCHO began to evolve NO_2 after refluxing for 25 minutes. Analyses of the final concentrations have not been received at this time.

Several Sulfex runs in glassware, wherein the instantaneous penetration rates were determined from gas evolution rates, have demonstrated at least a five-fold change in penetration rate between different samples of type 347 stainless steel.

A Lucite canister for hydraulic studies of air lift circulation rates in canister systems is being modified to have a tapered bottom plug seating on a shoulder in order to seal off the annular space between the canister and the dissolver wall. Preliminary experiments indicate that substantial flows can be induced through beds of 1/2-inch Berl saddles contained in the canister upon a perforated bottom plate. Sparge air is presently introduced about two feet below the bottom plate.

Recirculating Dissolver Studies - Several PRTR reject rods consisting of swaged UO_2 clad in Zircaloy-2 were declad in 5.5 M NH_4F-0.5 M NH_4NO_3 Zirflex solution at an F/Zr mole ratio of seven. The dissolvent was heated to boiling using steam jackets as heat sources and an air sparge for liquid motivation. When the dissolvent reached boiling, the air sparge was replaced by steam at 4 psig (throttled down from 100 psig) and the steam jackets were shut off. A steam sparge rate of two lb./min. provided a gas boil-off rate of 0.182 lb. mol/hr.-sq.ft. and a liquid recirculation rate of 17 gpm at 75 percent submergence. A maximum Zircaloy dissolution rate of 43 mils/hr and an integrated rate of 15 mils/hr were attained. Uranium losses to the decladding solution after centrifugation were 0.07 gm/l. or approximately 0.03 percent of the core charged.

Materials of Construction

Hastelloy F and 304-L stainless steel coupons which were present in the 321 Building dissolver during a recent Zirflex feed preparation had overall corrosion

rates of 1.2 and 1.5 mils/mo., respectively, assuming all corrosion occurred during the decladding step. Steam sparging was used for ammonia removal during the decladding step. This step was completed in 3.5 hours indicating operation at relatively low pH.

Battelle Memorial Institute personnel have completed casting and rolling of the second series of twelve experimental alloys to be tested as materials of construction for fuel element dissolvers. Corrosion testing of these alloys will be started at Battelle in early May and at HLO as soon as samples are received.

"In Tank" Boron Monitor

Calibration curves for the neutron absorptiometers for the Redox IBX and 2DA make-up tanks were determined this month. Development work is now in progress on the monitor for the F-5 concentrator.

A fission counter is to be used on the F-2 concentrator monitor in place of a BF_3 tube due to the high gamma field in this vessel. Suitable fission counters have been secured and are under test in the laboratory.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Design and acquisition of equipment to enable testing of the Salt Cycle Process concept on fully irradiated oxide fuels in cell C of the High Level Radiochemistry Facility is proceeding. It is expected that cold shake-down runs in the cell will begin in June.

Electrolytic Preparation of UO_2

A pronounced tendency to form easily-removed dendritic UO_2 cathode deposits when the cathode region is kept relatively free of chlorine was confirmed by a series of runs in a larger-scale apparatus. The same technique previously employed in a small apparatus was employed, viz., the anode was enclosed in a shroud tube communicating with the molten salt solution only through a porous quartz frit at the bottom and the shroud tube was filled with UO_2 or U_3O_8 powder to react with chlorine produced at the anode. Under these conditions the deposits formed at 750 C were dendritic in appearance and quite readily removed from the cathode. However, as in the earlier work, the recovered UO_2 powder exhibited an undesirable high O/U ratio of about 2.2 (as deduced from the uranium(VI) content of a dissolved sample).

The observation that thermal decomposition, with production of powder with an O/U ratio approaching that of U_3O_8, occurs quite readily in molten NaCl-KCl solutions of UO_2Cl_2 in vacuo at 800 C prompted a run which gave a very encouraging result. An electrolysis was conducted at 700 C. The anode was enclosed in a shroud tube which was left open at the bottom to allow some access of chlorine to the cathode compartment. The UO_2 deposit formed was dendritic in appearance and was quite readily removed from the platinum cathode. Further, the recovered

powder had an acceptable low O/U ratio of 2.01. This represents the lowest O/U ratio yet obtained for a mechanically tractable deposit, and this result is considered quite encouraging in that it was achieved under conditions which are not at all difficult to establish. This observation obviously strengthens a long-standing interest in salt systems melting at a lower temperature than the NaCl-KCl eutectic (mp 670 C). However, it should be recognized that most other chloride salts which might be used in a lower melting reaction medium are also much more hygroscopic than either NaCl or KCl and may therefore be barred from use. Contemporary theory regarding plutonium behavior in the Salt Cycle Process is that scrupulously anhydrous conditions are essential for separation of plutonium and uranium.

In line with the aforementioned incentive for reducing the temperature at which UO_2 is electrodeposited, some exploratory work has been done with the LiCl-KCl eutectic at 450 C. All electrolytic reductions attempted have resulted in rapid evolution of gas at both the anode and cathode. It is presumed that the gas evolved at the cathode is hydrogen arising from incomplete drying of the melt. A finely divided brown precipitate of UO_2 having an O/U ratio very close to 2.00 is formed under these conditions, presumably via hydrogen reduction of UO_2Cl_2 in solution. It is interesting to note that the dissolution of U_3O_8 with chlorine at 450 C in this melt was as rapid as at 725 C in the NaCl-KCl eutectic and that no thermal decomposition of the dissolved UO_2Cl_2 occurred.

Determination of O/U Ratio in "UO_2"

It has been previously thought that occasional variations in uranium(VI)/uranium(IV) ratio in dissolved "UO_2" analyzed by the controlled potential coulometric methods were due to partial oxidation of the solid sample when it was being ground or dissolved. However, repetitive analyses of a near-stoichiometric UO_2 powder have shown no evidence for such oxidation. Further, it has been found that better reproducibility can be maintained on samples which have been sieved, i.e., analyses are more reproducible on electrolytic UO_2 powder containing particles within a given size range than on samples presumably covering the full gamut of particle size. In addition to emphasizing the care which must be taken in assuring homogeneity of powder samples, this observation permits the interesting speculation that the particle size of electrolytic UO_2 powder may be related to its O/U ratio.

Interaction of UO_2 Powder with Dissolved UCl_4 and UO_2Cl_2

Additional experiments have confirmed that the oxygen content (measured as uranium(VI)/uranium(IV) ratio in a dissolved sample) of non-stoichiometric "UO_2" can be reduced by equilibration with a solution of UCl_4 in molten NaCl-KCl eutectic. A three-hour equilibration at 725 C in which two grams of UO_2 was exposed to a melt containing 2.7 g UCl_4 reduced the O/U ratio in the "UO_2" from an initial value of 2.24 to 2.04. A fraction of the recovered UO_2 was present as a very fine suspension in the molten salt and was recovered by allowing the melt to freeze, dissolving it in water and centrifuging the aqueous slurry. Only about 50 percent of the initial UO_2 was recovered. A repetition of the experiment with a lower velocity helium sparge resulted in recovery of about 70 percent of the initial UO_2, as a somewhat coarser powder with a measured O/U ratio of 2.100.

Aside from the possibility of gaining some insight as to the manner in which excess oxygen is combined in non-stoichiometric UO_2, it should be noted that such studies may lead to an economic method for "upgrading" non-stoichiometric UO_2.

Studies of the interaction of solid electrolytic UO_2 with molten NaCl-KCl eutectic at 700 C and 800 C have continued. Four equilibrations of -20 +32 mesh powder with a melt containing 2.3 w/o UO_2Cl_2 under an argon atmosphere showed no appreciable change in size or shape of the particles. Some conversion to plate-like particles was observed however when a fifth sample of the same powder was equilibrated with a melt containing 19.3 w/o of UO_2Cl_2 under an air atmosphere. About 60 percent of the UO_2 powder remained in the -20 +32 mesh range and was visually unchanged. In the finer fractions the relative abundance of plates increased as the particle size decreased, from about 20 percent as plates in the -32 +48 mesh size to about 80 percent as plates in the -100 mesh size. However, a -32 +200 mesh fraction of the same initial powder showed no appreciable tendency to convert to plates despite the fact that its rate of dissolution should have been greater.

In no case was recrystallization observed to the same extent as in the experiment reported last month in which about half the powder converted to plates.

Properties of Electrolytic UO_2

Attempts to measure the solubility of electrolytic UO_2 in molten NaCl-KCl eutectic have confirmed that the solubility of UO_2 is indeed very low. In no case has a salt-soluble uranium(IV) species been found. The apparent solubility observed appears to arise from partial oxidation of the uranium dioxide to uranium(VI) species. From the results obtained to date it appears that the true solubility of UO_2 in molten NaCl-KCl eutectic must be considerably less than 16 micrograms uranium per gram of eutectic. A highly sensitive spectrophotometric analytical method has been employed for these measurements. The uranium in an aqueous solution of the salt is converted to uranyl with nitric acid and extracted into TBP. After buffering to pH 7 with an organic base in alcohol, dibenzoyl methane is added to form a colored uranium complex, the concentration of which can be determined spectrophotometrically. The method is sensitive to 10^{-7} molar uranium(VI) or to 0.1 microgram uranium in a 2 cm cell.

For concentrated solutions of uranyl chloride in NaCl-KCl eutectic, direct spectrophotometric measurements on an aqueous solution of the salt suffice. If the salt content is maintained constant, the method is accurate to ± 0.01 percent UO_2Cl_2 for salt systems containing 1 w/o or more of UO_2Cl_2. The molar extinction coefficient for uranium(VI) in the aqueous salt solution is only 8.8 so this method is applicable only to salt melts containing substantial amounts of uranium.

X-ray diffraction patterns on 12 samples of electrolytic UO_2 show several weak lines not evident in diffraction patterns of UO_2 prepared in more conventional ways. Most of these lines appear in only a few samples but three as yet unidentified lines were present in all 12 samples.

Preparation of Pilot Quantities of Electrolytic UO_2

Commercially available uranyl chloride monohydrate may be a suitable starting material for the production of UO_2 electrolytically in pilot plant lots. When added to molten NaCl-KCl eutectic at 700 C, the monohydrate dissolved instantaneously to about 20 weight percent UO_2Cl_2. Although some gas evolution was noted, the reaction was violent only when large lumps were added. Analysis of the cooled solution showed less than five percent of the uranium to be in the water insoluble UO_3 form. Chlorine introduced over a ten-minute period reacted with this small amount of UO_3 to form UO_2Cl_2.

Electrolysis of the solution at a potential of 1.5 volts produced at the cathode an easily removable deposit of granular UO_2 with 20 to 40 weight percent of the product in the 50 - 100 mesh particle size range. Product oxygen to uranium ratios of 2.13 and 2.29 were obtained with current efficiencies of 95 to 120 percent respectively. These data indicate that appreciable U_3O_8 was formed by thermal decomposition of UO_2Cl_2. Electrolyses performed after the cooled solution had been exposed to the atmosphere for several days resulted in a potential drop of four to seven volts across the cell. Severe corrosion of both platinum and graphite cathodes by the liquid phase caused complete electrode failure within half an hour.

Continuous Ion Exchange Contactor Development

Preliminary studies of the operational stability and hydraulic characteristics of the Multi-Stage Agitated-Bed Ion Exchange (MABIE) contactor have been completed. Very stable operation has been demonstrated at all aqueous flow rates up to 450 gal/hr.sq.ft. and all resin flow rates up to 180 gal/hr.-sq.ft. The three-stage contactor reached stable hydraulic operation approximately five minutes after startup. Improved hydraulic performance resulted from the use of sieve plates (0.08-inch hole diameter, 21 percent free area) in place of fine wire mesh for the stage separators. The effect of this modification on efficiency is predicted to be minimal.

In the one thorium transfer run for which analytical results are available, stage efficiencies of 80 percent of theoretical (based on the resin residence time and an assumed diffusion coefficient of 4.4×10^{-8} cm^2/sec) were obtained at an aqueous flow rate of 290 gal/hr.-sq.ft., a temperature of 35 C and an aqueous-to-resin flow ratio of 20 liters/kg dry resin. The waste loss from the three-stage contactor was 23 percent. The operation was very stable throughout the run, as evidenced by the constancy of the raffinate analyses.

RADIOACTIVE RESIDUE PROCESSING DEVELOPMENT

Radiant-Heat Spray Calcination

As has been pointed out in previous reports, sulfate decomposition is troublesome in waste calcination. This is true both because of severe off-gas handling and corrosion problems during calcination and because of subsequent decomposition during storage, with evolution of non-condensible gases. The use of calcium hydroxide, vice caustic, to neutralize high-sulfate Purex waste prior to calcination was accordingly tried. The slurry was sprayed and calcined without difficulty to a fine orange-red powder, density 0.7 g/cc. The weight loss on subsequent heating (from 300 to 900 C) was only 2.4 to 6.0 percent as compared to 37.8 percent with caustic neutralized waste.

Other studies, with special sample collection and classification techniques, implied that powder which has experienced hold-up on the wall of the calciner is calcined to the same degree as the rest. It had been thought that drops might impinge on the colder portions of the calciner near the nozzle, dry, and then fall off and plummet through the hottest zone too rapidly for reaction. This is apparently not the case.

Corrosion in the Radiant-Heat Spray Calciner

Several potential materials of construction were exposed in the hottest (850 C) region of the radiant-heat spray calciner during several hours of operation while processing simulated wastes and the corrosion rates measured. Monel and Carpenter 20 corroded at a very high rate while Nionel suffered severe pitting attack. A nickel sample was not recovered. Stainless steel type 446 corroded at a rate of 0.05 mil/hr., Inconel at a rate of 0.1 mil/hr., and stainless steel type 304-L at a rate of 0.3 mil/hr. However, both the 304-L and Inconel formed adherent oxide coatings which might reduce these rates on longer exposure. Other test samples are scheduled for longer exposure.

Further details of the spray calciner work may be found in the Quarterly Progress Report - Radioactive Residue Processing Development for January, February, March, 1960. A trip report, HW-64862, Visit to Brookhaven National Laboratory and Oak Ridge National Laboratory, April 7-8, 1960, by B.M. Johnson, and a thesis, HW-64675, A Study of the Effects of Some Spray Column Variables on Radiant-Heat Transfer in Spray Calcination, by R.T. Allemann were issued during the month.

Mineral Reactions

Equilibrium distribution coefficients were measured for cesium in clinoptilolite adsorption systems. The coefficients were measured for mineral beds that had been irradiated to different dosage levels by a Co^{60} source and at both 25 and 55 C. Mineral beds irradiated to 0, 1.2×10^8 r, 2.4×10^8 r, 5.5×10^8 r, and 1.9×10^9 r, were examined. No differences in equilibrium adsorption were evident in this irradiation range from experimental data obtained at 25 C. At 55 C the mineral samples that had received 5.5×10^8 r and 1.1×10^9 r gave a K_d that was about 18% lower than those receiving lower dosages. At the higher irradiation level the mineral gave K_d values at 55 C about the same as those measured at 25 C. These data may reflect a real irradiation effect or may be caused by some unexplained experimental error. Calculations of the expected exposure rate for clinoptilolite loaded with Cs^{137} indicated that radiation damage studies must be conducted to exposure levels much higher than can reasonably be achieved with the existing Co^{60} source. A radiation source from 10 to 100 times as intense as that now available will be needed.

Laboratory studies to investigate the possibility of direct decontamination of some types of high level wastes continued. Aged Redox (high aluminum) salt waste was diluted 1:20 with distilled water and passed through four two-foot clinoptilolite columns in series at a flow rate of 50 gal/ft^2/hr. It was found that 98 percent loading could be attained in the first column before Cs^{137} reached 0.1 M.P.C. in the effluent from the third column. The waste used is the supernatant solution from a six year old Redox tank and its activity is more than 99 percent cesium-137. The breakthrough curves for strontium and rare earths are very similar and are flatter than that for cesium. The cesium from about 50 volumes of the undiluted waste can be loaded on one volume of clinoptilolite. After it was loaded with cesium the mineral column was leached with water. Only 0.14 percent of the cesium was removed by 100 column volumes of water and the concentration of Cs^{137} in the wash water decreased to less than 0.02 percent of that in the actual waste. Flushing the column with less than 25 bed volumes of saturated $NaNO_3$ solution eluted essentially all of the radiocesium from the bed.

Experiments were initiated to study the use of clinoptilolite for decontaminating decladding wastes. Initial data indicated a radiocesium decontamination factor of more than 10^7 for a 240 cm column. Again the waste was diluted 1:20 with distilled water. This dilution appears to improve the capacity of the mineral for cesium from high-salt wastes.

Several metals were tested in the laboratory to study their ability to decontaminate solutions with respect to ruthenium. The experiments were generally equilibrium adsorption systems using powdered metal. More than 90 percent of the ruthenium in a distilled water solution was removed by iron, aluminum, magnesium, zinc, manganese, and lead at pH 5 and 8. Column experiments with granular lead and magnesium showed lead to be superior for removing Ru from 1.0 M $NaNO_3$ solutions at pH 12. The mechanism for this removal is not clear but there is evidence that the ruthenium is associated with the lead oxide corrosion products; considerable corrosion of the lead is evident.

Condensate Streams

Studies on the decontamination of Purex Tank Farm Condensate in the 271-CR Building Micro Pilot Plant were continued. During Run 3 the waste was passed down-flow through a bed of clinoptilolite having a particle size of 0.4 to 0.5 mm, a bed height of 14.2 inches and a bed diameter of 1 inch. Temperature of the system was maintained at 25 C and the pH of feed and effluent varied from 8.5 to 9.4. The TBP concentration in both feed and effluent was about 110 mg/liter. At a flow rate of about 2.3 gpm/cu.ft., cesium was removed with a DF of 1100 and strontium with a DF of 11. Decreasing the flow rate to about 0.5 gpm/cu.ft. increased the DF for cesium slightly to 1200 and the strontium DF to 25. At both flow rates zirconium, niobium, ruthenium and cerium radioisotopes were not appreciably removed.

Run 4 was initiated with the clinoptilolite particle size increased to about 1.2 mm and with a bed of activated carbon preceding the mineral bed. Preliminary analytical results indicated that the activated carbon was effective in removing TBP but that radioisotopes present were not removed with high decontamination factors by this material.

When preparing clinoptilolite for packed beds the crushed mineral is mechanically separated into a suitably sized fraction by vibrating screen equipment and the adhering fines are washed out by upflowing distilled water through the bed at a velocity sufficient to expand it 25 to 50 percent. A considerable amount of very fine material is removed by this technique but the apparent self-attrition during this treatment tends to reduce the average size of the particles to an undesirable extent.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

Logs made by the Standard Oil Company of California of their stratigraphic test well on the Rattlesnake Hills were obtained for study. This well, drilled adjacent to the Hanford Works in 1957 and 1958, was bottomed at 10,655 feet without penetrating through the Columbia River basalt series. The records disclosed more than 100 basalt flows in that well, separated by scoriaceous interflow contact zones and tuff beds. The basalt flows comprise more than 70 percent of the section.

Neither the thicknesses of the individual basalt flows or the tuff beds, nor the ratio of amount of tuff to basalt appear to vary in a recognized trend between top and bottom of the penetrated series. The flows appear to vary little other than in the thickness of the scoria zones and possibly in secondary mineralization. Tuff beds varied widely as expected.

X-ray diffraction techniques were used to examine geologic samples obtained from natural outcrops and from well construction operations to assist with the identification and correlation of formations. Particular emphasis was placed on samples from various basalt flows and basalt interbeds. Three ash beds are exposed on the southwestern side of Gable Mountain. Two of these outcrops were found to be the same interbed, the outcrops being separated by folding and subsequent erosion. This same folded interbed has now been traced to the vicinity of the 200 East Area through correlation of X-ray diffraction data obtained from samples of well cuttings. This work will increase our knowledge of the structure of the basalt and the extent to which erosion has modified the surface of the bedrock.

A distinct layer of volcanic ash occurs in the post-glacial sediments near the ground surface at Hanford; it was shown that this bed is correlative with an ash bed widely distributed throughout the Pacific Northwest. The age of this ash deposit was reported to be 6700 years on the basis of radiocarbon dating. Thus an important time reference is obtained in the chronology of geologic history of the Hanford area.

The application of mathematical models to the solution of field problems at Hanford is handicapped by inability to measure potential distributions along the lower boundary of a flow system. The potentials indicated by water levels in wells may be distorted by vertical variation of piezometric head and by the fact that the well casings are generally perforated throughout their length beneath the water table. Thus the potential distribution indicated by water levels may have little relationship to that along the bottom boundary of the aquifer. A numerical method of estimating such boundary values by an iteration process was obtained. The method is based on solving numerically the partial differential equations valid for the bottom boundary. By using a method of images it was found possible to estimate boundary values by means of a difference equation and the iteration process used to obtain potential values of interior points. The accuracy with which this method can be applied in the field will probably be established by how precisely the position of the lower boundary is known. When tested by a hypothetical case the technique appeared to give consistent results.

A chemiluminescent reaction was tested for application in a laboratory model for studying waste density effects. The reaction produces a blue-white light when aminophthalhydrazide dye contacts an oxidizing agent in the presence of a catalyst. By introducing the reagents in the two streams entering the model their juncture is clearly defined. The light emitted may be bright enough to record photographically. Initial tests of a radioactive tracer-technique for studying the flow pattern in this model were also performed. It was determined that the concentration of gamma emitting tracer material required to permit the face of the model to be scanned by a scintillation instrument through a collimating slit would probably dictate shielding around the model.

Soil Chemistry and Geochemistry

From the influence of solution pH on the anion replacement reactions calcite to fluorite, calcite to apatite, gypsum to calcite and gypsum to apatite, it was deduced that the reaction rate is determined by the difference in solubility between the initial and final product. The pH has the greatest effect of all the system variables studied on this solubility difference because these systems have products containing both OH^- and CO_3^{-2} radicals. Several experiments with systems containing calcite, PO_4^{-3}, SO_4^{-2}, F^-, and CO_3^{-2} tended to confirm the belief that the final product is solubility-controlled. When several final products are possible only the least soluble is stable under the conditions of the experiment. These experiments produced only one stable product but another product might be formed if experimental conditions (such as pH) were altered. The concomitant removal of Sr^{+2} from solution by these reactions is chiefly determined by the ease with which it fits into the crystal lattice of the product formed.

Laboratory research to characterize the soil chemistry of rare earth elements is complicated by the fact that some of them are known to exhibit more than one oxidation state. Cerium is an example of these, for which oxidation states of +3 and +4 are known. Data obtained with Ce(III) may be complicated by its oxidation to Ce(IV) under some experimental conditions. This behavior would make cerium a poor representative of rare earth fission products in wastes. Some of these experiments were therefore repeated using Pm-147, as promethium exists only in the +3 oxidation state. Both Pm and Ce are essentially completely removed from solution (greater than 99 percent) by soils from systems near the neutral point or slightly acidic. Under slightly basic conditions both are associated completely with the solid phase which may be peptized to colloidal form in low salt systems. The apparently identical behavior of cerium and promethium in these experiments tends to indicate that the cerium remains in the +3 oxidation state. In this event the cerium data may be applied to other rare earth species with validity.

Ground Waste Investigations

Tests were made of a commercial soil moisture (neutron) probe and a commercial soil density (gamma) probe in preparation for another survey of the Gable Mountain experimental crib site. Comparison of the results from these two probes might disclose tc what extent moisture content differences were caused by the nonhomogeneity of the soil. It was feared that density differences resulting from differences in moisture content would prevent identification of porosity or grain-size variations within the soil. The test results indicated that the density probe can easily differentiate between porosity and moisture content variables.

The breakthrough data from five unsaturated flow experiments were plotted on logarithmic probability paper. Three of these sets of data resulted in straight lines while the other two were too scattered to permit this construction with assurance. The breakthrough relationship implied by these results is similar to that for saturated soil adsorption.

Field Apparatus Development

Results of gross beta measurements of well water samples taken near the bottom of nineteen wells showed no significant concentration differences between top and bottom. The newly developed sampler was used to obtain these samples.

A sensitive thermistor flow detector was ordered for use in instrumentation for measuring vertical flow patterns in wells. Experiments were performed to measure head loss through a flow constrictor to be used to amplify the vertical velocity in a well. Head loss at flows anticipated is negligible and with the thermistor element inserted at the constriction, flow rates of the order of 1 to 5 ml/min in an eight-inch well should be measurable.

The flow model scanning scintillation probe and shield were tested with satisfactory operation. High backgrounds in the laboratory will require additional shielding. Other assistance included design of an isotope storage cabinet, automatic controls for a water still, and a soil model permitting moisture measurements with screened plugs tested earlier.

Micromeritics

Retention of particles in sampling lines was further demonstrated. In a 1" pipe 72' long, 86 percent of the entering particles were retained on the pipe walls when 8 and 13 cu.ft./min of air flowed through the pipe. Based on equations developed from laboratory tests, some 92 percent loss would have been predicted for the ZnS particles with Mean Mass Diameter of 4u. Re-entrainment was negligible when clean air was passed through the duct.

Compton Cancelling Spectrometer

A second Compton cancelling spectrometer was assembled and tested. This spectrometer consists of a 3" x 3" NaI(Tl) detector placed inside a 9-3/8" diameter NaI(Tl) well crystal as the anticoincidence shield. Although the efficiency and sensitivity of this arrangement are not as high as those of the spectrometer using the 5" x 5" NaI(Tl) detector and large plastic shield, this spectrometer is very practical since the large crystal can also be used alone for large sample counting. One immediate application of this spectrometer is in the counting of As^{76} in reactor effluent water samples. In standard gamma spectrometry of these samples Cu^{64} interferes with the As^{76} measurement. With this spectrometer the interference from Cu^{64} is reduced a factor of 15 and As^{76} is readily measured.

Reactor Addition Studies

Two parts per million of EDTA were continuously added to the cooling water of a reactor process tube for three weeks to test the effect of a complexing agent on the process of formation of radioisotopes in the effluent water. Only minor fluctuations were observed in the concentrations of most radioisotopes except for Cu^{64} which rose rapidly to a value 15 times normal and then decreased rapidly to a value only about 25 percent lower than normal. No practical beneficial reduction of radioactivity was observed as a result of the addition of this agent.

L. P. Bupp

Manager
Chemical Research & Development

LP Bupp:cf

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BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

No significant changes occurred in organization.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

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

Location	μc/g Wet Thyroid Average	μc/g Wet Thyroid Maximum	Trend Factor
Wahluke Slope	4×10^{-4}	5×10^{-4}	+ 2
4 Mi SW Redox	3×10^{-4}	6×10^{-4}	-
Prosser Barricade	3×10^{-4}	3×10^{-4}	-

Columbia River Contamination

Concentrations of gross beta emitters in Columbia River organisms collected at Hanford were about two times those observed one year ago. Values follow:

Location	Organism	μc/g Wet Weight Average	μc/g Wet Weight Maximum	Trend Factor
Hanford	Minnows (entire)	2×10^{-3}	2×10^{-3}	+2
Hanford	Juvenile Chinook Salmon (entire)	3×10^{-3}	5×10^{-3}	+10

Fallout Contamination

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

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

Effect of Reactor Effluent on Aquatic Organisms

Routine monitoring of effluent from the 100-KE reactor was carried out with a new test initiated on April 6. This test involves the exposure of migrant size chinook salmon fingerlings to concentrations of effluent typical for the Columbia River at this time of the year, at a slightly higher concentration predicted as a consequence of future increased reactor capacity, and at a concentration twice that predicted for the future. This test simulates the conditions which would be encountered in the Columbia River by young salmon originating upstream from the Hanford Operations during their migration to the ocean. No adverse effect was observed in any of the conditions at the end of the month.

The susceptibility of various strains of Chinook fingerling salmon to the columnaris disease was studied by mortality tests run in 68° F water. The strains tested were Hatchery stock (146 FR Bldg.), White Salmon Hatchery, and the local Columbia River strain. Mortality was observed in all strains, however, the local Columbia River strain appeared to be the most susceptible.

Preliminary studies were made to check for antibody protection and phagocytes in fish blood. Results were negative.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Phosphorus

The results obtained from exposing cichlids to P^{32} in water have not been fully satisfactory. The average concentration of P^{32} in the fish was higher than intended from the experimental design but in spite of this, no gross evidence of radiation damage was apparent. The number of egg lots obtained under the aquarium arrangement used has been disappointingly small. Consequently, it is planned to discontinue this test early next month and to revise the experimental design in hopes that more meaningful results on the effect of deposited P^{32} on the viability of sex products can be obtained.

Strontium

The first phase of a study on strontium transport across the gills of trout was completed. The strontium moved from within the gill to the outside much more readily than in the reverse direction (influx rate 5.2×10^{-8} cm sec^{-1} vs. outflux rate of 1.6×10^{-6} cm sec^{-1}). The ability of the gill to excrete strontium against a concentration gradient was confirmed by a test which started with equal concentrations of strontium on both sides of the gill membrane.

After eight weeks' exposure no evidence of radiation damage is evident in trout force fed Sr^{90}-Y^{90} five days a week. (The slight indication of the depression in growth rate reported last month for the fish receiving the

highest level turned out to be an artifact.) The average size of the fish in all groups is now approximately 200 g and consequently, individuals in the high level group are receiving about 100 μc Sr^{90}-Y^{90} each day.

The blood picture of the adult miniature swine fed 1, 5 and 25 μc/day of Sr^{90} for over one year and of their three-month-old offspring continues to be indistinguishable from that of the control animals. Histological examination of the newborn and six-week-old 25 μc level F_1 generation swine revealed no evidence of damage. (The neutrophilic infiltration previously reported in the fetal livers of the 25 μc group was apparently no significant or representative of permanent damage. Fetuses to be removed from a dam receiving 50 μc/day of Sr^{90} may provide clearer evidence on this point.)

Recent X-ray plates of representative swine on chronic Sr^{90} feeding showed no skeletal abnormalities except a general reduction in size of the six-month-old 25 μc F_1 animals.

It is estimated that the F_1 generation swine on the 25 μc/day level in which there is some suggestion of damage, as indicated by weight and general appearance, received an average total skeletal dose of 80-100 rads during fetal life and the suckling period. The radiation dosage to tissues other than that adjacent to bone may be considered negligible (since the concentration in soft tissue was less than 0.005 of that in bone). Equipment is being prepared for the direct estimation of radiation dosages to skeletons of the swine on the toxicity experiment.

Preliminary results were obtained from the experiment studying the effect of simultaneous variation of phosphorus and calcium levels in the diet of rats on the distribution and retention of orally administered Ca^{45} and Sr^{90}. Data thus far obtained indicate a considerably more complex picture than has been described by others. Any conclusions must await the completion of additional analyses.

The uptake of Sr^{85} and Ca^{45} by bean plants was followed during a 24-hour period from high salt and low salt solutions. High salt solutions consisted of standard nutrient solution in which one-fourth of the Ca was replaced by carrier Sr (Ca was a 1.5 mM and Sr was a 0.5 mM). The low salt solution was a 10-fold dilution.

The new growth arising from the nodes accumulated Ca and Sr to a greater extent than the fully developed tri-foliar leaves. In many cases this accumulation was greater than in the young terminal growth and consistently altered the usual distribution pattern.

General uptake of both Ca and Sr was not appreciably different. During the period of continuous illumination, two rates of uptake were evident; a rapid initial rate of uptake during the first 8 to 10 hours, followed by a slower rate. These rate differences were especially evident in the stems of low-salt treatment.

Iodine

The first phase of a series of studies to determine if biological availability of the I^{131} of *in vitro* radioiodine-labelled milk is similar to that of radioiodine labelled *in vivo* (by the ewe) was completed in six lambs. The percentage uptake and time of peak concentration was approximately the same in each group. The next phase involves the reversal of the type of I^{131} labelled milk for each group.

Cesium-Rubidium

When bean plants were grown in nutrient cultures having equal but low concentrations of stable potassium, rubidium, and cesium, the accumulation of these elements in tissues of the plants were in ratios of 100, 10, and 1, respectively. Increasing nutrient potassium as much as 500-fold did not significantly affect the percentages of adsorbed Cs^{137} and Rb^{86} on the roots.

Plutonium

Complete data are now available on three pigs which were injected with Pu followed by treatment with a single 9 g dose of DTPA. The treated pigs retained less than 0.5 per cent of the administered dose in liver and less than 6 per cent of the administered dose in bone. This compares with the retention of 14 per cent in liver and 56 per cent in bone of untreated control pigs. The treated animals excreted 88 per cent of the administered dose during a six-day period following treatment, as compared with an excretion of less than 3 per cent by the control animals during the same period.

Studies on the lethal effects of combined Pu deposition plus X-irradiation were continued with groups of rats being administered 32 μc Pu/Kg followed at intervals of 30 minutes, 14 days, or 28 days, by a 400 r X-irradiation. Preliminary indications of survival following the X-ray dose suggests that there is little effect attributable to the delay period. This is in contrast to earlier results obtained at lower Pu and X-ray levels.

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

Varying degrees of bone pathology were revealed in the X-ray plates of the various aged swine in this study. Generally, there was a slight increase in cortical bone in all groups. Small areas of apparent resorption were evident in the animals administered plutonium while a washed-out medullary cavity was noted in the radium and strontium animals. (All of the animals received single I.V. dosages of the respective radionuclides in amounts that would cause comparable damage within a relatively short period of time. If the radionuclides were uniformly distributed, the average dose to the bone would be about 20 to 30 rads/day.)

Tissue Transplantation for Radiation Therapy

Six miniature swine exposed to 950 to 1000 r total-body X-irradiation, four of which received 110-day fetal hematopoietic cells at 72 hours after exposure, died within two weeks.

One animal that survived for two years after 550 r total-body X-irradiation followed by a transfusion of adult marrow was sacrificed. Histologic evidence of damage was restricted to a diffuse fibrosis of the spleen and lymph nodes. Testicular tissue and bone marrow appeared normal.

Radioactive Particles

Preliminary studies with non-radioactive aerosols indicate that the amount deposited in the lungs is proportional to the positive pressure during the filling of the lungs. Techniques for heart-lung preparations were also tested for use in studies of lung clearance.

To date about 30 dogs have died following a single inhalation exposure to $Pu^{239}O_2$. Over a wide dose range, roughly estimated at 25 to 300 uc initially deposited, death occurred no earlier than two months after exposure and within four months. Clinical symptoms leading to death are well defined and include lymphocytopenia, anorexia, emaciation, dehydration, and alteration of normal breathing. Further evidence of the rapid accumulation of Pu^{239} in tracheobronchial lymph nodes was obtained.

Gastrointestinal Radiation Injury

A number of procedures have been studied in an attempt to influence the increased PVP excretion following irradiation of the intestine. Shielding segments of the intestine had no effect on the radiation induced increase. Administration of drugs known to decrease capillary fragility and permeability had no effect. Ligation of the bile duct decreased PVP loss following a 1000 r X-ray by a factor of two or more. Further studies of this effect are in progress.

Urinary excretion of orally administered xylose was shown to be markedly decreased by intestinal X-irradiation.

Population Dynamics

The annual survey of nesting Canada geese on river islands within the Hanford reservation was initiated. A record number of nests is indicated.

Jack J. Davis
BIOLOGY OPERATION

J. J. Davis:es

C. Lectures

a. Papers Presented at Meetings

L. K. Bustad, "Hanford Biology", Meeting of Benton-Franklin Medical Auxiliary, April 26, 1960, Richland, Washington.

b. Off-Site Seminars

D. E. Warner, "Hanford Biology," Kiwanis Club, April 13, Manson, Washington.

H. A. Kornberg, "Strontium-Calcium Relationships", Oak Ridge, Tennessee, April 22 (UT-AEC Agricultural Research Laboratory).

D. E. Warner, "Hanford Biology," Greater Spokane Science Teachers Assoc., April 27, Spokane, Washington.

W. C. Hanson, "Narrated color slides of Alaska," Senior High Class, Kennewick, Wash. - April 14, 1960.

H. E. Erdman, "Radiation Biology at Hanford with Special Emphasis on Radioecology," Seniors and advanced biology group at Pasco High School, April 18, 1960.

c. Seminars (Biology)

A. C. Case, "Aspects of Scintillation Counting," April 6, 1960.

Capt. R. L. Persing, "Skin Irradiation", April 6, 1960.

Dr. S. G. Kenzy, "Viruses in Avian Neoplasia," WSU, Pullman, April 12, 1960.

N. L. Dockum, "Preparation of Decalcified and Undecalcified Pig Bones," April 27, 1960.

L. K. Bustad, "Radiation and Aging", April 27, 1960.

d. Seminars (local)

W. C. Hanson, "Project Chariot", IPD's Project Engineering Group, (Information and Safety Meeting), April 21, 1960.

R. F. Foster, "Significance of Radiological Effluents to Aquatic Organisms," personnel in Redox, April 8,1960.

D. Publications

a. HW Publications

Ballou, J. E., "Metabolism of W^{185} in the Rat," Document HW-64112 (UNCLASSIFIED) March 10, 1960.

b. Open Literature

None

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OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - APRIL, 1960

ORGANIZATION AND PERSONNEL

R. L. Richardson transferred to Operations Research & Synthesis from IPD effective April 18, 1960. D. C. Gray, a Western Region Technical Trainee, started a six-month assignment with the group effective April 19. C. L. Childress resigned to accept employment elsewhere effective April 8, 1960.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

A report was issued on an analysis of dimensional distortion data from the first 24 tubes discharged under the Quality Certification Program. In examining fuel element position effects on distortion for tubes having widely different flux patterns, significant differences were noted. This was taken to indicate that when the use of IBM machines makes possible an analysis on an individual fuel element basis, it will be possible to express distortion as a function of reactor variables associated with each fuel element. The practical consequences of this were discussed. A procedure was also set up to utilize control charts in routinely presenting post-irradiation data from this program.

Fuel Element Failures

Further work was done in connection with the use of control charts to monitor rupture performance. Two presentations were made to the area engineers in order to acquaint them with the method. Expressions were derived giving the distribution of the time to accumulate R ruptures adjusted for reactor variables in the case when the true average time between ruptures is not constant over time, but is a function $\lambda(t)$ of time. It was shown that if the function is linear, the use of the average λ gives equivalent results. Preliminary work was also done in evaluating various decision rules to use in connection with the control charts. A document is being prepared jointly with Process Technology personnel in which this method of interpreting rupture data will be discussed and recommended.

Optimization of Reactor Operations

The work done in connection with control charts for fuel element ruptures has application in this area in that recommendations for changing reactor operating conditions are made on the basis of rupture experience.

Assistance was provided in presenting to personnel from GEL various aspects of the optimization model. This is in connection with an engineering audit of this model requested of GEL personnel by Research and Engineering Operation.

Process Tube Leak Detection and Replacement

Data were made available to permit an investigation of the process tube leak problem on a broader scale. Attention has thus far been directed toward trying

to predict which tubes are potential leakers. This was not too successful. Attention will be directed in the future towards deriving, if possible, a model which will indicate the consequences on future leak rates of continuing to operate with leakers.

Z-Plant Information Studies

No major effort was expended during April. Bid acceptance closure date for the computer to be used during the experimental period is May 10, after which date activity in this area will be resumed.

Reliability Studies

At the request of a member of the Facilities Engineering Operation, work was begun on a statistical evaluation of a proposed NPR GM tube type fuel rupture monitor.

A seminar-type discussion was held with personnel of CPD and IPD. The purpose of the discussion was to acquaint these personnel with the variety of kinds of reliability studies being conducted by Operations Research & Synthesis, and with the powerful techniques being developed to conduct these studies.

The single branch reliability matrix technique which has been developed in the course of the reliability studies has been found to be directly applicable to the simplification of, or the removal of redundancies from, switching circuits.

Inventory Studies

On the basis of agreement in a meeting on inventory sampling with representatives of all departments on April 8, a letter was forwarded by Inventory Accounting to obtain Atomic Energy Commission approval for a sample inventory. If such approval is forthcoming, the spare parts inventory will be taken May 27, 1960.

Redox Dissolver Study

The literature study to obtain sufficient background to understand the chemical kinetic theory of the dissolution process was continued this month. Formulation of one semi-empirical model is nearing completion. This model utilizes only information which is currently available concerning the redox dissolution process, and upon completion the model will be checked against operating data. A second model, which more correctly reflects the dissolution mechanism, is also being considered; however, it will not be possible to test the reliability of this model at the present time because some critical variables are not monitored. It is hoped that the existence of such a model will stimulate measurement of the critical variables on the part of operating personnel.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

A rough draft report was issued presenting the results of the experiment designed to evaluate the effects on porosity and can wall thickness of canning bath temperature, vibration frequency, and time of vibration. A thorough discussion

of the experimental design employed in this experiment was contained in this report.

An experiment was designed to evaluate different combinations of core-can annuli, where the two annuli considered are the internal and external annuli. Three levels of each annulus are involved, and the design employed was a 3^2 factorial with the corner points replicated once, and the center point replicated twice to result in a total of 15 points.

Some sixty fuel elements were canned five times, being measured for warp after each canning, stripped, and recanned. The purpose of this was to evaluate the effects of canning on warp. A linear effect was found once the data were appropriately transformed to give homogeneous variance.

Two sets of stud pulling data are being evaluated to determine if this technique can effectively be used as a part of the Quality Certification Program to measure bond strength.

Data were analyzed from an experiment designed to evaluate Diversey 600 in the cleaning of aluminum components. Huge unexplained differences between tanks used in the experiment plus the inability to conduct the experiment as designed due to a shortage of materials did not permit a clear-cut evaluation of Diversey 600.

An experiment had previously been designed to evaluate the effects on changes in dimensions after heat treating co-extruded tubes of varying quench rates, delay times, and surfaces quenched. This had been designed as four replicates of a Latin Square, where each replicate represented a delay time. Unfortunately, several observations were missing which did not permit a clear-cut estimation of all the effects. However, since most missing observations were from one level of one of the factors, it was possible to remove this level from consideration and estimate the effects of primary interest.

Irradiation Processing Department

An analysis is being made of data from two production tests, one concerned with the self supported fuel elements in the run to rupture test (IP-247-A), and the other with the continued comparison between chloride and carbonate salt heat treated fuel elements (IP-84 A).

A final report was issued on the problem concerned with assessing the accuracy of the reactor power level calculations.

A study was initiated to determine the number of coolant pressure gauges which may be by-passed and tripped simultaneously without invalidating any normal scram signal. Mathematically, the answer to the problem can be obtained by considering the solutions to a set of simultaneous Diophantine equations with complex coefficients. A program has been written for the IBM-709 computer to obtain these solutions under various assumptions made on the electronic devices employed in the safety circuit.

Chemical Processing Department

The reproducibility of the gauge used for measurement of internal radius and wall thickness of a shell was evaluated.

Several multiple regression analyses were made which relate the amount of steam produced, and the amount consumed in a facility to other variables such as BTU-days and degree-days.

A program of study was begun to investigate the mathematical requirements and techniques needed for the accurate control of template, cam, and numerically controlled metal cutting machines. Typical subjects under study are:

a. Methods of contour description,
b. Contour curve fitting techniques,
c. Contour data transmission, and
d. Error detection routines.

Alternate IBM 709 programs have been written to convert contour descriptions into Gorton lathe cam specifications to cover the two major methods of cam manufacture.

Mathematical aid in developing a set of formulas for the fluxes resulting from several specific but irregularly shaped geometric sources has been requested. Such formulas are important in dosimetry and shielding studies.

Contract and Accounting Operation

Review of 709 main frame production data did not indicate any one significant contributor to the loss time and scheduling problem. The breakdown of losses by functions involved indicated that machine failures and tape failures cause an estimated 16% of the loss time. The remaining losses which can be related to the various functions performed by the sub-organizations within Electronic Data Processing Operation contributed less than 3% for each functional class. The highest loss, that attributable to the control function, was estimated at 2.4% and indicates a weakness in the input-output function. Data are being recorded to further measure this area.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Aluminum Alloys Corrosion Rate

The initial phase of the statistical analysis of Al-Ni-Fe alloy corrosion data from a study currently being conducted by the Corrosion and Coating Operation was completed. The effects of heat treating time, heat treating temperature, and method of cooling on the corrosion rate of various aluminum alloy samples as a function of time in a steam autoclave environment were determined. The results of the analysis are being used to aid Corrosion and Coating Operation personnel in designing similar experiments using zirconium alloys.

Pulse Column Test Facility Study

Statistical consultation on a continuing basis has been requested for the pulse column test facility program. Orientation discussions have been held to become familiar with the experimental apparatus in general, with special emphasis on the numerous data collection devices. The problem of estimating

the precision and accuracy of a device for electrically sizing the organic phase without interrupting the column operation was posed and is being considered.

Separations Development

Data from an experiment to test the reduction of sensitivity of a beam balance when the balance pan is separated from the beam by a liquid seal were analyzed for Chemical Development Operation. The results of the analysis were compared with those of an earlier experiment using a rubber seal in place of the liquid one.

4000 Program

Plutonium Recycle

Further discussions were held with personnel of Programming Operation to direct the use of statistical methods for determining a maximum of a function defined over a multi-dimensional space. The program will be used with HLO's Meleager Physics code to optimize plutonium reactor fuel as a function of initial plutonium isotopic composition.

An unclassified document was issued to HLO personnel which discusses the statistical analysis of the Phase I pressure test of the PRTR containment vessel and considers the design of the Phase III test. Recommendations were made on the positioning within the vessel of temperature and pressure monitoring devices, and a method was suggested for analyzing the data collected from these devices in order to estimate the vessel leak rate.

Swelling Studies

Final work is being done on the generalized theoretical model representing the extrusion introduced in the sample preparation of replicates for electron microscopy. This work was discussed with J. E. Hilliard and J. W. Cahn of GERL during a recent visit to the Research Laboratory. It was ascertained that the continuing theoretical quantitative metallography effort being carried on jointly with Physical Metallurgy Operation is in no way superseded by Hilliard's and Cahn's theoretical work but is an extension of their work.

6000 Program

Biology and Medicine

Work continued on statistical analysis of data from an experiment involving a challenge dose of radiation applied to pre-irradiated, and non-pre-irradiated, mice. Mortality curves for experimental and control groups were plotted, and the LD50(15) was computed for the experimental and control groups.

General

A mathematical formula was derived for the volume common to two cylinders of different radii which intersect at a right angle. The formula will be used in the calibration of hot cell gamma analyzers.

A least squares curve fitting formula was developed which fits a saw tooth signal of arbitrary amplitude and frequency to empirical data assuming only that each individual data point can be identified with a particular tooth.

An investigation is under way to devise mathematical methods of calculating more reliably than has been previously possible the total integrated concentration resulting at any particular geographical location due to known contaminant releases at any other specified point under various assumptions on meteorological conditions. This program was suggested by the Consulting Radiological Scientist, Programming Operation.

A system for codifying technical personnel was developed as requested.

The HLO Computer Study Group met twice during April to scope and formulate objectives. Each participant reviewed technical computing requirements of assigned HAPO organizational components. The Operations Research & Synthesis representative reviewed these requirements for FPD.

Assistance in the mathematical design of a surface of revolution for a helical strip welding follower guide was requested. Every solution found was seen to involve the extraction of roots of some quartic equation. It was finally advised that a trial-and-error method of design in the machine shop would yield a faster and more economical solution to the design program than would a mathematical approach.

Carl A. Bennett

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:kss

PROGRAMMING OPERATION
APRIL 1960

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. ADVANCED SEPARATIONS STUDIES

A study of pyrochemical separations processes from the viewpoint of waste disposal problems was begun. This involves the establishment of bases and flowsheets. Although pyrochemical (in which we also include pyrometallurgical) processes have been studied at many sites for many years, details of complete processes apparently do not exist. In addition, many of the processes were considered for application with very special types of reactors. Some of these reactor programs have been practically abandoned. It appears, therefore, that there may be only a very few processes which will justify study. In addition, such processes may have applications for only certain reactors or special fuel cycles and may therefore not be readily compared.

B. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. Advanced fuel cycle studies have indicated the need to include examination of large fuel lumps cooled by multiple internal passages. Accordingly, an IBM-650 code prepared for earlier work on the basis of an analytical solution is being revised and reprogrammed for the IBM-709. This work is nearing completion.

Except for a few refinements of data print out and operating options, the debugging of the Puck Code is complete. While the completion of this work will make Puck a fully operable code, updating of the physics section to incorporate latest cross section information will be done before it receives widespread use.

The new LOLA code has been flow-charted and programming is now under way. LOLA utilizes both first-order (Yates) and higher-order (Box-Wilson) methods to find desired maxima and minima for fuel cycle characteristics, starting either with experimental or calculated data.

Parts 1 and 2 of the RBU input code have been compiled, and the third and final part is now about 50 per cent complete. Assistance was provided to personnel of Atomics International in carrying out a study of the Hallam reactor lattice with the RBU Monte Carlo. Relatively little progress was made in debugging due to low availability of machine time.

Modified versions of the Meleager code were developed to make possible automatic optimization of fuel cycle characteristics. The new codes are:

(a) Meleager A2, which will adjust the concentration of a given isotope to provide an assigned initial reactivity.
(b) Meleager B2, which places on tape incremental changes in concentration of four plutonium isotopes, which are then available as input to Meleager A, which determines exposure results.
(c) Meleager C, which performs a Yates analysis on the results of Meleager B2. The Yates analysis provides a first-order set of derivations of attainable exposure with respect to the concentration of four plutonium isotopes.
(d) The GPR code for steady recycle has been modified to conform to the physics methods used in the Meleager codes.

Fuel Cycle Studies. Evaluation of results of general plutonium recycle studies reported last month was started. It appears that, as expected, the attainable exposure increases with moderator/fuel ratio in most of the cases, particularly those with highly burned plutonium in reactors with high neutron leakage ($k_{\infty} = 1.30$).

A study is under way to determine the extent to which the utility of plutonium fuels in thermal reactors can be increased by employing multiple reactor systems and other fuel resources such as thorium and U-233. The more promising combinations selected for initial study are U-233 enriched U-238 machines combined with plutonium enriched Th-232 machines, the latter device being considered as a thermal converter on one hand and a fast converter on the other. Initial studies, using crude models, indicate considerable promise for these systems. These results are now being checked with more rigorous mass balances based on Meleager and other codes. The data indicate that as far as plutonium utility is concerned, such reactor combines may yield maximum productivity. The data have been organized so as to allow investment of excess neutrons in either breeding or in leakage and parasitic loss. So far it appears that enough excess neutrons will be made available by such combined operations to permit substantial use of stainless steel in the thermal reactors involved and yet achieve currently acceptable fuel element lifetimes.

PRTR Startup

PRTR startup planning included scheduling of power level steps and coolant temperature from the period following critical tests to full power operation. Also, review of critical test procedures and process specifications continued as part of Startup Council activities.

The description of the Critical Tests for PRTR startup was completed by members of the Critical Tests committee reporting to the PRTR Startup Council. The report will be issued shortly as HW-61900, Part B.

PRTR Plans and Schedules

A modified schedule for PRTR fuel requirements was prepared. This new schedule takes into account latest data on construction completion, uranium fuel test scheduling, re-evaluation of inventory needs,

and delivery of high exposure plutonium. A late and significant development has been the information that a desirable amount of high exposure plutonium may be available from Canada. This material appears to be highly advantageous for physics testing of high exposure material in PCTR.

Consolidated schedules for the Plutonium Recycle Program were prepared. These include (1) a general description of proposed activities for each of the thirteen plutonium recycle sub-programs and the three related programs, (2) a listing of 70 target items, (3) distribution of PRP funds and manpower for the next five years, (4) major capital expenditures, (5) major equipment needs, and (6) a schedule showing PRTR loadings and flow of fissionable materials used in the PRP.

Other Activities

Status and recent progress in the Plutonium Recycle Program were reviewed with D. E. Stewart, Assistant Director for Civilian Reactors, Division of Reactor Development, AEC, Washington, on April 12, and with C. W. McLaughlin, AEC Division of Reactor Development and H. B. Rahner, AEC-Savannah River Operations Office, on April 26 and 27.

2. SPECIFIC FUEL CYCLE ANALYSIS

Programming of computations is continuing. Considerable exploratory investigations have been carried on to define a ready means of achieving convergence of the plutonium value terms. The nature of this study, wherein the value of various unrelated compositions of plutonium are to be determined, introduces alternatives which simply cannot all be investigated. Several methods of achieving convergence have been defined; the best method is yet to be determined.

Six repetitive fuel exposure cycles at three enrichments (2.5%, 3.0%, and 4.0% fissile) were completed. Plutonium from each discharge was combined with depleted uranium to form the fuel charge for the next cycle. The reactivity lifetime showed the expected large increase for the first plutonium-fueled cycle, followed by a gradual decrease attributable to Pu-242 buildup. In addition, 24 cases for Yates analysis of the value of the individual plutonium isotopes have been completed.

Arrangements were made for early consultation with APED physicists on the latest techniques for applying plutonium fuel cycle analysis to boiling water reactors.

C. BIOLOGY AND MEDICINE - 6000 PROGRAM

1. RADIOLOGICAL CONSULTATION

Material was prepared for hearings to be held on Radiation Protection Standards by the Subcommittee on Radiation of the Joint Committee on Atomic Energy of the U. S. Congress.

Consultation was rendered on emergency dose, the Rattlesnake Springs ecology program, a Radiation Protection Standard on emergencies, and Zn^{65} concentrations in the Columbia River.

A meeting of the Washington State University Sanitary Engineering Advisory Committee was attended at Pullman. During this meeting, arrangements were made for visits to Hanford by members of the staff of the Sanitary Engineering Department.

D. OTHER ACTIVITIES

A. J. Nerad of the General Electric Research Laboratory discussed "Super-Pressure Research and Man-Made Diamonds" at a Hanford Science Colloquium on April 13.

A group of senior Hanford Laboratories personnel visited the General Electric Research Laboratory for a general review of research and development programs plus detailed discussions on technical topics of special interest.

Assistance was rendered in arranging 18 tours (involving 385 people) through HLO and HAPO facilities.

L H McEwen
Manager
PROGRAMMING

LH McEwen:dl

RADIATION PROTECTION OPERATION MONTHLY REPORT -- APRIL 1960

A. ORGANIZATION AND PERSONNEL

G. E. Backman transferred to the Radiological Evaluation Working Group from CPD on April 15, 1960. R. F. Ballard was deactivated for personal illness effective April 11, 1960. One employee was transferred within the Operation to provide broadened experience. The force of the Radiation Protection Operation remained at a total of 133.

B. ACTIVITIES

There were five cases of plutonium deposition confirmed during April. The total number of deposition cases that have occurred at HAPO is 254 of which 185 are currently employed. Two of the confirmed deposition cases were discovered by the routine sampling program and three following known incidents of exposure. The mode of exposure for the three incident cases was inhalation for one and was by contaminated injury for the other two. Four of the deposition cases appeared to be minor involving less than 10 per cent of the maximum permissible body burden (mpbb). The other case involved a contaminated injury to an HLO employee working with plutonium metal in the 231 Building. The tiny Pu sliver associated with the incident contained about 33 μc Pu and was removed at the area first aid station. Final surface decontamination of the wound area was accomplished with Na_4EDTA. Subsequent examination of the wound at the Whole Body Counter revealed about 0.04 μc Pu still remaining in the wound site. The tissue was excised and the final examination indicated only ~ 600 d/m Pu remaining at the wound site. The first urine sample collected about three hours after injury indicated a possible intake of several times the mpbb. Subsequent bioassay samples did not appear to confirm this. Superficial use of Na_4EDTA may have influenced the excretion rate indicated on the first bioassay sample. Medical treatment of CaDTPA was administered. Preliminary bioassay data indicated that the body deposition probably is from one-quarter to one mpbb.

Two members of a charging crew at the 105-H reactor handled an irradiated solid aluminum slug which had washed out of the process tube on the front face of the 105-H reactor. The maximum whole body dose as measured by the film badge for the period covering the incident was 220 mrads including 190 mr. The localized dose to the hands was estimated to be less than 5 rads.

Air contamination up to 2.1×10^{-10} μc U/cc and 3.9×10^{-9} μc FP/cc resulted from a fire involving the rupture of a quartz tube enclosing a uranium slug at 305-B. No personnel were exposed and facility decontamination was completed without incident.

Planned deviations from normal loading techniques to accomodate a damaged sample can at the Radiometallurgy Building resulted in measured dose rates

to 50 r/hr. Inadvertent dropping of several coupon samples also caused higher than normal dose rates and air contamination. Personnel exposures in both cases were well controlled; although, particulate contamination was spread to the change room.

On April 12 about 5 to 10 pounds of UO_3 powder escaped from the loadout room at 224-U to the loadout pad, the asphalt ramp, and the road along side 224-U. The fire department hosed down the road and other outside areas successfully. Inside of 224-U it was estimated that up to a ton and one-half of UO_3 spilled out of the hose when it broke. The majority of this was salvaged. No personnel contamination problems of concern were encountered.

An exposure in excess of operational control limits was received by a laboratory assistant in CPD as a result of a contaminated glove. The maximum estimated dose to a small skin area of the employee's thumb was 9 rads including 0.1 r.

Surveys of five Tri-City residences followed discovery of a pair of highly contaminated coveralls and a contaminated film badge. No contamination was detected.

A four-fold increase in the frequency of hand and shoe checks resulted from recommendations of radiation monitoring to operating supervision following a review of hand and shoe check practices in the Plutonium Fabrication Pilot Plant.

A total of 21 curies of I^{131} was released from the separations facilities at a rate well within control limits. All vegetation samples within and outside of the plant perimeter were less than the detection limit of 1.5×10^{-6} μc/gm. Radioisotopes of cerium were present at about the same concentrations throughout all sampling zones indicating residual material from bomb fallout.

The Columbia River flow rate returned to about normal for this time of the year after the filling of the Priest Rapids pool. The flow pattern of the river for this year is predicted to be substantially below normal.

Bioassay procedures for personnel associated with Project SOAP have been expanded to provide specific analyses for palm material.

Examinations made during April in the Whole Body Counter (WBC) included: 115 routine, four pre-employment, seven incident, and two nonemployees. There have been 406 examinations made in 1960. Improvements made at the WBC facility include fabrication of a more substantial chair, fabrication of a removable bed, and installation of a screw drive to permit accurate scanning of subjects.

Studies of the performance of the 12-inch polyethylene spherical neutron moderator were completed and the sphere diameter was reduced to 11 inches. Data obtained using this reduced sphere size showed a decrease in the slope of a curve relating c/m/mrem/hr and neutron energy. This decrease

in slope indicates that the reduced neutron diameter is approaching a size giving a less energy sensitive instrument.

The assembly of 20 ionization-type finger ring dosimeters was started for field testing. With a charging voltage of 35 volts, these rings have a range of 50 mr to 600 mr and a leakage rate of about seven per cent in four days. No dose rate dependency up to 30 r/hr has been observed. Energy dependency of these rings is under further study.

Scope designs for improved personnel dosimeters neared completion. Considerations factored into these designs include such things as reduced size, capability for duel film loading for monthly and yearly film, additional and improved absorbers, and accomodation of security badge.

Two plutonium foils and one neptunium foil were irradiated as part of the calibration program for the Oak Ridge criticality dosimeters. Further exposures were suspended until it can be determined whether or not the maximum operating flux of the positive ion accelerator of 5×10^5 jakes (~ 5 rems/hr) is sufficient to provide adequate calibration of these foils. A neutron moderator for use with the positive ion accelerator is being designed in conjunction with Radiological Physics personnel. This moderator will provide a high thermal neutron flux suitable to a second approach to the calibration of the Oak Ridge dosimeter foils. The availability of the calibrated thermal neutron flux will be useful for a variety of studies.

The charcoal iodine air sampler unit on test at 105-KE continued to operate satisfactorily. A few sharp peaks in counting rate were observed in purges or dropping of the vertical safety rods. It is planned to move the equipment to the 291-A Building for monitoring of the Purex stack gases. Results obtained with gamma spectrometers of the charcoal cartridges will be compared with the routine caustic scrubber samples from Purex.

Formal approval for the use of Na_4EDTA for skin decontamination was received from the Industrial Medicine Operation. A supply of this chemical and procedures for its use were delivered to Radiation Monitoring groups throughout the plant.

The distribution of the periodic revision of the Manual of Radiation Protection Standards was started on April 22.

On April 22, 50 students from the Charles Francis and Coulee Dam High Schools visited the exposure records facilities. Bioassay and Whole Body Counter facilities were visited by three visiting high school groups totalling about 120 students, faculty members, and school board members from Wenatchee, Spokane, and Pendleton. A total of 399 special tour film badges were issued throughout the plant during April.

C. EMPLOYEE RELATIONS

Three suggestions were received for evaluation. One suggestion evaluation was made during the month. There are four outstanding suggestions at month end. Four suggestion awards totalling $30.00 were received by Radiation Protection personnel.

There were four medical treatment injuries during the month for a frequency of 1.83. No security violations occurred during April. Revision of all job hazard breakdowns in the Radiation Monitoring Operation was completed.

Radiation protection training included: Four 90-minute lectures to Fire Protection shift personnel, two one-hour lectures to 90 employees in Technical Shops and 328 Building, one 2-hour orientation talk to a new member of Plutonium Metallurgy Operation, and two new-employee orientation meetings. Construction forces were given two lectures on radiation zone and special work permit procedures. Three of 13 lectures on the PRTR conducted by the Radiation Monitoring Operation were attended by exempt employees of the Radiation Protection Operation. A half-day lecture and drill was held during a training session of the 300 Area Rescue Crew.

D. SIGNIFICANT REPORTS

HW-64757 "Analysis of Radiological Data for the Month of March, 1960" by R. L. Junkins.

HW-64979 "Monthly Report - April 1960, Radiation Monitoring Operation" by A. J. Stevens.

"Some Studies of Film Dosimeter Variables" by W. V. Baumgartner has been accepted for presentation at the Health Physics Society meeting in June, 1960.

"Some Contributions to the Stratigraphy and Indicated Deformation of the Ringold Formation" co-authored by R. E. Brown and M. W. McConiga was accepted for publication in the May issue of "Northwest Science".

"Surveillance of a Municipal Water System to Assure Control of Radionuclides - A Study of the Hanford Atomic Products Operation" was presented by R. L. Junkins at the 1960 Nuclear Congress.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-March 1960 - Mid-April 1960)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.6	% MPC_{GI}*
Separations Areas	Gross Beta	9.4×10^{-8}	µc/cc
Pasco	Isotopic	5.2	% MPC_{GI}**
Kennewick	Isotopic	< 1.2	% MPC_{GI}**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	7.0×10^{-9} ***	µc/cc
100-F Area	Isotopic	2.7	% MPC_{GI}*
Hanford	Isotopic	2.6	% MPC_{GI}*
Pasco	Isotopic	17	% MPC_{GI}**
McNary Dam	Gross Beta	1.8×10^{-6}	µc/cc
Vancouver, Washington	Isotopic	0.4	% MPC_{GI}**
Atmosphere			
I^{131} Separations Areas	I^{131}	1.8×10^{-13}	µc/cc
I^{131} Separations Stacks	I^{131}	0.7	Combined curies/day
Active Particles - Project	--	2.2	ptle/100 m^3
Active Particles - Environs	--	0.4	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	$< 1.5 \times 10^{-6}$	µc/gm
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/gm
Eastern Washington and Oregon	I^{131}	$< 1.5 \times 10^{-6}$	µc/gm
Fission Products less I^{131} - Wash. and Oreg.	Gamma Emitters	$< 1.0 \times 10^{-5}$	µc/gm

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

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

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

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
April	1	1
1960 to Date**	1	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
April	16,944	273	4	0
1960 to Date	74,040	968	16	7

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)
April	14,962	914	271	64	35	12.96	19.69
1960 to Date	47,527	3,855	829	191	130	11.35	20.02

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
April	704	0	0	0	3
1960 to Date	4,274	1	0	0	16
Fast Neutron					
April	85	4	2	0	1
1960 to Date	841	57	25	0	11

Bioassay

	April	1960 to Date
Plutonium: Samples Assayed	688	2,878
Results above 2.2×10^{-8} µc/sample	48	177
Fission Products: Samples Assayed	638	2,776
Results above 3.1×10^{-5} µc FP/sample	2	3
Uranium: Samples Assayed	315	1,225
Confirmed Plutonium Deposition Cases	5	10*

*This brings the total number of plutonium deposition cases which have occurred at Hanford to 254.

**Reclassified to conform with new standards.

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	26	6.2	64	18	3.4	66
Hanford Laboratories	18	5.1	32	12	3.4	30
Chemical Processing	28	5.7	62	18	3.2	57
Chemical Processing*	14	14	1	7.1	7.1	1
Special Incidents	0	0	0	-	-	-
Random	1.7	1.2	2	-	-	-

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

Thyroid Checks	April	1960 to Date
Checks Taken	0	0
Checks Above Detection Limit	0	0
Hand Checks		
Checks Taken - Alpha	35,274	128,346
- Beta-gamma	50,226	182,818
Skin Contamination		
Plutonium	21	90
Fission Products	51	166
Uranium	1	20

CALIBRATIONS

	Number of Units Calibrated April	1960 to Date
Portable Instruments		
CP Meter	939	3,609
Juno	331	1,192
GM	821	3,103
Other	197	737
Total	2,288	8,641
Personnel Meters		
Badge Film	1,374	5,350
Pencils	-	1,912
Other	328	1,601
Total	1,702	8,863
Miscellaneous Special Services	182	1,670
Total Number of Calibrations	4,172	19,174

A R Keene
Manager
Radiation Protection

AR Keene:ks

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LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - APRIL, 1960

GENERAL

Security performance for the Operation was unsatisfactory with one violation during the month. Year-to-date performance is now the same as last year with a total of one violation.

Safety performance of the Operation was considered satisfactory. There were no major injuries; the minor injury frequency rate was 3.94 which is considered about average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the month was 16,552 hours. This includes 13,586 hours performed in the Technical Shops, 2,419 hours assigned to Minor Construction, 225 hours assigned to other project shops, and 322 hours assigned to off-site vendors. Total shop backlog is 22,266 hours of which 60% is required in the current month with the remainder distributed over a 3-month period. Overtime hours worked during the month was 5.2% (1,196.8 hours) of the total available hours.

Distribution of time was as follows:

	Man-Hours	% of Total
Fuels Preparation Department	1,579	9.5
Irradiation Processing Department	973	5.9
Chemical Processing Department	1,139	6.9
Hanford Laboratories Operation	12,728	76.9
Construction Engineering & Utilities	46	.3
Miscellaneous	87	.5

Requests for emergency service remained at a higher than average level requiring an overtime rate of 5.2%. Total backlog decreased approximately 20% but the short range nature of the requests will require an increase in the level of the work assigned to subcontractors.

One machinist was added to the shop force and a requisition filed for one additional machinist. Requisitions were also filed for the replacement of a welder who resigned and for a stock and tool attendant who was promoted to an engineering assistant job.

Quotations offered in response to a request for bids on several major pieces of shop equipment were evaluated and recommendations furnished to the Purchasing Operation.

RADIOGRAPHIC TESTING OPERATION

A total of 3,293 tests were made of which 1,082 were radiographic (including x-ray and gamma-ray) and 2,211 were supplementary tests. Out of a total of 2,321 man-hours, 812 (35%) were in connection with radiographic tests, and 1,508 (65%) were used on supplementary tests. The supplementary test work included; autoclave, borescope, eddy current, penetrant (fluorescent O.D. and I.D.), surface treatment (alkaline cleaning, pickling, and vapor blasting), and ultrasonic (flaw detection, core integrity, bond testing, and thickness measurement.

The number of pieces handled this month totaled 3,242 items. The feet of material represented by these items amounted to 40,981 feet. Work on tubular components continues to account for a large percentage of the footage of material tested.

Work was done for 17 different organizational components representing most of the operating departments and service organizations. A total of 37 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 28 different occasions for advice and information on general testing theory and applications for other than the jobs tabulated in Part II - Testing Statistics.

Development work on the pickling of the NPR process tubes has been initiated using short lengths of tubing so that the existing autoclave installation can be used. Preliminary data using liquid ANN solutions appears to be satisfactory as a stop bath. Prior to this time the solutions were made up using crystal chemicals. Testing has been started on nine additional Harvey NPR process tubes received this month.

Field work is proceeding routinely with major effort involving pressure vessel survey work, process vessel fabrication, and PRTR site liaison. An order has been placed for the mobile laboratory truck chassis. Outfitting the laboratory will be completed by project forces.

Testing of fuel element sheath tubes is being extended to the examination of another zirconium alloy, Zr-4. The first lots of a 7,000 tube order have been received and testing has been started.

Testing Statistics

Component	No.of Tests	Ft.of Weld or Material	No.of Pieces	Description
CE&U	482	241	482	Film interpretation of radiographs taken by weld-X-Corp of California at PRTR.
CPD	46	63	1	Radiograph welds on H-4 vessel.
FPD	16	28	10	NPR Fuel Elements.

Testing Statistics (Cont'd.)

Component	No.of Tests	Ft.of Weld or Material	No.of Pieces	Description
HLO	2,015	36,479	2,588	UO_2 Pb pellet fuel element; Zr-2 clad UO_2 rods with T.C; s.s. clad UO_2 rods with T.C; Thermocouples; Zr-2 clad I and E fuel element; 0.680" I.D.; Zr-2 tube; 0.072" O.D.; Zr-2 wire; TPU unmachined rods; Radiograph development fuel rods; Plan fabrication and development program; Radiograph thermocouple leads for location in iron oxide; Radiograph welds on "Y" header; 0.033" wall x .505" I.D., s.s. tubes; 0.680" I.D., Zr-4 tubes; 1-1/4" O.D., s.s. tubes PRTR tubes; 0.505" I.D., Zr-2 burst samples; TPU fuel rods.
IPD	734	4,169	161	Radiograph welds on test bench pressure vessel; Radiograph flange welds for KAPL 12-Loop - 105-H Bldg.; NPR Zr tubes; NPR development; Ultrasonic thickness measurement; pressure vessel survey 100-F Area.
Total	3,293	40,981	3,242	

CONSTRUCTION OPERATION

There were 53 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $262,004. Fifty-three new orders, 7 supplements and adjustments for underruns amounted to $74,196. Expenditures during the month on HLO work were $182,769. Total J. A. Jones backlog at month's end was $153,431. Fifty-seven orders were closed out during the month.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	47	$ 212,998	6	$ 49,006
Issued during the month(Inc.Sup.& Adj.)	53	49,196	0	25,000
J.A. Jones Expenditures during month (Inc. C.O. Costs)		120,917		61,852
Balance at month's end	45	141,277	4	12,154
Orders closed during month	55	64,591*	2	51,071

* Face Value of Orders Closed

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All but one of the 17 major pieces of equipment are now in the 306 Building Addition (Project CA-744). Ten of these are ready for acceptance tests and/or vendor installation engineers. The electrical buses were energized on 4/11/60 and everything was ready for the installation engineer from the Bliss Company for the 700 ton press on May 3. J. A. Jones work is now at 56.60% complete on this project.

The lump sum sub-contractor to J. A. Jones has completed the plastering on the 2nd floor and the two concrete block walls on the 1st floor of the 308 Building (Project CA-747). The oxide hoods were set in rooms 208 and 210 by Jones forces and connection to the hood exhaust system is in progress. All motor control centers have been set and bus duct installation is 50% complete. Cryolite hood piping is complete and electrical about 85% complete.

FACILITIES ENGINEERING OPERATION

Projects

There were 17 authorized projects at month's end with total authorized funds of $6,358,765. The total estimated cost of these projects is $8,227,765. Two projects were completed and one new project was authorized during the month. One project proposal was submitted to the Commission.

The following summarizes the status of HLO project activity:

Number of authorized projects at month's end:	17
Number of new projects authorized during the month: CAH-888, Biology Laboratory Improvements	1
Projects completed during the month: CAH-848, Geological & Hydrological Wells, FY-1959 CGH-801, X-Ray Diffraction Cell, 327 Building (cancelled)	2
New project proposals submitted to AEC during month: CGH-896, Stress-Rupture Testing Facility	1
New projects awaiting AEC approval: CGH-832, Full Scale Physical Constants Testing Reactor CGH-874, Consolidation of Plutonium Metallurgy Facilities	2

The attached project report details the status of individual projects.

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals. The proposal work included the Field Servicing Center for Atmospheric Physics.

Title	Status
329 Building Cooling Problem	Part of the materials are available and field work was started.
Electric Hoist - Graphite Shop - 3730-C Building	Procurement was initiated for crane, hoist and rails.
Refrigerated Air Conditioning Room 130 - 146-FR Building	Procurement was initiated. Unit is scheduled for installation during May.
Pressure Vessel Study	This is a continuing work program involving vessels and systems and safety devices.
Coaxial Cable Between 325 and 329 Buildings	Field work has started.
Additional Improvements to Air Supply - Rooms 204 and 206 - 3706 Building	Filters are being procured.
Laboratory Furnace Installation Room 39-B, 326 Building	Engineering complete.
Alterations to Negative Ion Accelerator - 3745-A Building	Work review approval has been received. Design details have been submitted for estimate.
Glove Boxes - 325 Building	Engineering design is progressing.
Equipment for Critical Mass Studies	Procurement specification in preparation for proposed thermatrol drive. Detail design is about 25% complete.
Revision to Drain System - Truck Access - 325 Building	Design and cost estimate completed.
Study Potable and Process Water System - 325 and 329 Buildings	Work in progress.

Title	Status
Hot Water Tank - 108-F Building	The existing tank is being repaired for operation.
Fire Detection System - 314 Building	Field work to start during May.
Criticality Alarm - 300 Area	Field work to start during May.

Drafting and Design Services

Work load is constant with heavy backlog. Branch offices in 306 and 308 Buildings are busy with steady work loads. The central drafting room has been performing an increasing amount of work for the recycle program.

Major design and drafting work in progress includes the following:

1. PRTR Gas Loop - In-Reactor (17 drawings - 100% complete).
2. Break away Corrosion Loop (6 drawings - 50% complete).
3. Special Tools - Scope - High Level Utility Cell - 327 Building.
4. PRTR Fuel Element Rupture Facility - Scope.
5. PRP Critical Facility - Service piping, weir, shielding block, and safety rods. Work complete.
6. Loading Dock Enclosure - 321 Building (approximately 90% complete).
7. A, B, and G Hand and Shoe Counter - (approximately 16 drawings - 13 drawings completed).
8. Ultrasonic Test Tank - (8 drawings required - 30% complete).
9. Physical and Mechanical Properties Test Cell - 327 Building - Equipment Scope (6 work sheets completed).
10. Extrusion Tools for 700 Ton Press (8 drawings required - 6 drawings completed).
11. Hood design for pyro-chemical work (50% complete).
12. "In-Pile" Test Loop - "C" or "K" Reactor (12 drawings required - 65% complete).

In addition to the above work, miscellaneous small design-drafting jobs are in progress including Project CG-681 "As-Built" work.

Approximately 165 drawings including sketches, work sheets, and formal drawings were completed during the month of April.

Maintenance and Building Engineering - Landlord Functions

Costs:	February	- $ 152,204
	March	- $ 131,404
	Total through March	- $1,212,973

Analysis of Costs

At the beginning of this month, some of the funds were restored to the budget. This increased the total from $1,457,700 to $1,525,700. Using the new budget and the corresponding forecast, the expenditures to date are 79.5% of the budget, and 100.5% of the forecast to date.

Improvement Maintenance

Item	March	FY to March
Heating & Ventilation Correction	$ 4,038	$ 66,411
Relocation & Alteration	2,037	34,381
Paint	0	11,736
Electrical Improvements	- 698	1,342
Lighting	0	413
Crane Installation	0	24,910
Miscellaneous	397	2,174
Total	$ 5,774	$ 141,367

Miscellaneous

Approximately 20,500 square feet of prints were reproduced during the month.

The total estimated value of the 12 requisitions issued during the month was $5,000.

TECHNICAL INFORMATION OPERATION

Late last year HOO Security asked HAPO to institute new controls on the off-site distribution of classified, non-categorized, informal reports prepared primarily for internal HAPO use, but which receive some limited off-site distribution. These controls required that every non-categorized classified document intended for off-site distribution be cleared through the AEC and a special mailing address be used. A suggestion has been forwarded to the HAPO Specialist, Security Practices and Procedures, that the whole problem be again reviewed with HOO Security in an attempt to abolish the new procedure which appears in some instances to provide less security control than the procedure used by HAPO for many years and certainly introduces delays in the release of information.

Revisions to the "Proposed Guide to Atomic Weapon Data at Hanford", HW-63726, were recommended by HOO. The recommended revisions were reviewed and the HAPO views were forwarded to HOO. At month's end a meeting of HAPO and HOO personnel was scheduled for the purpose of reconciling differences of interpretation of certain of the topics proposed in HW-63726.

All currently available NPR classification guidance was compiled into a single document, HW-64809, and distributed to the field.

Authorization was obtained to proceed with the design and installation of the PRP Critical Facility on an unclassified basis. However, a decision on classification of "operation" of the facility was withheld pending the outcome of current AEC studies of plutonium classification.

Topics covering the NPR were incorporated in the Hanford Classification Guide. Several other changes were also made in the guide to bring it up-to-date. A total of seventy pages were revised.

Three Classification Information bulletins were distributed to HAPO personnel. The bulletins are entitled:

"NPR Fuel Elements"
"Tritium"
"Material for Unclassified Projects"

A memo was received from the AEC setting forth new criteria for the classification of plutonium. The intent apparently is to safeguard information on the isotopic content of production grade plutonium, but it is difficult to see how the instructions provided will do this. A memo covering the status of plutonium classification (HW-64799) was distributed to HAPO personnel having a direct interest in the problem. Unfortunately, it has not been possible yet to clarify the effect of the new criteria on certain unclassified programs at HAPO, e.g. PRTR.

In February Files announced that it would no longer send clerks to individual offices to clear and re-route the document holdings of employees who are terminating or transferring to a new assignment. As a result of some inquiries, we have agreed to provide assistance in terminations and transfer situations that cannot be handled in any other way.

Considerable time was spent during the month studying the possibility of automating the issuance and distribution of documents from Files. It appears that machine equipment is available which will permit simultaneous generation of File Record Cards, off-site receipts, the on-site routings, the index cards for use in the catalog, and copy for the Weekly List of Additions to The Files, and a number of other records.

Work Volume Statistics

	March	April
Document Distribution and Files		
Documents routed and discharged (copies)	14,969	18,297
Documents issued (copies)	12,127	10,054
Documents sent off-site (copies)	6,047	3,821
Document reserves filled (copies)	810	844
Documents picked up and delivered	19,775	19,470
Document Accountability		
Holders of classified documents whose files were inventoried	409	609
Documents inventoried in Files (copies)	19,500	11,777
Documents destroyed or retired (copies)	4,361	2,973
Documents revised (copies)	585	1,350
Documents pulled and documents filed (copies)	11,486	13,274
Documents reclassified	274	460
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	205,935	207,673

Reference and Publication	March	April
Books cataloged (new titles)	276	140
Books added to the collection (volumes)	276	259
Ready reference questions answered by professional staff	120	125
Literature searches by professional staff	76	95
Reports abstracted (titles)	327	302
Formal reports prepared (titles)	7	8
Off-site requests for HAPO reports (copies)	624	325
Reports released to CAP (titles)	27	31

Library Acquisitions and Circulation		
Books ordered (volumes)	371	292
Periodicals ordered	149	59
Books circulated (volumes)	2,038	2,082
Periodicals circulated (issues)	3,611	3,208
Inter-Library loans	69	82
Films borrowed or rented	39	32
Industrial film showings	89	93
Bound periodicals added to the collection	199 (Feb. & Mar.)	81

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	29,223	8,381	1,591	2,012	41,207
No. of bound periodicals	13,489	1	1,431	96	15,017
	42,712	8,382	3,022	2,108	56,224

Classification and Declassification		
Documents, including drawings and photographs reviewed for downgrading or declassification	45	4
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	41	46
Documents submitted to Declassification Branch, Oak Ridge	13	6

J. L. Boyd

Manager
Laboratory Auxiliaries

1240303

JL Boyd:jw

UNCLASSIFIED

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64898
MONTH April, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED COMP. DATE
			AMOUNT / DATE	DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	DESIGN / CONST.	DESIGN / CONST.	DESIGN / CONST.
CG-731	Critical Mass Laboratory	$1,000,000	$1,000,000 / 3-23-59	100 / 100	82 / 84	5-22-58 / 6-4-59	- - - / 6-30-60	2-24-59 / 6-30-60

USING COMPONENT: Physics and Instruments, R & D

FEO ENGINEER: D. S. Jackson

REMARKS: The main instrument panels finally arrived on the job site on April 8, 1960, just 4-1/2 months later than the vendor's promised delivery date. The fixed price contractor is 98% complete. Work remaining on his contract consists of instrument and electrical wiring, performance of acceptance tests and cleaning up minor punch list items.

Installation of round ventilation exhaust ductwork (the cause of a jurisdictional dispute earlier) was performed by pipefitters during a period that the sheetmetal workers were not on the job site. The sheetmetal workers are back on the job and no further difficulty is anticipated over this work.

A work order was issued to J. A. Jones Const. Company for installation of glove ports and other hood work. The vendor fabricating the reactor control system has indicated inability to deliver this equipment until late in June. This will necessitate completion of the reactor assembly installation work after the project completion date or an extension of the

USING COMPONENT

FEO ENGINEER

REMARKS:
directive completion date. Originally this phase of the work was scheduled to be performed during start up of the facility by G.E. Plant Forces.

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-[illegible]-60

USING COMPONENT: Reactor & Fuels, R & D

FEO ENGINEER: J. T. Lloyd

REMARKS: The fixed price contract for the building and services is scheduled for completion by May 6, 1960, however, the actual completion is expected to take six weeks longer. The chemical processing contractor will receive the first shipment of tanks about May 2, 1960. Equipment installation by the J. A. Jones Company is progressing satisfactorilly except that percentage completion is laging percent funds expended by about 20%.

*Total Project 72%; Jensen-Rasmussen 95%; J. A. Jones 50%; Frank Lohse 50%
**Total Project 72%; Jensen-Rasmussen 95%; J. A. Jones 55%; Frank Lohse 30%

AM-7300-019 (5-58)

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MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64898
MONTH April, 1960

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

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-790	High Level Radioactive Receiving and Storage Addition - 327 Building	$ 349,000	$ 345,000 4-23-59	100 100	98 97	6-23-58 10-9-58	--- 6-1-60	12-31-58 6-1-60
		USING COMPONENT: Reactor and Fuels, R & D				FEO ENGINEER: J. J. Peterson		

REMARKS: Ran Acceptance Test Procedures on decontamination chamber and heating and ventilation equipment. Solenoid valves do not function on decontamination chamber. Heating and ventilation unit does not give the cooling efficiency expected across the cooling pads. CPFF forces painting new basin.

General Plant Projects - FY 1959

CAH-837	Animal Pens, Isolation and Examination Facilities	$ 80,000	$ 80,000 3-17-59	100 100	100 98	3-30-59 7-10-59	- - - 4-1-60	6-5-59 5-15-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS: The work authorized to Minor Construction by A.E.C. is about 85% complete. The mixing valve for steam injection has been on order for some time but has not been received. The parking lot work is nearly complete. The Animal Farm fencing removed by construction forces will be installed at new locations for complete area enclosure. This work will be under the direction of Facilities Engineering Operation.

CAH-848	Geological & Hydrological Wells - FY-1959	$ 56,600	$ 56,600 6-18-59	100 100	100 100	5-21-59 7-16-59	- - - 5-31-60	7-6-59 4-8-60
		USING COMPONENT: Chemical, R & D				FEO ENGINEER: H. E. Ralph		

REMARKS: Construction work was completed and accepted by the using agency April 8, 1960.

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UNCLASSIFIED

AM-7300-019 (5-58)

UNCLASSIFIED

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64898
MONTH April, 1960

BUDGET CLASSIFICATION: General Plant Projects - FY 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-819	Increased Laboratory Waste Facilities 300 Area	$ 193,765	$ 193,765* / 2-19-60	100 / 100	N.S. / 0	2-5-60** / 6-15-60	- - - / 5-31-61	5-1-60 / 3-1-61
		USING COMPONENT: Chemical, R & D				FEO ENGINEER: J. J. Peterson		

REMARKS: Drawings and specifications have been completed. Obtaining construction estimate from completed drawings.

*Includes transferred Capital Property valued at $10,765.
**Design started on revised scope.

CGH-860	Access for PRTR Fuel Elements - 327 Building	$ 81,000	$ 81,000 / 10-8-59	100 / 100	N.S. / 24	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: Fixed price contractor has poured footings and foundations walls, removed existing siding and erected temporary barrier between canyon and new addition. CPFF forces fabricating cask cart and placed order for filters.

CAH-864	Shielded Animal Monitoring Station - 100-F	$ 52,000	$ 52,000 / 4-18-60	100 / 100	0 / 0	10-22-59 / 5-5-60	- - - / 8-1-60	2-1-60 / 8-1-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS: Project CAH-864 and CAH-878 were awarded to George A. Grant Company as a combined contract. Notice of Award and Notice to Proceed dated April 20, 1960, was sent to George A. Grant Company.

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64898
MONTH April, 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-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 proposal has been held by A.E.C. since October 8, 1959.

* Months after authorization.

CGH-877	Pyrochemical Test Facility - 321-A Building	$ 70,000	$ 70,000 / 11-17-59	100 / 100	25 / 30	12-8-59 / 2-17-60	- - - / 9-30-60	4-17-60 / 9-30-60
		USING COMPONENT: Chemical, R & D				FEO ENGINEER: R. C. Ingersoll		

REMARKS:

Approved hood drawings were returned to S. Blickman Company 4-18-60. Hood delivery has been promised 6 weeks after receipt of approved drawings. A construction schedule was submitted to the Commission 4-7-60. All induction heating equipment has been received.

CAH-878	Additional Facilities for Isotope Study on Animals - 141-C Building Addition	$ 66,000	$ 66,000 / 4-18-60	N.S. / 100	N.S. / 0	12-7-59 / 5-5-60	- - - / 8-1-60	2-20-60 / 8-1-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS:

This was combined with CAH-864. The A.E.C. mailed the Notice of Award and Notice to Proceed to George A. Grant on April 20, 1960.

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UNCLASSIFIED

HW - 64898

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

MONTH April, 1960

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 60-a-1

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.
CAH-870	Facilities for Recovery of Radioactive Materials - 325-A Building	$ 486,000	$ 486,000 3-22-60	100 100	0 0	9-18-59 6-1-60	- - - 6-1-61	3-1-60 6-1-61

USING COMPONENT: Chemical R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS:

A bid package has been prepared and issued April 8, 1960. Bid opening will be May 10, 1960.

Installation for Support of Bio-Medical Research - 60-h-1

CAH-888	Biology Laboratory Improvements	$ 300,000	$ 30,000 4-18-60	N.S. -	N.S. -	5-15-60* -	- - - - - -	12-15-60* -

USING COMPONENT: Biology

FEO ENGINEER: J. T. Lloyd

REMARKS:

The project proposal requesting design funds was approved by Washington A.E.C. on April 18, 1960. Preparation of the Directive by A.E.C. is in progress.

*Based upon assumed directive date 5-1-60.

Improvements to Production and Supporting Facilities - 61-a-1

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:

The Project Proposal requesting preliminary engineering funds is still being reviewed by A.E.C.

UNCLASSIFIED

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64898
MONTH April, 1960

BUDGET CLASSIFICATION
General Plant Projects - FY 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 (Or Actual) DESIGN / CONST.
CAH-885	Geological & Hydrological Wells - FY 1960	$ 84,000	$ 69,000 2-5-60	100 100	0 0	2-15-60 6-1-60	- - - 11-15-60	4-1-60 2-15-61

USING COMPONENT: Chemical, R & D
FEO ENGINEER: H. E. Ralph

REMARKS:
Bids for construction work were opened 4-12-60 for Project CAH-885 and parts of Projects CGI-790 and CIC-843. One bid was received for $130,945 which was 79% above the fair cost estimate of $73,000. Contract will be readvertised with a bid opening set for May 3, 1960.

Project Proposal revision has been prepared requesting an increase in funds to $84,000 and an extension of Directive completion date to 2-15-61. These changes were necessitated by the unfavorable bid on the April 12, 1960 bid opening.

CGH-896	Stress - Rupture Testing Facility	$ 80,000*	$ None None	0 0	0 0	5-30-60** 11-1-60**	- - - - - -	7-1-60** 5-1-61**

USING COMPONENT: Reactor & Fuels, R & D
FEO ENGINEER: R. K. Waldman

REMARKS:
The Project Proposal was submitted to AEC - HOO April 25, 1960

*Includes Transferred Capital Property valued at $500.00
**Based on AEC authorization by May 15, 1960.

Improvements to Production and Supporting Facilities - 60-a-1								
CGH-866	Shielded Analytical Laboratory - 325 Building	$ 750,000	$ 10,000 8-12-59	0 0	0 0	9-5-59 4-1-61	- - - - - -	12-1-60 12-1-61

USING COMPONENT: Chemical R & D
FEO ENGINEER: R. W. Dascenzo

REMARKS: Approval has not been received from Washington, D.C. - AEC for design funds for this project. An information request was received April 29, 1960, from Washington AEC concerning the building size and other possible laboratory sites in the 325 Building.

UNCLASSIFIED

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64898
MONTH April, 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
			AMOUNT / DATE	DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	DESIGN / CONST.	DESIGN / CONST.	DESIGN / CONST.
CG-785	In-Reactor Studies Equipment - 105-KW Building	$ 320,000*	$ 276,000 12-8-58	100 99	1 1	1-5-59 3-22-60	- 12-31-60	6-1-60* 2-28-61*
		USING COMPONENT: Reactor & Fuels, R & D				FEO ENGINEER: H. Radow		

REMARKS: Field activity is progressing on the electrical work and the placing of curbs for the major instrumentation panel assemblies, which have been shipped. Placing of orders and co-ordinating of shop effort is also underway for the fabrication of the capsule removal facility.

It has been requested that the helium conservation modification be incorporated in the project. A Project Proposal revision is being prepared requesting authorization of the revised scope as well as additional funds indicated to be required in the cost-to-complete estimate.

*Estimated total cost and completion dates per cost-to-complete estimate and revised Project Proposal. Will pertain if revised scope and additional funds are authorized.

CGH-801	X-Ray Diffraction Cell	$ 9,000*	$ 9,000* 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 Physical Completion Notice was issued April 1, 1960. This project will no longer be reported upon.

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: The revised Project Proposal requesting additional time and funds has not been approved by local HOO - AEC. Mr. J. E. Travis of the AEC has requested additional information concerning the planning and programs for the 327 Building. Mr. Johnson furnished this information on April 15, 1960, by letter.

Washington Iron Works shop drawings for the cell structure were reviewed and returned with comments. Improvements in finishes in some locations were requested, which may require renegotiation of the purchase order.

UNCLASSIFIED

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64898

MONTH April, 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-834	Modifications and Additions to the High Pressure Heat Transfer Apparatus 189-D Building	$ 700,000	$ 700,000 4-8-59	100 99	93* 73*	4-20-59 4-22-59	- - - 10-15-60	5-15-60 10-15-60
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: H. Radow		

REMARKS: The steady state phase has been accepted with exceptions. Concrete for the outside cells has been poured and work on the transient piping is progressing. Other field activity is progressing at a reduced rate until receipt of the off-site fabricated vessels and other components.

*The revised Construction Progress Schedule, which reflects the weighted portion of the long delivery quick-acting valve order as well as increased man/day forecasts to complete the remaining phases of the job, has been submitted to the Commission.

CGH-857	Physical & Mechanical Properties Testing Cell - 327 Building	$ 500,000	$ 75,000 10-1-59	5* 5*	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: The General Manager has not approved the project proposal changing the scope of work on this project as yet, as he is awaiting AEC's review of the program for this building.

Vendors from Arcweld Manufacturing Company, manufacturers of the creep furnaces and Richle Testing Equipment Company, participated in conferences this month concerning the design of their equipment.

Other vendors were contacted by Purchasing with replies requested by the end of the month.

*Equipment scope design, cell design not started.

CGH-858	High Level Utility Cell - 327 Building	$ 500,000	$ 70,000 10-1-59	12* 12*	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: Bruce Dixon, engineering designer, attended the Tool Design Show in Detroit this month, following up on design suggestions on the milling machine and lathe. Detail design is continuing on the milling machine.

The lathe is still undergoing preliminary engineering.

*Equipment design, cell design not started.

UNCLASSIFIED

AM-7300-019 (4-60)

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of April 30, 1960, the staff of Hanford Laboratories totalled 1304 employees, including 620 exempt and 684 nonexempt. There were 528 employees possessing technical degrees, including 313 B.S., 114 M.S. and 101 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for April was 1.68 as compared to 2.01 last month. There were 3 security violations during the month, bringing the total for the year to date to 9.

An employee of Plutonium Metallurgy Operation sustained a puncture wound from a Plutonium sliver. The contaminating source was removed and he was held for a 24-hour observation at Kadlec Hospital.

The revised 300 Area Emergency Plan was issued to all exempt personnel and a phamphlet concerning the plan was issued to every employee in the 300 Area.

PROFESSIONAL PLACEMENT

Three offers were extended to Ph.D. candidates, and 1 offer was accepted by a Ph.D. pharmacologist. At month's end there were 4 open offers, including 2 to ceramic engineers, 1 to a statistician, and 1 to a metallurgist. Recruiting at the American Physical Society Meeting has developed several Ph.D. Physics candidates who will be invited to visit Richland for interviews.

Recruiting for the Technical Graduate Program will be completed during early May. There are currently 74 acceptances for program assignments, including 16 electrical engineers, 25 mechanical engineers, and 10 physicists.

Four Technical Graduates were added to the program, and 12 accepted permanent assignments during April. At month's end there were 39 Technical Graduates, including 10 employees of the Engineering and Science Program assigned to program rolls.

TRAINING

Two courses in Applied Creativity were continued during April, and 1 class was initiated in "Business Operations in our Changing Environment."

COMMUNICATIONS

Filming of the HLO portion of the television show on Jobs at Hanford was commenced late in the month. The show is scheduled for May 19 on KEPR TV.

COMPENSATION

The New Nonexempt Salary Plan was implemented during the month.

Manager
Professional Placement
and Relations Practices

TG Marshall:lmh

1240313

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Mar.	April
Requisitions		
At end of month	11	28
Cancelled	2	1
Received	18	25
Filled	10	7

Nonexempt Transfer Requests	Mar.	April
Transfers		
Active cases at end of mo.	68	74
Cancelled	4	1
New	4	8
Effected	6	1

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to Date

	Cases Considered	Visits to Richland: Invited	Visited	To Visit	Offers*: Extended	Accepted	Open	On the Roll**
Ph.D.	610	141	40	24	20	7	4	4½
Exp. BS/MS	380	90	59	8	77	44	7	35
Prog. BS/MS	458	-	-	-	191	74	56	11

*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: Invited	Visited	To Visit	Offers*: Extended	Accepted	Open	On the Roll**
Ph.D.	610	141	40	24	17	6	4	3
Exp. BS/MS	249	35	20	2	15	9	-	8

*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, 15 exempt employees have transferred int HLO from other HAPO departments and 15 technical graduates have accepted off-Program placement in HLO to date.

C - Technical Graduate and Technician Training Program
Month ending April 30, 1960

	TG Program	TT Program
Number of Personnel on Assignment	39	5
(HAPO Tech Grad Program..... 29		
(Western District E. P. 10		
Distribution of Assignments by Departments		
HLO	17	1
CE&UO	2	0
FPD	1	0
IPD	15	4
CPD	3	0
C&AO	1	0
Distribution of Assignments by Function		
R&D or Engineering	30	5
Other	9	0

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FINANCIAL OPERATION MONTHLY REPORT
APRIL 1960

Personnel

Mr. A. J. Scott was transferred from Chemical Research and Development Operation to fill the position of Specialist - Measurements.

Activities

GENERAL ACCOUNTING

Statistics on the number of trips started in FY 1960 as compared with FY 1959, are shown below. The number started in the first six months of FY 1960 exceeded the year earlier period by 13%, however, during the last four months (January through April 1960) the number started has declined from the year earlier level. Totals for the first ten months of the two years are almost identical (1,044 to 1,048). Activity during May and June 1960, is expected to increase, but the total number of trips in FY 1960 will probably not vary significantly from FY 1959 experience.

	Number of Trips Started	
	FY 1959	FY 1960
July - December	527	605
January	104	95
February	96	100
March	153	88
April	164	160
	1 044	1 048
May	123	
June	218	
Total	1 385	

Expenditures for equipment in April were low since no large items were received during the month. Several larger items are scheduled for May delivery. This coupled with planned accruals at the end of May will reflect a substantial expenditure for the month. Expenditures and commitments at April 29, 1960 are shown below by Program.

Program	Commitments	Expenditures
2000	$830 810	$ 941 930
3000	18 323	30 586
4000	79 036	203 816
5000	24 240	12 658
6000	26 518	61 947
Totals	$978 927	$1 250 939

Total expenditures for FY 1960 are expected to exceed our present allocation by approximately $70,000. We have been assured by Contract and Accounting that funds will be available to cover the overrun.

Effective with April business, Property Accounting assumed the responsibility of determining taxability of purchase requisitions covering material being charged directly to Cost. Taxability will be indicated on the purchase requisition.

A recent memorandum issued by the AEC reclassified reactor grade graphite and niobium from special reactor materials to stores. The Property Management Manual will be revised to reflect this change in classification in the near future.

SS Material custodians were requested to submit their material forecasts for Diversions Inside Production Channels for the first and second quarters of FY 1961. In general, this means material in activities remaining within production channels but diverted from the normal flow or process streams either for development or for direct production use.

Reconciliation of the physical inventory of movable cataloged equipment in custody of Reactor and Fuels R&D continues. A listing showing unlocated items was submitted to the Manager, Reactor and Fuels with a request that the items be physically located or that a Missing Property Report be prepared. Included in the listing were items valued at $2,462 procured with Project Whitney funds.

The physical inventory count of movable cataloged equipment in the custody of Chemical R&D Operation is complete and the reconciliation is in progress.

Forty-two items valued at $16,291, were received at the Laboratory Equipment Pool during April. Three items valued at $448 were loaned in lieu of placement of requisitions and one item was withdrawn by the custodian. There are 233 items, valued at $108,000, currently located in the storage area.

Quarterly inventory reports for the quarter ending March 31, 1960 were received from all HLO custodians of "Other Special Materials". Reconciliation of the inventory reports with Financial records is in progress and upon completion a report of results will be issued.

Relocation of the badge house and fence at 100-F Area placed certain property which was formerly the responsibility of IPD outside the 100-F perimeter. Property valued at $31,996, identifiable with HLO, was transferred from IPD during the month. The transfer which consisted of paved areas, fences, underground sprinkler system, sewer lines and general land grading required establishing five new plant accounts within HLO to record the transfer.

COST ACCOUNTING

The Hanford Laboratories operating cost control budget for April reporting was adjusted as follows:

(Amounts in Thousands)	Adjustment	New Total
4000 Program		
Plutonium Recycle Program	$109	$ 5 579
GCR - Reactor Graphite (GETR irradiations)	(92)	328
Specific Fuel Cycle Analysis	(17)	78

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(Amounts in Thousands)	Adjustment	New Total
5000 Program		
Isotopic Analysis (Equipment Reduced $15,000)	$ 15	$ 636
6000 Program		
Biological Research	29	1 115
Biophysics Research	(12)	464
Instrumentation	(3)	129
Environmental Sciences (Equipment Reduced $2,000)	(12)	283
Charges to Other Departments	95	1 886
Transplutonic Elements (Fab. & R&D)	(226)	175
DMA - Pu 240 Elements	350	350
Special Materials Inventory	46	104
Total Hanford Laboratories	$282	$24 875

Information was received from HOO-AEC that a procurement directive in the amount of $11,300 is being issued by the San Francisco Operations Office to support the Fiscal Year 1960 portion of Hanford Laboratories' participation in this summer's Project Chariot. The procurement directive is expected locally within the next two weeks; personnel will depart for Alaska about May 20, 1960. A further authorization of $30,200 will be requested to support the costs of this work during the early months of Fiscal Year 1961. Total authorization will be $41,500 in support of incremental costs; full costs of participation are estimated at $100,000.

A new program code was established during the month for:

.25 DMA Elements Fabrication - 2000 Program Production

The quarterly report listing Hanford Laboratories planned expenditures of $5,000 or more for each item of material, off-site contract and prototype procured for Research and Development programs during the balance of Fiscal Year 1960 was prepared and transmitted to Contract and Accounting Operation. The totals reported for the 2000, 4000, and 6000 Programs were $138,000, $372,000, and $7,000, respectively.

At the request of the Manager - Radiation Protection, Fiscal Year 1959 operating costs at HAPO generated by radiation and safety activities were compiled for inclusion in the pre-print material for the Division of Production's submission during the forthcoming Joint Committee on Atomic Energy Hearings on Radiation Protection Standards.

New Time Distribution Report forms were designed for exempt and salaried employees of the work order servicing organizations, in order to provide cost-to-date information on Monday following the preceding work week which is several days earlier than under the preceding system. Reporting period is now Friday through Thursday and the new procedure eliminates using the back of the weekly time card for time distribution. Meetings were arranged with representatives of the participating

organizations to explain the details associated with this procedure. Effective date for the change-over was April 11, 1960.

Action as indicated occurred on the following projects during the month:

New Funds Authorized Hanford Laboratories

CAH-842	Critical Facility	$192 000
CAH-878	Additional Facilities for Isotope Study On Animals, 141-C Building Addition	(800)
CGH-888	Biology Laboratory Improvements	30 000

Physical Completion Notices Issued

CGH-801 X-Ray Diffraction Cell
CAH-827 Automatic Columbia River Monitoring Station

Construction Completion and Cost Closing Statements Issued

CAH-828 Central Storage Facility, 300 Area (AEM Services Only)
CGH-829 Building 325 Basement Improvements

Miscellaneous capital work order fund allocation was increased $3,000 for a new total of $138,000, by Contract Accounting during the month. Expenditure of all available funds has been authorized. Close liaison is being maintained with Facilities Engineering to assure maximum expenditures without exceeding the allocation.

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 300	618	682
Additions and Transfers in	18	10	8
Removals and Transfers out	14	8	6
Employees on Payroll at End of Month	1 304	620	684

Overtime Payments During Month	April	March
Exempt	$ 4 205	$ 4 291
Nonexempt	10 508	13 290
Total	$14 713	$17 581

Gross Payroll Paid During Month		
Exempt	$525 934	$530 566
Nonexempt	326 254	399 438
Total	$852 188	$930 004

Participation in Employee Benefit Plans at Month End	April Number	April Percent	March Number	March Percent
Pension Plan	1 155	99.5	1 136	99.5
Insurance Plan				
Personal Coverage	1 300	99.8	1 292	99.8
Dependent Coverage	926		926	
U.S. Savings Bonds				
Stock Bonus Plan	79	39.9	78	39.1
Savings Plan	91	7.0	89	6.8
Savings & Security Plan	1 021	88.0	1 025	88.7

Insurance Claims	April Number	April Amount	March Number	March Amount
Employee Benefits				
Life Insurance	0	$ 0	0	$ 0
Weekly Sickness & Accident	30	2 100	29	1 539
Comprehensive Medical	125	12 863	62	4 238
Dependent Benefits				
Comprehensive Medical	188	10 443	145	9 950
Total	343	$25 406	236	$15 727

Good Neighbor Fund	April	March
Number Participating	915	917
Percent Participating	70.2	70.5

W Sale
Manager - Finance

W Sale:bk

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INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to results in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

INVENTOR	TITLE OF INVENTION OR DISCOVERY
J. J. Hauth, R. J. Anicetti, W. E. Roake and D. W. Brite	High Density Ceramic Fuel Elements.
W. I. Steinkamp	Field of Resistance Projection Welding.
R. J. Sloat and J. Dunn	A Means for Reducing Bearing Wear in Canned Motor Pumps.
G. A. Nicholson, A. M. Platt and W. J. Carlson	A Continuous Countercurrent Liquid-Solids Contactor.
R. W. Stromatt and W. L. Lyon	A Means for Reducing the Oxygen Content of Non-Stoichiometric "Uranium Dioxide".
G. E. Benedict and W. L. Lyon	Methods for Separating Uranium and Plutonium and for Incorporating Plutonium in Uranium Dioxide.
R. T. Allemann	Process Technology: Elimination of Cracks and Preferential Fracture in Compressed Powder Pellets by Vibration (HW-64861).

P. P. Bupp
for H. M. Parker