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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
MARCH, 1960

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Compiled by
Operation Managers

April 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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1252662

	Page
Staff	iv
Force Report and Personnel Status Changes	v
General Summary	vi through xiii
Reactor and Fuels Research and Development Operation	A-1 through A-49
Physics and Instrument Research and Development Operation	B-1 through B-27
Chemical Research and Development Operation	C-1 through C-25
Biology Operation	D-1 through D-6
Operations Research and Synthesis Operation	E-1 through E-6
Programming	F-1 through F-4
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Invention Report	K-1

1252663

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE March 31, 1960

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	128	102	230	127	101	228	1	3	0	2
Reactor & Fuels Research & Development	194	169	363	195	171	366	0	1	1	3
Physics & Instrument Research & Development	66	35	101	67	34	101	0	1	1	0
Biology Operation	37	45	82	35	46	81	2*	0	0	1*
Operation Res. & Syn.	16	4	20	16	4	20	1	0	1	0
Radiation Protection	34	100	134	34	100	134	0	1	0	1
Laboratory Auxiliaries	53	189	242	53	191	244	0	2	0	4
Financial	13	13	27	14	13	27	0	0	1	0
Prof. Placmt. & R. P.	60	19	79	62	20	82	5	2	7	3
Programming	16	4	19	15	4	19	1	0	0	0
General	1	2	3	1	2	3	0	0	0	0
Totals	618	682	1300	619	686	1305	10	10	11	14
Totals excluding internal transfers.	618	683	1300	619	686	1305	8	3	10	6

* Includes one Nonexempt to exempt.

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BUDGETS AND COSTS

Costs for March were $2,072,000, an increase of $176,000 from February. Fiscal year-to-date costs are 69% of the amounts currently authorized to Hanford Laboratories. Research and Development programs sponsored by Hanford Laboratories have the following cost-budget relationship as of March 31:

(Dollars in Thousands)	Cost	Budget	% Spent
2000 Program	$ 394	$ 616	64
4000 Program	5 157	8 208	63
5000 Program	414	621	67
6000 Program	1 628	2 198	74
	$7 593	$11 643	65%

Program funds authorized to Hanford Laboratories for FY 1960 were increased by an additional authorization of $52,000 from Irradiation Processing Department for 2000 Program research and development.

Costs of HLO research and development for Hanford Product Departments are in line with amounts authorized.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels Research and Development

The PRTR Phase III construction contract is estimated to be 65% complete versus a scheduled 65% and the over-all PRTR project 82% versus 82%. The calandria and bottom shield have been delivered to the site for installation, and the fueling vehicle will be delivered by the end of March. The PRTR exhaust stack contract has been completed.

Difficulties encountered in mock-up testing of the PRTR mechanical seal pump have been traced to excessive mechanical and hydraulic vibrations. The pumps will be modified by the vendor.

Calculations disclosed that flow monitor response would not scram the reactor in time to prevent fuel element overheating in the event of a PRTR process tube leak within a certain size range located anywhere between the orifice and the top level of the fuel element. Revised instrumentation is planned.

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All of the PRTR Critical Test descriptions have been reviewed by the Startup Council, and review of startup Process Specification drafts was started. Writing of the Power Tests continued.

Only etching, wire wrapping, autoclaving, and assembly operations remain to complete the fabrication of thirty 19-rod PuAl clusters for the first PRTR loading. However, because of the poor quality of the Zr-2 tubing -- nearly 90% of the tubes have cracks deeper than 9 mils -- these elements will be used for critical testing only. Better quality tubing will be received in May, and new elements will be fabricated for power operation of the reactor.

The 72 UO_2 fuel elements needed for startup tests and operation of the PRTR were completed. One was made by the vibratory compaction process, the remainder by cold swaging. The over-all yield for 2,068 fuel rods fabricated by the swaging process between January 1, 1959 and February 1, 1960, was 70.8 per cent. Nearly one-half of these were swaged during the fourth quarter of CY-1959 with a yield of 80.2 per cent.

Mixtures of PuO_2 and UO_2 were found to sinter to high density in 74 hours at 1300-1500 C in contrast with decreases in sintered density with increasing PuO_2 concentration observed in one- and eight-hour sintering periods. Considerable plastic flow was found in pellets containing 40 w/o or more PuO_2 which were sintered for long periods.

PuO_2 formed from plutonium oxalate calcined at 500 C or higher is partially reduced to Pu_2O_3 when heated in hydrogen at 1500 C. PuO_2 formed from the oxalate calcined at 300 C or lower is not so reduced but remains as PuO_2.

Post-irradiation examination of a Zircaloy-2 clad, swaged UO_2 fuel rod purposely defected in-reactor revealed evidence of zirconium hydride formation, even though the specimen was irradiated only 90 minutes in 40 C water coolant. Concentration of the hydride in the Zircaloy-2 cladding increased uniformly from ~150 ppm at the 0.005-inch diameter hole to ~250 ppm at a 0.4-inch radius from the defect. Beyond this radius the hydride concentration was ~150 ppm.

Changes observed in the microstructure and electron diffraction patterns of UO_2 as a function of irradiation exposure and irradiation environment are found to be quite different from those in ThO_2 irradiated under identical conditions.

[redacted]

The irradiation of an in-reactor creep capsule containing an annealed Zr-2 specimen is in progress. Preliminary data obtained during the past month at a test temperature of 500 F (260 C) and a stress of 30,000 psi indicate that the creep rate of the in-reactor specimen is of the order of ten times that of a duplicate control specimen tested under the same conditions ex-reactor. Additional measurements are in progress.

The protection afforded by a ZrO_2 film against hydriding of Zircaloy-2 by dry hydrogen at 500 C appears to be destroyed by local breaks in the film caused by mechanical damage or by thermal cycling between 100 and 500 C.

Ten Zircaloy-2 tensile test samples cut from an irradiated KER tube ranged in ultimate strength from 108% to 75% of the unirradiated controls. Partial recrystallization of the originally 70% cold-worked grains had occurred in the two samples of lowest strength.

The ruptured rod from the third ETR rupture test of irradiated (2400 MWD/T) NPR fuel has been examined. The rod was swollen and the cladding split in several places. This specimen had caused high activity readings in the loop requiring shut-down of the reactor within 33 minutes after the defect was opened up. In contrast, the earlier, second rupture test had run for 14 hours after the defect cap was sheared off with no buildup of fission product activity in the loop.

An experimental study was reported in HW-64398, indicating the effects of enlarged outlet fittings on the thermal hydraulic characteristics of BDF type reactors. It was concluded that greater flows would result with the enlarged fittings and that adequate reactor safety would be ensured by using the present specification for outlet water temperature limits.

2. Chemical Research and Development

Process water quality, as affected by Purex plant demineralization treatment, was shown to be responsible for severe capacity reductions in both the old and new Purex plant 1 C columns.

Salt Cycle conditions have been established for the reproducible preparation of dendritic UO_2 deposits from which the UO_2 should

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be easily recoverable by remote handling methods. Some success has also been had in controlling the behavior of plutonium in the Salt Cycle system. A dry hydrogen chloride-chlorine sparge of the electrolytic cell during UO_2 deposition prevents plutonium from co-depositing with the uranium. An air sparge, following the HCl-Cl_2 treatment, permits the deposition of the mixed plutonium-uranium dioxide product.

Calcination of composited Purex coating waste and Purex IWW waste in the radiant heat spray calciner appears attractive. The powder product is readily reduced to a glass upon the addition of 40 per cent boric acid and heating to 850 C.

Initial pilot testing started on decontamination of Purex tank farm condensates by passing the actual plant samples through a bed of clinoptilolite. The initial cesium decontamination factor was 900 with the effluent concentration for this isotope well below the MPC value.

Experiments with samples of clinoptilolite irradiated with a Co^{60} source indicated no significant change in the equilibrium distribution coefficient for cesium from solution contacting this mineral after it had been subjected to irradiation doses up to 2.9×10^8R.

3. Physics and Instrument Research and Development

In the NPR program, fabrication of the full-scale mockup of the fuel failure monitor is under way, and development of the building radiation monitoring instruments is on schedule. An infrared radiation pyrometer for possible use for graphite temperature measurements was successfully demonstrated at the development stage. Confirmatory data were obtained on the physics parameters of the lattice but complete information in this area will require development of new techniques and work on these is in progress.

In the nuclear safety program, experiments continued to determine quantities of boric acid needed to prevent criticality in dissolving enriched uranium under various conditions. Assurance that present procedures for storage of natural uranium are safe from a nuclear standpoint was obtained from experiments which agreed with earlier ones at other sites.

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In the Plutonium Recycle Program, experiments continued to determine reactivity of lattices of Pu-Al rods in ordinary water. These data will be useful both in the technology of recycle in light water reactors and for nuclear safety in processing and storage of plutonium fuels outside of reactors.

In the Nondestructive Testing Program work was initiated on a combined ultrasonic and eddy current method for improved determination of clad thickness and air-gap thickness in unbonded fuel elements. Work also continued on the infrared method of thermal bond testing.

In the atmospheric physics program, field experiments designed to determine dispersive capacity under certain conditions of unstable vertical temperature gradients were initiated and two such experiments were completed.

In the area of basic reactor physics, developments in the methods of treating neutron thermalization in a lattice cell moved closer to a significant solution of the problem in such a cell when the components are at different temperatures; investigation of computation methods currently used in the industry to study reactor power stability revealed that under some conditions they may give misleadingly reassuring results; utility of all reactor computer codes will be increased by the library of cross section information whose storage on magnetic tape was completed during the month; and information was obtained experimentally on the fission properties of certain isotopes which appear in long exposure fuels.

4. Biology

A new chelating agent from Geigy Chemical, RA-491, increases fecal excretion of Pu. Since DTPA increases urinary excretion, the possibility of an effective combination of the two is suggested.

In studies with rats, pulmonary deposition of aerosols was noted to be higher at slow breathing rates. This suggests that radiation workers run, not walk, from sites of accidental release of radioactive particles.

5. Programming

An analysis indicates that benefits may accrue to irradiation of plutonium enriched fuel elements in reactors with several discrete

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zones of fuel-moderator ratios. As irradiation proceeds, the fuel elements would be moved batch-wise to zones with increasing moderator to fuel ratios. Such a fuel shuffling sequence leads to increased fuel exposures (as limited by reactivity considerations).

TECHNICAL AND OTHER SERVICES

The analysis of data from an experiment designed to evaluate the effects on porosity and can wall thickness of canning bath temperature, vibration frequency, and time of vibration was completed.

The mathematical model for the reliability of NPR safety circuits with respect to unscheduled outages has been completed. The programming of this model and the computation of results are under way.

The applicability and technical feasibility of applying recommended sample audit procedures to the verification of spare parts and stand-by inventory were determined.

There were no new cases of plutonium deposition confirmed during March. The total number of deposition cases that have occurred at HAPO is 249 of which 180 are currently employed.

No Columnaris infections were found in fish caught in local portions of the Columbia River. Toxicity caused by the microorganism might be related to the presence of flagellae. Apparently this observation has not been reported elsewhere.

There are 30 currently active HLO projects having combined authorized funds in the amount of $23,537,000. The total estimated cost of these projects is $29,651,000. All but 8 of the authorized projects are on or ahead of schedule. Of the 8 only 2 are more than 3 per cent behind schedule; these are CGH-790 - "High Level Radioactive Receiving and Storage Addition - 327 Building", and CAH-827 - "Pressurized Gas Cooled Loop". It is expected that all fully authorized projects will be completed on schedule and within the authorized funds.

There were 30 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $344,409. Fifty-two new orders, 2 supplements and adjustments for underruns amounted to $74,343. Expenditures during the month on HLO work were $156,748 (includes C.O. Cost). Total J. A. Jones backlog at month's end was $262,004. Twenty-nine orders were closed out during the month.

The 1959 annual inventory of Research and Development reports was completed March 25 with the following results: 9,980 accountable copies; 28 copies outstanding from previous years; 2 copies outstanding this year; or a total of 30 copies outstanding. The official results will be reported to GE Security by month's end.

SUPPORTING FUNCTIONS

Proposals for Research and Development (Form 189) for the FY 1962 Budget were submitted during the month to Contract and Accounting. There were 66 proposals consisting of 335 pages.

A special request in the amount of $10,000 was received during March to fabricate plutonium test samples for the Bettis Plant.

There are presently 191 items, valued at $91,850, currently located in the Laboratory Equipment Pool.

Dr. Joseph Kaplan, eminent geophysicist, and professor of physics at UCLA spoke on Highlights of the IGY at a very successful Hanford Science Colloquium on March 22.

Negotiations were completed and instruction began on a new graduate level course, N. E. 501, Nuclear Reactor Theory Laboratory. This is the first complete laboratory course for college credit to be given using the facilities of Hanford Laboratories. Nine students are enrolled.

As of March 31, 1960, the staff of Hanford Laboratories totalled 1300 employees, including 618 exempt and 682 nonexempt. There were 528 employees possessing technical degrees, including 312 B.S., 115 M.S., and 101 Ph.D..

The medical treatment frequency for March was 2.01 as compared with 1.44 last month. There were two security violations during the month, bringing the total for the year to date to 6 as compared with 14 during the same period in 1959.

An employee of the Radiographic Testing Operation sustained a severe medical treatment injury to his hand on March 2nd.

Thirteen Ph.D. candidates visited Richland for interviews during March. Three offers were extended to Ph.D. candidates, and there are currently four offers open. Follow-up visits were conducted with Chemistry and Chemical Engineering candidates at the University of Washington.

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All campus visitations are completed for 1959-60 recruiting of BS/MS graduates. Follow-up visits were conducted at Oregon State, Washington and Montana State during March. One hundred seventy-five offers have been extended, with 31 acceptances received by month's end, and 128 offers continuing open.

Four Technical Graduates were added to the program rolls, and 8 accepted permanent assignments during March. Two Technician Trainees were dropped for failure to maintain a "C" average and transferred to more suitable employment.

An additional class in Applied Creativity was started to accommodate the number of semi-technical personnel who have expressed an interest in taking the course.

There were 10 nonexempt vacancies filled during the month. With the receipt of 18 new requisitions and 2 cancellations, there are currently 11 openings for which 6 candidates are in process, 2 transfers pending, and 3 yet to be procured.

Final preparations were made to implement the New Nonexempt Salary Plan which will become effective April 11th.

F. W. Albaugh

for Manager
Hanford Laboratories

HM Parker:pmg

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REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Hydriding of Zircaloy-2. Significant concentrations of hydrogen will be formed in the NPR stack gas if water leaks into the stack and contacts the hot graphite, and even the normal steady-state concentration of hydrogen in the stack gas may be on the order of 0.1 percent. Consequently, the rate of hydriding of Zircaloy-2 by molecular hydrogen is being studied at conditions pertinent to the above. Temporary protection against hydriding (in dry hydrogen gas at 400 mm pressure and 500 C) is afforded by a good ZrO_2 autoclave film, with variable induction times ranging from about two hours to more than 30 hours. However, this induction time can be shortened and hydriding initiated if the ZrO_2 film is broken by any of several mechanisms, such as: (a) intentionally scratching the film, (b) bending the Zircaloy sample, or (c) thermal cycling the sample from 500 C to 100 C and back to 500 C. Although the presence of water vapor in the gas is effective in repairing defects in the protective ZrO_2 film (especially at lower temperatures such as 400 C), carbon monoxide is much less effective. Carbon dioxide is under investigation.

Scouting tests have been conducted to evaluate other coatings for the Zircaloy, including dip coats of aluminum, zinc, and lead, and copper plated by immersion plating. All of these failed more rapidly than the standard autoclave film.

In other hydriding mechanism studies, an autoclaved Zircaloy-2 wire with one end freshly cut to form a "window" for hydriding was exposed for 20 minutes to 520 C dry H_2 at 400 mm of Hg. Hydrogen analyses of one-quarter-inch segments of the wire showed the massive hydriding (5000 to 20,000 ppm H) to be confined to the first half inch. The massive hydriding was localized in the vicinity of the coating defect, with the hydrogen diffusing along the wire as a sharp front. Under conditions which favor rapid hydriding, it appears that high local hydrogen concentrations can build up in the metal at a film defect or scratch resulting in local embrittlement while the Zircaloy a few centimeters away is still ductile.

Mechanical Properties of ZrO_2 Autoclave Films. The relative abrasion resistance of ZrO_2 autoclave films formed by different surface pretreatments has been measured by Structural Materials Development, using a Tabor Abrasor machine. Vapor blasting the Zircaloy surface, rather than etching, prior to autoclaving, resulted in a heavier autoclave film and a 15-fold increase in the number of abrasor cycles before the autoclave film was worn through to the underlying metal.

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Copper Removal from Extruded Zircaloy Surfaces. A test was run to determine whether Zircaloy would pick up hydrogen during the removal of the copper coating with nitric acid. Several samples of extruded Zircaloy-2 rod covered with 10 mils of copper were stripped in different baths and metallographically inspected. None of the samples exhibited any signs of hydriding.

The types of stripping baths tested were 30% nitric acid, chromic-sulfuric acid, and an electrolytic bath using 5% nitric acid and making the sample anodic. Of these methods, the electrolytic bath exhibited much faster copper removal than the nitric acid, which in turn was faster than the chromic-sulfuric acid bath.

Etching Process for NPR Tubes. A continuous etching process is being developed for possible application to NPR process tubes. The normal sequence of etch, stop solution and rinses are pumped as slugs through an inclined rotating tube containing a short section of NPR process tube. Autoclaving tests of etched tube samples suggest that this handling technique permits some simplification in the etching process -- elimination of the stop bath, for example.

Reactor Decontamination. The galvanic currents between carbon and stainless steel surfaces immersed in a number of proprietary acid cleaning solutions are being measured in the laboratory as a function of oxygen concentration and reagent velocity past the metal surfaces. The lesser corrosion attack of Turco 4518 (oxalic acid type) correlates with generally lower measured galvanic currents.

Radiometallurgy Laboratory Studies

Ten irradiated specimens of Zr-2 process tubing (cold worked 70% during fabrication) were tensile tested at 300 C. Comparison with comparable unirradiated control samples shows that the samples with the highest induced radioactivity exhibited an 8% increase in ultimate strength, but all of the other irradiated samples ranged in ultimate strength from 75% to 97% of the control values. Metallographic examination of the two lowest ultimate tensile strength samples showed that partial recrystallization of the cold worked grains had taken place (RM-502).

Fifteen Zr-2 capsules were received after being irradiated under controlled temperature and pressure conditions for three months. Seven of the capsules had been ruptured. Examination of the intact specimens was begun (RM-551).

Visual examination of the third ETR ruptured fuel element showed swelling and several longitudinal splits starting one-half inch upstream and terminating one inch downstream from the defect. Only two small, loose pieces of uranium were found in the swollen part. Measurements of the rod and weights of the remaining parts showed that 53 grams of uranium were missing from the rod (RM-564). Metallographic examination of the second ETR ruptured fuel element was also continued (RM-558). Four

natural and four 1.732 a/o enriched uranium tensile specimens, which were irradiated in NaK-filled Zircaloy-2 cans with rotating capsules (GEH-14-1,2), were found to be broken into many pieces when examined. The remaining pieces were twisted, warped, and had a very porous surface (RM-504).

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

Basic Metallurgy Studies

Radiation Effects in Fissionable Materials. A turbo-mechanism has been developed that will rotate an irradiation capsule so that the enclosed specimens will receive a radially uniform exposure to the neutron flux. Two rotating capsules and one stationary capsule have been irradiated and were examined in Radiometallurgy during the month. The uranium contained in the capsules consisted of four flat tensile specimens having a thickness of 0.050 inch. The maximum calculated fuel temperature was 200 C, and NaK was used as a heat transfer medium. The irradiated specimens were removed and observed to be broken into several pieces. In addition, they exhibited rough surfaces and appreciable growth. The fractured surfaces and ends of the specimens appeared porous to the unaided eye, and some dimensional instability was observed. The principal difference in appearance between the specimens irradiated in the stationary and the rotating capsule was that the specimens in the former were broken into more pieces.

Radiation Effects in Structural Materials. A Zircaloy-2 tube which has been exposed to neutron radiation over a 25-month period was removed from the KER facility. This tube and an unirradiated control are being mechanically tested and metallographically examined to determine the effects of high neutron exposure at elevated temperatures on Zircaloy-2 and to establish testing methods for monitoring NPR tubing. During the month two specimens from each of five irradiated tube sections were tested in tension at 300 C. Two of the specimens exhibiting low strength and high ductility were examined metallographically and found to be partially recrystallized. Since recrystallization has been observed from specimens taken from three separate locations along the irradiated tube, it is likely that recrystallization occurred along the entire portion of the tube within the neutron flux. The unirradiated control specimens exhibited 300 C values of tensile strength and ductility of 58,500 psi and 4.3 percent compared to room temperature values of 96,000 psi and 7.0 percent. In addition to the lower ductility, the unirradiated specimens underwent less uniform deformation at the higher temperature. The highest exposure specimen exhibited the highest tensile strength at 300 C which amounted to 66,000 psi compared to 110,000 psi at room temperature. In most cases the total elongation of the irradiated specimens at 300 C was equal to or less than the room temperature value.

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Mechanical and Physical Properties of Materials. The creep properties of Zircaloy-2 are considerably improved by small amounts of residual cold work. The extent to which increasing amounts of cold work influence creep properties and the effects of recovery during testing are being determined on specimens cold worked in the range 15 to 45 percent. A series of tests at 400 C on the annealed and on the 25 and 45 percent cold worked material have been completed at stress levels from 18,000 to 21,000 psi. The results show a marked reduction in initial deformation and first stage creep by increasing the amount of cold work. The second stage rates, however, are higher for the 45 percent specimens than for the 25 percent specimens, but neither rate is as high as that for the annealed specimens at 400 C. The specimens were examined by x-ray diffraction after creep testing. The 45 percent cold worked Zircaloy-2 showed marked evidence of recovery. The 25 percent cold worked Zircaloy-2 showed considerably less evidence of recovery. It is thus apparent that recovery of the 45 percent cold worked material accounts for the observed higher second stage creep rate at this temperature. Activation energies were determined for the 25 and 45 percent cold worked tests after the second stage creep rates were firmly established. The temperature was increased in 25 C increments and each new creep rate was measured.

An activation energy for creep of 59.7 K cal/gm-mole was determined. The data for two 25 percent cold worked specimens and one 45 percent cold worked specimen displayed no differences in the activation energy. It is interesting to note that the activation energy appears to be independent of cold work level. The primary reason for determining the activation energy on this series of specimens was to provide a basis for tests on creep in-reactor. These rates, activation energies, and frequency factors will be used as a comparison between in-reactor tests and ex-reactor tests.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material after irradiation is a direct way of detecting radiation damage in these materials. Thin films or foils offer advantages, since radioactivity restrictions are a minimum. The preparation of thin films and foils suitable for electron microscopy is continuing. Irradiation and subsequent examination of foils of aluminum and films prepared by vacuum evaporation or sputtering is progressing.

Three micron diameter particles of uranium dioxide dispersed in thin evaporated films of aluminum have been irradiated in air filled and also in evacuated capsules to exposure of 2×10^{16}, 3×10^{17}, 3×10^{18}, 4×10^{19}, 4.4×10^{19} nvt (thermal). Similar irradiations have been performed on sputtered films of ZrO_2, containing polystyrene spheres and uranium dioxide evaporated at an angle of 15 degrees with the ZrO_2; on sputtered ZrO_2 films only; and on sputtered ThO_2.

Changes observed in the microstructure and electron diffraction patterns of uranium dioxide as a function of irradiation exposure and irradiation environment are entorely different from those in ThO_2 irradiated under

identical conditions. After an exposure of 4×10^{19} nvt (thermal), the diffraction pattern of uranium dioxide becomes diffuse, whereas no change in ThO_2 films occurs. In air filled capsules, uranium dioxide thin films revert to heterogeneous flocculent crystals, but in evacuated capsules the film reverts to dense rounded particles; no change in ThO_2 films other than the appearance of fission fragment trajectories occurs.

Thin films of carbon and ZrO_2 irradiated in close proximity to fissionable uranium and thorium atoms show fission fragment damage similar to that observed in UO_2 and ThO_2 thin films, namely fission fragment trajectories several microns in length and 150 Å in cross sectional diameters.

Zirconium oxide films formed by sputtering of zirconium yield an electron diffraction pattern unless they are heated to an elevated temperature in vacuum; the resultant films are cubic ZrO_2. Such amorphous films have been irradiated to exposures as high as 4.4×10^{19} nvt. After the highest exposure, the film shows crystallinity and a diffraction pattern which deviates somewhat from that of cubic ZrO_2 is obtained.

Cold worked aluminum foils irradiated to an exposure of 3×10^{17} nvt (thermal) have been studied in the electron microscope. Dislocation movements occurred. On a qualitative basis irradiation to the indicated level has not perturbed dislocation movements.

Metallic Fuel Development

Cluster Fuel Elements. The ruptured rod from the third ETR rupture test has been examined. Both the second and the third rupture test fuel elements were irradiated to 2400 MWD/T before charging into the ETR. The third rupture test was terminated by a reactor shutdown because of high activity readings in the loop 33 minutes after the defect was opened up, whereas the second rupture test ran for 14 hours after the defect cap was sheared off with no buildup of fission product activity in the loop. The rupture rod from the third test was swollen in the region of the defect so that it contacted the center rod and the two adjacent peripheral rods. The cladding was split in several places. An estimated 53 grams of uranium were converted to oxide and were either washed out when the cladding split open or were shaken out during the process of cutting the rod. Two pieces of metallic uranium remaining inside the cladding indicated that cracking of the fuel was involved in the failure mechanism.

The cluster element which ruptured in KER Loop 1 on February 8, 1960, has been sent to Radiometallurgy for examination. A visual examination, only, has been made to date. A scratch was seen to extend from one end of the split in the failed rod for about one inch along the rod surface. This scratch was filmed over, indicating that it had been there during irradiation and was not made during the discharge of the cluster or during subsequent handling.

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Tubular Fuel Elements. The tube and tube fuel elements for PT IP-300A have been completed and are ready for charging. Ten each of outer and inner tubes, 20 inches long, were autoclaved. One of the outers was rejected on the basis of a small white oxide stringer in the OD clad. All but two of the inner tubes, which were closed by hot heading and projection welding, exhibited a few white specks in the ID clad. One was sectioned longitudinally to obtain a better look at these spots. They are associated with minor galled areas and are probably caused by foreign material entrapped in folds caused by the galling. The corrosion is self-healing and no deeper than 0.002 inch. It is felt that this abnormality is innocuous, and it is recommended that the elements be charged.

Tube/tube metallic fuel elements are being tested in the Hanford KER loops. A charge of 18-inch long elements with coextruded Zircaloy-2 clad have reached 2000 MWD/T in KER-2. In this charge are two elements with unalloyed uranium cores and two elements with uranium - two percent zirconium cores. Power generation in these enriched elements is 130 kw/ft or 25 watts/gm. Coolant outlet temperature is 273 C. Goal exposure is 3500 MWD/T.

In addition to these four elements, two 18-inch long elements, one alloyed and one unalloyed, and a 36-inch long alloyed element are being irradiated in KER-4. The thermal conditions are similar to the Loop 2 charge. Exposure of the elements in KER-4 is now 1000 MWD/T.

An NPR size tubular element was completed for operation in the ETR 6x9 loop. This element is 18 inches long, Zircaloy-2 clad, and fitted with positioning spiders so that measurements can be made after each ETR cycle. The element will be removed from the irradiation basket after each cycle, photographed, measured, and reinstalled in a new basket. Maximum heat flux in the element will be 1,250,000 BTU/hr/ft^2 based on present estimates of ETR neutron flux. Maximum estimated core temperature will be 650 C.

A trial charge of ten KER tube-in-tube fuel elements was nondestructively tested. Techniques used were the Vectorscope test for ID and OD of both sizes of fuel tube, confirmed by borescope examination. The Vectorscope appears sensitive to small zones of porosity, surface roughness, embedded particles, or other conditions affecting the permeability or resistivity of the jacket metal. In addition to monitoring the cladding thickness, it is able to pinpoint the location of either internal or external defects. In most cases defects indicated by Vectorscope can be confirmed visually, externally by eye, internally by borescope.

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 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. The elements are prepared for closure and attachment of supports.

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Two Zircaloy-2 clad, coextruded I & E elements containing natural uranium have been assembled for MTR irradiation in the GEH-4 facility. The elements are 1.470-inch OD, 0.400-inch ID, 9-inch over-all length, with 0.100-inch thick end caps electron beam welded. The elements will operate at a calculated 95 kw/ft, 667,000 BTU/hr/ft^2 maximum heat flux, 430 C maximum uranium temperature, and approximately 100 C clad surface temperature. The goal exposure of the test will be 1000 MWD/T.

Tubular fuel element components for production test number IP-300A were autoclaved for 69 hours at 400 C and 1500 psig. Cleaning before autoclaving included vapor blasting, prior to installation of supports, followed by the standard etch as outlined in HW-60433. One and one-half mils of Zircaloy was removed during etching. The etching procedure was modified slightly in that the surfaces were hand brushed while in the aluminum nitrate stop bath. Resulting autoclave finish was quite good and only one outer tube had to be rejected because of white oxide formation.

Component Fabrication. A coextruded Zircaloy-2 clad uranium rod has been successfully stretch straightened. Prior to straightening, the rod was beta treated at 730 C for seven minutes and then air cooled. This treatment caused the rod to bow about six inches in the 72-inch length. Also, there was a slight reverse bend in the rod located about 15 inches in from one end that was there prior to heat treating. A tensile load of about 50,000 psi eliminated most of the six-inch bow but none of the reverse bend. A load of 30,000 psi at an over-all temperature of 200 C removed all of the six-inch bow, and a load of 30,000 psi with a localized temperature of 200 C at the reversed bend fully straightened the rod. Acceptable straightening may be accomplished by the application of heat and axial stresses. However, all sharp and/or reverse bends should be removed by roll straightening. The elevated temperature stretch straightening should remove the non-axial residual stresses induced by the roll straightening.

Different behavior by heat treated and as-extruded KER inner tubing during expanding by draw sizing indicates that further examination of this material is necessary. It is not known why the uranium in the KER inner tube in the as-extruded condition cracks more readily than similar material that has been beta heat treated. Rod sizing has shown that uranium in 0.617-inch diameter coextruded rod is more resistant to cracking during draw sizing in the as-extruded form than that which has had a beta heat treatment. One explanation is that the direction of maximum ductility is parallel to the extrusion axis. The maximum tensile stress during rod sizing is parallel to the extrusion axis. The maximum tensile stress during tube expanding is normal to the extrusion axis. The other possibility is intergranular cracking which may occur during the extrusion of KER inner tutular material, and the possibility that intergranular cracking if present may be healed by beta heat treatment. Examination is now in progress of the fracture zones in the KER inner as-extruded material to determine if there is any evidence of intergranular cracking.

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In the testing of fuel elements it is desirable to be able to cause an element to fail at will. This has been done by shearing a fixture previously welded over a defect on the side of the element. These fixtures have been welded by electron beam vacuum welding, but this is a slow and difficult process and the rejection rate is high. A method of resistance projection welding is being developed which should be fast, economical and highly reproducible. It consists of a pre-placed ring projection inserted between the fixture and the element then welded.

Closure and Joining. Work has continued on the vacuum braze closure of tubular fuel elements using a 95 w/o Zr, 5 w/o Be brazing alloy. A six-element charge has been prepared for flow testing in the Elmo loops. An effort is being made to reduce both the time and temperature of the brazing cycle. Using a ternary 85 w/o Zr-10 w/o Fe-5 w/o Be alloy between the cap and the uranium, with regular 95 w/o Zr-5 w/o Be alloy on top of the cap, has been effective in reducing the brazing cycle to one minute at 1050 C. A more homogeneous ternary braze alloy may reduce this time even further. The additional iron in the ternary alloy causes a more rapid diffusion reaction between the uranium and braze alloy. A literature search is underway to determine which braze alloys have been investigated and the relative corrosion resistance of each. As this information is rather scarce, a parallel effort is being made in a selective search for low melting alloys which possess good nuclear and corrosion resistance properties. A series of test coupons will be made to investigate the braze quality on three points:

1. Room temperature strength of the Zircaloy to uranium bond;
2. Room temperature strength of the Zircaloy to Zircaloy bond; and
3. Corrosion rate in 300 C process water.

A projection welded end closure is being developed for tubular fuel elements. The welding for this is being done at Sciaky Bros., Los Angeles Research Division. A production test lot of KER inner size elements have been closed by this method. Metallographic examination indicates that true double closure exists with two ring welds approximately 0.040-inch wide separated by an unbonded area about 0.025 inch wide on either side of the uranium ring which is about 0.045 inch wide. The unbonded areas are separated from the cap a maximum of 0.005 inch.

Allied Fuel Studies. Ex-reactor tests show that Zircaloy-2 supports on full sized 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. As a bearing surface for the fuel element support, Sheffield steel, a low Cr-Mo alloy steel, shows the best results of several metals and ceramics tested. A simulated Zircaloy-2 fuel element support flame sprayed with a layer of the Sheffield steel, showed excellent wear performance against an autoclaved Zircaloy-2 surface. This test demonstrated the feasibility of the method of attachment to the fuel element support. Samples of the Sheffield steel wear tested

after they were autoclaved in 300 C water show as good or better performance than the samples tested with an oxide free surface. From autoclave tests made in 300 C water, corrosion compatibility of Zircaloy-2 and Sheffield steel in intimate contact appears to be good. Further wear tests will be made on other metals for the bearing surface. Also, wear tests will be conducted on Zircaloy-2 surfaces autoclaved under conditions that have been demonstrated to improve the abrasion resistance of the Zircaloy-2 film.

In-reactor swelling experiments of Zircaloy clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposures are being conducted. Four swelling capsules, GEH-14-97, 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, 2400, 1600, 1800, 2300 MWD/T, and 675, 275, 310 C, 335 C. Goal exposures to as high as 5000 MWD/T have been established.

Additional autoclave defect tests of coextruded fuel rods with different metallographic ratings of the bond have been made. The tests show that material of numerical rating 6 (good -) corrodes slowly with little distortion and that material of numerical rating 2 (poor -) corrodes rapidly with severe distortion. These results are in agreement with previous tests made on numerical rating 8 (good +) and numerical rating 1 (very poor).

Autoclave defect tests have been made on coextruded fuel materials which have been processed through simulated end closure brazing temperature cycles. A brazing temperature of 1050 C and brazing time of one minute weakens the bond of coextruded ingot uranium (300-700 ppm C). The bond of coextruded dingot uranium (30 ppm C) is not affected by the same braze cycle. The weakening on the bond of coextruded ingot uranium may be caused by the formation of zirconium carbide in the bond at the high brazing temperature.

KER size outer tubes (ingot) with brazed end caps and braze-cycle heat-affected bonds have been autoclave defect tested. There is little evidence that bonding the end cap by this method improves defect behavior. The improved corrosion resistance provided by the bonded end cap is compensated for by the weakened coextruded bond of the clad. Similar comparative tests are also being made in an ex-reactor loop.

Assemblies of fuel specimens to be autoclave defect tested after irradiation have been fabricated, tested, and shipped to the 100-K reactor area. Scheduling of the loading and irradiation of these assemblies by IPD in a KER loop facility is in progress.

The fifteen Zircaloy-2 burst capsules tested in 100-KE reactor at controlled temperature and internal gas pressure were discharged and inspected. A brief inspection was sufficient to show the specimens tested in-reactor were fully as ductile as controls tested ex-reactor. As reported previously, the in-reactor burst strength was lower than

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the burst strength of control specimens tested ex-reactor. This in-reactor strength was, however, higher than the tensile creep strength of rolled specimens tested ex-reactor. Since the in-reactor burst strength falls below ex-reactor burst strength but above ex-reactor tensile creep strength, designs based on tensile creep are still on the safe side.

Cyclic temperature constant load creep tests on uranium are in progress. The present test is operating between 150-450 C, with one temperature cycle per day, and at a stress of 500 psi. After eight cycles, ~ 0.4% strain occurred. Over the week-ends the specimen remains loaded and the temperature is held at 150 C. The specimen shrinks ~0.1% during these times, but strains sufficiently on the next cycle to more than regain its former length. Even though the load is low (500 psi), the uranium has strained sufficiently to cause deformations which could be limiting in certain types of reactor fuel elements (long self-supported horizontal elements or vertical elements subjected to buckling forces).

Design Analyses and Computations. The analytic method and numerical evaluation for determining the temperatures in the end caps of tubular or plate type elements are complete. Examples of Zircaloy end caps twice, once, and one-fifth as thick as the uranium fuel material were evaluated. For these cases, the central outer surface end cap temperatures are, respectively, 38, 68, and 95.5 percent of the total temperature drop of the fuel material above the coolant. Report HW-64161, describing the above analyses, is complete.

2. REACTOR PROGRAM

Coolant Systems Development

Evaluation of Fuel Elements for Present Reactors. Nickel plated fuel elements are being tested in process water at 120 C and 165 C. Examination of the elements after 12 weeks of exposure still indicated excellent corrosion resistance. The test at 80 C to evaluate galvanic corrosion was discontinued after 12 weeks of exposure. Visual inspection revealed no unusual corrosion at defected spots.

A test was started to evaluate two GERL aluminum "cermet" tubes. Three different rolling conditions of each alloy are being investigated. The alloys are being tested in process water at 120 C with a flow velocity of 21 feet per second past the coupons.

Decontamination of Present Reactors. A test in ELMO-6 indicated that carbonic acid would remove scale-containing Ca and Fe coupons. To determine the effect of carbonic acid on present reactor scale, a test was run in the Single Pass Facility at 242-B using an H Reactor pigtail. The CO_2 was ineffective, removing practically none of the radioactive crud. A solution of phosphoric acid (5%) and chromic acid (2%) employed with a once-through procedure on an H Reactor pigtail produced a very low over-all decontamination factor of about three.

NPR Decontamination Studies. A section of carbon steel piping from the KER Loop 1 was decontaminated with 10% Turco 4512 (inhibited phosphoric acid) using a single-pass technique. After 19 minutes, the activity was reduced essentially to zero.

For decontamination of the entire NPR system after a rupture, it appears that the best procedure is one using three steps: (a) peroxide-carbonate-bicarbonate, (b) alkaline permanganate, and (c) some inhibited acid. If UO_2 and fission products are not present in large amounts, the first step may be omitted. Several inhibited acids are being considered for step (c). During the past month comparative tests were made in the IRP (Irradiated Rupture Prototype) to determine the relative efficiencies of phosphoric acid, oxalic acid, and ammonium citrate. The phosphoric acid and ammonium citrate both effected good decontamination, and the sample surfaces appeared good with no excessive or localized corrosion. For the phosphoric acid, the decontamination factors were about 100 for carbon and stainless steel and 15 for Zircaloy, and corrosion of the carbon steel was about 0.12 mil. The ammonium citrate effected decontamination factors of about 100 for both the carbon and stainless steels and about 40 for Zircaloy; the quantitative corrosion data are not available as yet.

The results with oxalic acid are somewhat puzzling. The decontamination factors were lower, about 40, and the surfaces were not defilmed even after two hours.

Decontamination of ETR Rupture Loop. After the most recent rupture experiment in the ETR 3x3 Loop, the loop was decontaminated using a modification of the standard three-step APACE procedure. Immediately after the rupture, the loop was contaminated with fission products and UO_2, one portion of the loop reading approximately 80 R/hr. The loop was flushed with water to effect physical removal of the bulk of the UO_2. The flushing and the natural decay resulted in considerable lowering of the activity level. At the start of the chemical flushes, the highest reading was 600 mr/hr. The first step, the peroxide-carbonate-bicarbonate, was carried out as an initial 15-minute recirculation followed by a 30-minute recirculation with fresh solution. After rinsing, the alkaline permanganate solution was recirculated (Step 2). The loop was then rinsed again, and the final Step 3 solution containing ammonium citrate and ethylenediamine tetra-acetic acid was recirculated. The activity after the final rinse was very low, about five mr/hr, in all spots except one which read 35 mr/hr. The high reading at this one location was probably due to a high background. The entire decontamination took 40 hours but could be cut approximately in half with experience and improved facilities for disposal of the active solutions.

High Flow Rate Deionization. Several tests were performed to establish the feasibility and operating characteristics of high flow rate deionization systems. Results to date indicate that operations at high flow rates are feasible using filtered Columbia River water as the influent.

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A duplex ion exchange system (cation unit followed by an anion unit) has been tested at liquid flow rates of 25, 50, and 75 gpm/ft^2. In general, the effluent water quality has been quite good, usually ranging between 4×10^5 and 7×10^5 ohm/cm specific resistance. This compares favorably with an average distilled water specific resistance of approximately 3×10^5 ohm/cm. System lifetimes of 8.5, 4.2, and 2.1 hours were obtained at flow rates of 25, 50, and 75 gpm/ft^2, respectively. At 75 gpm/ft^2, anion leakage (predominantly silicic acid) caused premature breakthrough and accounted for some decreased lifetime.

Tests were conducted using a mixed bed (mixed cation and anion) exchange unit with artifically prepared solutions as the influent. With influent impurity concentrations of four and 12 ppm (NH_4Cl and Na_2SO_4) the system lifetimes obtained were 16.5 and 10.0 hours, respectively. The average effluent specific resistance values were 1×10^7 and 9×10^6 ohm/cm, respectively.

One test was run using duplex effluent water as the mixed bed influent. This test was discontinued after eight hours without exhausting the resin. The average specific resistance of the effluent was about 9×10^6 ohm/cm.

Fuel Element Rupture Testing. One programmed shutdown run was made using an NPR size coextruded uranium-Zircaloy-2 outer tube, in the isothermal beta heat treatment condition at 300 C, 1600 psi, and about 16 fps. The tube was defected with a 0.025-inch hole in the side of the tube. Following the first rupture indication from the hydrogen detector, the loop was cooled at the rate given for the NPR. The tube ruptured considerably more than the fast-cooled pieces. The rupture had completely filled the 120-mil annulus for an area about one inch by two inches.

Galvanic Corrosion Tests. A 304 stainless steel stress coupon holder containing Zr-2 stress-crevice coupons exhibited areas of galvanic attack on the stainless steel at the regions of contact between the two metals after three weeks exposure in CEP-4. This loop was operating at 300 C with pH 10 (LiOH), deionized water. Three weekly decontaminations with alkaline permanganate-sodium bisulfate had been made. The attack was three to five mils deep and about 1/16 inch wide around the 1/2 inch x 1/8 inch slots which holds the Zr-2 coupons.

Coupons of Zr-2 which are coupled to graphite by a tight mechanical joint have been charged into CEP-1 to determine whether a galvanic couple exists between these two materials during the alkaline permanganate-oxalic acid decontamination process. Graphite fuel supports are being considered to minimize galling between the NPR fuel elements and the process tubes.

Structural Materials Development

Burst Tests on KER Tubing. Three unirradiated samples of KER tubing, with about 70% cold work, were burst tested at 300 C. The primary purpose of these tests was to evaluate, at elevated temperature, the mechanical end

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closures designed for room temperature testing of irradiated tubing. The high pressure seal is made with a combination neoprene and copper gasket. It was found that the neoprene seals effectively at low temperature but chars completely at 300 C. By pressurizing the burst test assembly moderately before heating, the neoprene provides the initial seal and the soft copper part of the seal takes over when the temperature increases sufficiently to cause charring of the neoprene. The burst tests were successful, with data listed below. These tube samples are nearly equivalent in size and fabrication history to the Zr-2 tube now in KER Loop 1 and scheduled for removal soon.

Test No.	Temp., °C	Bursting Pressure, psi	Percent Elongation
1	300	8300	6.6
2	275	8350	5.8
3	300	8350	5.8

NPR Process Tubes. Allegheny Ludlum Steel Corp., Chase Brass & Copper Co., and Harvey Aluminum Company participated in a pre-bid conference with AEC and GE personnel. The purpose of the conference was to discuss specifications and purchase contract terms.

Pilot quantities of NPR pressure tubes from the above contractors have been inspected by Zyglo fluorescent penetrant dye and ultrasonics with test results as follows:

Test	No. of Tubes Tested	No. of Tubes With Indications
Ultrasonic (0.003" Scratch Standard)	19	11
" (0.005" " "	17	1
Fluorescent penetrant (outside)	18	13
" " (inside)	18	9
Weld Radiography	12	5

Each contractor was given the above information, plus detailed inspection reports covering only his own product.

Further testing showed that moderate surface conditioning to remove about 0.002 inch of metal would eliminate most defects, whereas removal of 0.005 inch eliminated all surface-defect indications.

Perhaps the most serious defect found in these tubes is porosity in the welds. Nothing can be done to remove this condition if it is found to exist. The x-ray images of the defects, except those found in the last two welds, have been measured with an optical comparator. All defects, with the possible exception of one, would pass the specification in effect at the time the tubes were fabricated. However, several of the defects would be rejectable under the latest revision of the specification. The vendor experiencing the most difficulty with his welds feels confident that recent improvements in his welding technique will minimize or eliminate this problem.

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Nothing in the present test results indicates any insurmountable obstacle for any of the vendors in providing NPR tubes that will meet current HAPO requirements.

Retubing Program. A total of 63 smooth-bore Zr-2 tubes for C Reactor have been delivered. Of the tubes yet to be delivered, 36 are awaiting final inspection and two are in the final processing steps. Two additional 100-tube orders have been placed for June 15 delivery.

Nonmetallic Materials Development

MTR Irradiations. The GEH-19 experiments contain eight graphite samples two each in four graphite holding cups. The four cups operate at different conditions of temperature and flux with the No. 4 position at the most extreme condition. During disassembly of GEH-19-3, No. 3 and No. 4 assemblies were not found, the carrier in the No. 2 position was corroded through from the bottom (heater) side, and the No. 1 position was intact and in good condition. Peripherally, the cup in Positions No. 1 and 2 did not appear seriously attacked. Three samples were recovered in all, but the sample from Position No. 2 is probably not measurable. Investigation into the cause of the graphite loss is continuing.

Fast Flux Monitoring. The results of Ni activation in 1573 DR, indicated that the integrated fast neutron flux per MWD/AT in an annulus tube facility is approximately one-half that in a cold test hole. No accurate absolute value can be reported since the fast flux spectrum in the annulus tube is not known. An estimate which is probably good to within 50 percent is 2×10^{16} nvt ($>$ 1 Mev)/(MWD/AT). Net thermal flux values were $1.34 \times 10^{17} \pm 0.02$ nvt/(MWD/AT) using Co activation, and the cobalt cadmium ratio was 13.0 ± 0.5, the indicated limits of error being the experimental deviations from the mean value. These improved fast flux values indicate that the temperature coefficient of the rate of radiation damage in graphite below 300 C is actually less than reported in HW-47776 and other Hanford documents presenting the work of annulus tube irradiations.

Flux Computations. Fast neutron flux calculations for C, K, and N Reactors have been completed using a multi-group, one-dimensional, diffusion type code. The results may be summarized as follows:

1. The ratio of the integrated fast flux/(MWD/AT) at K to that at C is 1.3.

2. The ratio of the integrated fast flux/(MWD/AT) in the NPR to that at K is 2.2.

3. The theoretically derived, absolute value for the integrated fast neutron flux/(MWD/AT) at the Y test hole in C is 4.6×10^{16} nvt ($>$1 Mev).

A document, HW-64393, is in preparation which will include the results of these calculations in greater detail.

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Conversion Factor for Y Test Hole, C Reactor. Since most of Hanford hot test hole data have been obtained at the Y test hole in C Reactor, an accurate knowledge of the fast flux in this facility is necessary to intercompare rates of damage in off-site irradiations with the old Hanford results. The final, best estimate for that conversion factor is 5.0×10^{16} nvt (>1 Mev)/(MWD/AT). This result was obtained using the shape of the fast flux spectrum from the computations cited above and a theoretically derived energy dependence of the activation cross section for the Ni-58 (n, p) Co-58 reaction.

Graphite Burnout Monitoring. Samples discharged January 25, 1960, from the center of channel 1960-C were highly pitted and showed a burnout rate of 35 percent per 1000 operating days. Emission spectroscopy analyses of scrappings of the pitted areas indicated the presence of trace-to-moderate amounts of iron, vanadium, and silicon, while gamma spectroscopy showed the presence of iron. The high concentration of impurities in the pitted areas was confirmed by auto-radiographs.

The catalytic effect of impurities on the graphite burnout rate has been demonstrated in the laboratory, where the burnout rate of treated samples (soaked overnight in 0.001 M solution of ferric chloride and vanadium sulfate) was three times greater than the control sample burnout rate of 3.8×10^{-3} gm/gm-hr at 600 C in dry air. The treated sample showed development of pitted areas, while the control sample was oxidized evenly.

Samples from 3066-KE were discharged on March 20, after thirteen months of exposure.

Thermal Hydraulic Studies

Heat Transfer Experiments Pertaining to Present Production Rear Fittings. HW-64398, "Hydraulic Demand Curves for BDF Geometry with Enlarged Outlet Fittings," was completed. This report presents steady-state hydraulic data under boiling conditions for an enlarged BDF outlet fitting assembly. The fitting used probably represents an upper limit in enlarged fittings of interest at the present time. This outlet assembly caused less process tube pressurization than present BDF fittings but more pressurization than K Reactor outlet assemblies. While no transient experiments were performed with this new assembly, previous experience with other geometries leads to the preliminary conclusion that use of the present specification for establishing outlet water temperature limits would lead to adequate reactor protection against inadvertent tube plugging.

Glass Heat Transfer Test Section. The test section using an electrically heated rod in a glass tube with annular cooling was modified to provide more precise adjustment of the tube with respect to the heater rod. The initial runs with the modified positioning table were taken at 50, 75, and 100 KW under concentric conditions. At the 50 KW level it had been necessary to increase the top annulus from the initial cold concentric position in order to get uniform water temperatures around the annulus. After this initial adjustment, the top annulus temperature was within 1 F of the

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bottom at 50 KW and about 2 F hotter at 100 KW. After running at 100 KW the power was returned to 50 KW to recheck temperatures. About three minutes after the power was reduced, a hot spot developed on the rod at 12-1/2 inches from the upstream end of the two-foot heated section. This bowed the rod and ruptured the glass tube. Investigation was started to determine why the unexpected hot spot had developed.

K Reactor Cross Tie Limit. The K Reactors are provided with a complex coolant cross tie system through which a reactor which has lost its coolant supply may be provided coolant from the other reactor of the pair. A problem of concern is the case where a BPA outage to both reactors is followed by the failure of the emergency electrical system of one of the reactors to pick up its load. In this case the emergency coolant from the aiding reactor is small, and the coolant supplied to the stricken reactor may be insufficient to prevent fuel element and process tube melting even though a power reduction is initiated almost immediately after the outage. It is desired to provide a reactor power level limit such that should the condition described above occur, adequate cooling of the stricken reactor be maintained at all times.

For a postulated case of any emergency shutdown of a K Reactor, the following may be said:

1. If flow and heat generation rates are such that bulk steam generation occurs for any length of time after the reactor is shut down, it is likely that excessive fuel element temperatures will result. One of the main factors contributing to excessive temperatures with bulk steam generation is the likelihood that most of the cooling water will pass through the lower tubes and leave the upper tubes deprived of coolant. However, a calculation of the certainty and the extent of any damage is very complicated, and the results are subject to considerable error.

2. The analysis of shutdown cooling conditions can be performed with considerable confidence if flow and heat generation rates are such that no bulk steam generation occurs after the reactor is shut down. For such cases, initial operating levels for the reactor can be accurately established to provide any degree of protection desired.

Effect of Bond Defects on Temperatures Within I & E Fuel Elements. The analytical investigation concerning the effects of a uranium-aluminum bond defect upon the temperature distribution within a typical Hanford I & E fuel element during irradiation was completed and reported in HW-64436. The calculations were restricted to the consideration of square defects ranging in size from 0.0625 to four square centimeters and specific powers ranging from 40 to 120 kilowatts per foot. The resulting temperature fields for defect conductance coefficients of 0, 6,000, and 10,000 BTU/hr, ft^2, ^{o}F were computed with the aid of an IBM 709 digital computer employing a conventional nodular analysis. Only

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the direct effects of a defect of bond were investigated, and no consideration was given to the simultaneous occurrences of incidental conditions such as eccentric or skew misalignment of the fuel element in the process tube and striation of the coolant.

The results show that without exception the maximum aluminum jacket temperature is attained at a point located immediately adjacent to the defect in a cross-section coincident with that of the geometric center of the defect. The minimum aluminum temperature always occurred immediately above the defect as was expected. The point of attainment of the maximum uranium temperature was found to be a strong function of the defect size and conduction coefficient. With defect sizes exceeding 0.6 cm^2 this maximum always occurred within the outer 0.025 to 0.100 inch of the uranium core on the radius through the center of the defect. Typical values obtained for maximum jacket temperature and maximum uranium temperature are 118 F and 880 F, respectively, for conditions of 80 KW/ft and 0 BTU/hr, ft^2, °F with a defect size of 2.25 cm^2.

The method used in this analysis yielded temperatures which were considerably below those of an earlier investigation (CP-1319). The reason for this can be attributed mainly to the fact that this earlier work considered only a solid cylindrical fuel element while the present considers the I & E element.

Laboratory Equipment. The first phase of the project to increase the flow and heat transfer capabilities of the 189-D high pressure heat transfer apparatus was completed. Modifications completed to date will allow completion of steady state heat transfer experiments for NPR while equipment to be installed during the remaining phase of the project will allow transient experiments to be performed.

Minor difficulties were experienced with the two new preheaters in that the heating elements displayed a low electrical resistance to ground. Following the manufacturer's suggestion that the insulation could pick up moisture during transportation, a partial electrical load was applied to dry out the heaters.

Shielding Studies

Neutron Attenuation Measurements. The following table summarizes the measured removal cross sections obtained recently in the Shield Facility.

Measured Fast Neutron Cross Sections (cm^{-1})

Bake Temp., °C	Ferrophosphorus (300 lb/ft^3)	Ordinary (150 lb/ft^3)	Iron-Serpentine (265 lb/ft^3)	Iron-Serpentine (210 lb/ft^3)
As Cured	0.131	0.0780	0.124	0.110
100	0.121	0.0735	0.113	
200	0.117	0.0724		
300	--	0.0702		
320	0.114			

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The 265 lb/ft^3 iron-serpentine concrete was placed in the shield facility for irradiation after being baked at 320 C. The 210 lb/ft^3 iron-serpentine concrete was removed from the shield facility and is being baked at 320 C.

The Argonne Laboratories have completed the assembly of the neutron recoil counter to be used in the shielding program. It is expected tc be used to evaluate several different resonance energy neutron fluxes at Hanford.

Gamma response calibrations up to 80,000 R/hr on nine aluminum shell ion chambers for use in the shielding program have been completed.

Design and Component Testing

NPR Charging Machine. Development of a quick disconnect magazine end cap has started. Two assemblies are being drawn prior to fabricating. Inquiry has been made into obtaining 54-foot long stainless steel tubes for the magazine.

B. WEAPONS - 3000 PROGRAM

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

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C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

PRTR Fuel Fabrication. Fabrication of the first thirty 19-rod Pu-Al clusters required for the initial spike enrichment loading of the PRTR is virtually complete with the exception of etching, wire wrapping, and autoclaving.

After swaging and straightening, the Zircaloy tubes were cut to length, counterbored, and the inside diameter was treated with emery to remove any burrs which interferred with loading. The tubes were then cleaned and first end caps were welded into 757 tubes.

Enough castings were made for 978 cores and from these a total of 859 cores were extruded. Of these, 797 were straightened, cut to length, and gauged. It was necessary to draw 282 of these cores to final dimensions for assembly into undersized tubes. Six hundred and thirty-four rods were assembled, welded, and leak checked. Allowing for a few extras, this is the number required to fabricate 30 elements. Eleven cores stuck part way in the tubes during assembly causing them to be rejected. Only two have stuck since a graphite lubricant has been used. Leaks were detected in four rods during the first helium leak check with three of the leaks due to stringers through the end caps and the leak in the other one not yet located.

Extensive effort has been expended in developing reliable standards for the ultrasonic testing of cladding integrity. Standards were made by using machined specimens with fabricated cracks and by using actual sections of tubing, which were related to metallographic measurements of defects giving similar ultrasonic indications. The results of this standardization indicate that the ultrasonic testing technique can detect a 10-mil defect in a 0.030 inch wall Zircaloy tube to an accuracy of about plus or minus one mil. It is on this basis, then, that 403 rods have been tested to date. Of those tested, 89% had ultrasonic indications nine mils deep or greater; 4% had cracks between five and nine mils; and only 7% did not have defects greater than five mils. These results had been predicted previously on the basis of a metallographic examination of the tubing. Because of the poor quality of tubing available for this fabrication, it has been decided to use these first thirty elements for critical testing only. Better quality tubing will become available in about May, and the elements will then either be recanned or refabricated for power operation of the reactor.

Considerable difficulty has been encountered with the water deionizer in the PFPP during the past month. The resulting lack of adequate deionized water for etching and autoclaving has delayed completion of the elements

by about three weeks and has created additional work because some of the rods have required sandblasting and re-etching. Poor etching results have been experienced, and the autoclaves have become contaminated with resin from the deionizer which decomposed when the vessels were heated. It was necessary to sandblast the inside surfaces of the two vessels to remove the contaminates. A large capacity deionizer is being purchased to remedy this problem.

Fabrication Development. A new mold is being designed for PRTR Al-Pu extrusion billets which will improve casting efficiency. With the new mold two billets will be poured simultaneously, but provisions in the design of the mold will allow for the interconnecting of several molds of the same basic design so that twelve billets may be cast simultaneously when there is sufficient melting capacity.

Crushable MgO swaging tubing, 1/2" OD, 1/8" ID, 3" long with the center hole filled with UO_2 powder as a stand-in for PuO_2 was swage reduced inside of Zr tubing to different diameters to determine compaction characteristics. This proposed technique has value as a self-shielded fuel of greater heat transfer surface. A 75% reduction sufficiently densified the oxides so that sectioning and sanding of the composite assembly did not dislodge any of the ceramics. When the ends were cut off of assemblies that were reduced 50%, the MgO and contained UO_2 crumbled and fell out of the sheathing.

Fuel Evaluation. Examination of the four-foot long Zircaloy clad Al-Pu 19-rod cluster which was irradiated to a burnout of 60 percent of the Pu atoms is continuing. As reported previously, the quick disconnect end caps were disengaged and the cluster was disassembled by means of manipulators in the hot cell. It was thought at first, that the tops of two end caps had broken, but a closer examination revealed that the quick disconnects on two of the rods had separated from the top end bracket. The helical wire wraps on the rods had loosened even though the stainless steel bands which held the cluster together were still tight. The loosening of the spacing wires was probably due to over-straining during attachment. No abrasion of the rods by the loose wires was observed since the protective black oxide coating was undamaged. Otherwise the banded cluster was straight and visually unchanged. Each of the 19 rods was examined for warpage, and it appears that all are warped to some extent but it was difficult to precisely determine the amount because of interference by the loose wires. However, the warpage, fully restrained in the banded cluster, varied from 1/16 to 1/4 of an inch over the 36-inch length of a single rod. The warp problem was probably aggravated by the fact that the diametral gap between the core and cladding was not closely controlled by the swage sizing technique and that 2000 psig (the operating pressure of the experiment) would collapse the cladding and promote interaction between the core and cladding.

A metallographic sample was taken from the center section of the center rod, one rod from the six-rod ring, and one rod from the 12-rod ring. They were also sectioned on the end to measure the amount of end gap.

It was found that all of the gap was at the top of the rods indicating that the cores were loose in the cans and had settled to the bottom. Measurements will now be made to determine if the amount of end gap has changed. Metallographic examination, density, and hardness determinations will be made on the core material.

Examination of the 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 currently in progress. The specimens contain 5, 10, 15, and 20 w/o Pu and were subjected to 0.1 a/o and 0.2 a/o burnout. Dimensional measurements on the dejacketed Al-Pu alloy fuel cores which had 0.1% burnout of total atoms were completed and are as follows:

GEH-14 No.	Fuel Alloy	Dimensional Changes on Fuel Cores*			
		Δ Diameter (in.)			
		Top	Bottom	Δ Length (in.)	Δ Volume (%)
8	Al-5 w/o Pu	0.0028	0.0027	0.0113	2.7 - 2.8
5	Al-10 w/o Pu	0.0006	0.0025	0.0116	1.1 - 2.6
9	Al-15 w/o Pu	0.0006	0.0016	0.0090	0.9 - 1.7
10	Al-20 w/o Pu	0.0025	0.0036	0.0112	2.5 - 3.4

*Fuel cores are about 0.5 inch diameter by 1.98 inches long.

The examination of the 24 irradiated UO_2-PuO_2 capsules was restricted during the month to dimensional measurements only and photographs of the clad specimens. As soon as the fission gas collection equipment is operating and available, the specimens will be punctured. After this step is completed, the other planned examination work may proceed.

UO_2 Fuel Development

PRTR Fuel Elements. The 72 UO_2 fuel elements needed for startup tests and operation of the PRTR were completed. Fifty-six are Class I elements for full power operation, while 11 are Class II for criticality tests and spares. The other five are Class III elements which will be used for zero power design tests only. One of the Class I elements was made by the vibratory compaction process, the remainder by cold swaging.

The over-all yield for fuel elements fabricated by the swaging process was 70.8 percent. A total of 2068 rods were swaged between January 1, 1959 and February 1, 1960. Nearly one-half of these were swaged during the fourth quarter of CY-1959 and resulted in the highest yield, 80.2 percent. Principal causes of rejection were swaging marks detected, and defects such as internal cracks in the Zircaloy cladding.

With completion of the swaged fuel elements for the PRTR, program emphasis has been gradually shifted to research and development studies of other fuels. For example, the vibrational compaction process is being applied to fuel assemblies of the rod bundle and nested tubular types. Modifications are being made to hot swaging equipment to permit either induction

1252694

or resistance heating, and fuel capsules and prototype elements are being prepared for a variety of irradiation experiments.

Fabrication Development. The first PRTR 19-rod cluster fuel element fabricated by vibrational compaction was completed. The individual fuel rods consist of fused UO_2 compacted in Zircaloy-2 tubes, 0.563-inch OD x 0.030-inch wall thickness x 89-1/2 inches long. The particle size distribution of the fused UO_2 was:

Size Mesh	Weight Percent
(-6) (+10)	60
(-35) (+65)	15
(-200)	25

The UO_2 compacted to 89 percent of the theoretical UO_2 density. Vibrational compaction of electrolytically reduced UO_2 obtained via the Chemical Research and Development Operation's salt cycle process, is also being investigated.

Initial operation of the "Magnetic-Force" Resistance Butt Welder at the vendor's plant was observed. A minor equipment design change will cause a two-week delay in delivery of the machine. The general arrangement of the equipment will allow very effective fuel rod closure procedures. The fuel rods may be evacuated and backfilled prior to closure with any desired gas atmosphere. The vacuum or inert gas atmosphere, normally used to protect Zircaloy during welding is not required with this equipment.

The Thermatool rib welder was installed. Initial operation revealed several problems which must be resolved to produce adequately strong, corrosion resistant welds between Zircaloy ribs and tubing. Techniques are being developed to continuously weld spiral ribs on PRTR fuel elements.

Experiments were performed to determine the feasibility of swaging with a solid lubricant rather than with the liquid lubricant presently being used. The impact surfaces of a set of swaging dies were chemically coated with Electrofilm 77-5, a high load solid lubricant, and several Zircaloy-2 clad, UO_2 fuel rods were swaged. Swaged rod surfaces were relatively good. The solid lubricant, however, began to break off the dies after several passes. It is believed that better techniques of applying the lubricant to the die surfaces may alleviate this problem.

The relationship between the optical density of UO_2 and the Pb-Sn alloy system with respect to Co-60 gamma radiation was established for UO_2 densities ranging from 70 percent to 93 percent of theoretical density. Density standards of any geometry desired for use with the gamma absorptometer can now be fabricated very quickly by simply casting a series of Pb-Sn alloys.

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Corrosion Studies

Aluminum Corrosion. A number of experimental new "super" aluminum alloys have now been in test in 360 C deionized water for two to six months and show little additional penetration after the first ten days of exposure. All of these alloys were cast using 99.995% base aluminum. One month's data from four melts each of the 1.5% Fe, 1.5% Ni; 1.8% Fe, 1.2% Ni; and 2.1% Fe, 0.64% Ni in 99.995% base aluminum have shown that these "super" alloys can be consistently cast with confidence in obtaining the desired corrosion characteristics in 360 C water. Penetrations of these alloys are on the order of 0.2 mil.

The three compositions mentioned above have been formulated using 99.999%, 99.995%, and 99.95% pure base aluminum. The corrosion results after one month in 360 C water have shown no dependence on base metal purity in this range.

Heat Treating of Al-Fe-Ni Alloys. Tests on X-8001 (1% Ni, 0.5% Fe) and M-400 (1% Ni, 1% Fe) aluminum alloys have indicated that heating these alloys at 550 C for longer than six hours has a detrimental effect on their corrosion resistance. However, the new "super" aluminum alloys, heat treated three weeks at 550 C, show no increase in penetration over non-heat treated material after one month in test. Metallography of the heat treated samples shows that the second phase material is starting to coalesce but apparently has not progressed to a detrimental point. Longer term tests are in progress.

Steam Phase Corrosion of Al-Fe-Ni Alloys. Three super alloys have been tested for short times in 500 C, 1000 psi steam. All seven samples of the 1.5% Fe, 1.4% Ni alloy were completely destroyed after 17 hours. Three out of seven 1.8% Fe, 1.2% Ni samples were half-destroyed in 17 hours and the remaining four were still good after 41 hours. One out of seven 2.1% Fe, 0.64% Ni samples was half-destroyed in 17 hours; the rest, still good after 41 hours. As these results indicate an increasing resistance to catastrophic attack with increasing iron content, alloys of 2.5% Fe, 0.64% Ni and 3.0% Fe, 0.64% Ni are being fabricated and will be tested.

Corrosion of X-8001 Aluminum. Additional corrosion data have been obtained on X-8001 exposed to 300 C water adjusted to a pH of 4.5 with CO_2. After 540 hours, penetrations ranged from 0.7 to 1.2 mils at velocities of 20 to 60 fps. The slopes of the corrosion curves after 540 hours show a rate of 0.80 mil/mo at velocities of 20 to 30 fps and 1.4 mil/mo at 60 fps.

Fretting Corrosion of Zr-2. Flow tests are being designed to evaluate the extent of fretting corrosion which may be expected on fuel and process tubes in the PRTR. One test in CEP-2 which has been started employs a small-scale mock-up of the PRTR geometry. In ELMO-7, a full scale test will start as soon as the necessary components can be obtained, probably by May 1.

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Structural Materials Development

PRTR Process Tube Monitoring. Design of the Mark I prototype process tube monitoring device, incorporating a TV camera and diameter measuring instrument is about 50% complete. A purchase order has been issued for the TV camera, and a work authorization has been issued to Systems Research Operation for development of the inside diameter measuring instrument. Statistical estimates are being made of the optimum schedule and frequency for inspecting the PRTR pressure tubes after reactor startup. A television camera for development of methods and investigation of problems in visually examining process tubes by closed circuit television has been rented and is now on-site. This equipment will be used initially to examine the process tube in the single tube prototype facility and the process tube used for bowed fuel element discharge tests. The equipment will also be used for more detailed examination of five tubes with questionable autoclave films and pits which were observed by borescope examination.

Radiometallurgy Laboratory Studies

A four-foot long 19-rod cluster of 1.8 a/o Al-Pu alloy and a defected UO_2 fuel rod (GEH-4-39) were examined following ETR loop irradiations. A 92.9% theoretical density UO_2 sample which was irradiated to a calculated 160 MWD/T was annealed for six hours at 850 C, fractured, and a replica then made. X-ray powder samples were mounted on fibres and submitted to the customer (RM-604). The results and conclusions from these examinations will be reported in connection with the research and development programs of Ceramic Fuels and Plutonium Metallurgy Operations.

Thermal Hydraulics Studies

Protection Against Inadequate Cooling of Fuel Elements in PRTR Process Tubes with Small Leaks. Present PRTR operating procedures stipulate use of individual tube high flow trips to guard against process tube ruptures. Implied in this, however, is the assumption that a leak in a process tube which would reduce the flow in the tube to dangerous values would cause the total flow through the monitor to increase sufficiently to effect the high flow trip. An analysis of this condition reveals that the above assumption is not necessarily true. There do exist small leak sizes, if they should occur, which would reduce the flow through the tube to values below any which have been experimentally shown to be safe and which cause such a small increase in total flow through the flow monitor that use of a high flow trip for protection would be dubious.

The problem arises from the fact that the inlet piping, including the orifice, of a PRTR process tube has a relatively large pressure drop compared with the pressure drop across the heated section and outlet piping. A small increase in flow through the flow monitor, such as would occur from a small leak from the tube, would cause a relatively large pressure drop across the inlet piping, and, consequently, a relatively large decrease in pressure drop and flow supplied to the heated section.

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The analysis made use of two-phase flow, pressure drop calculations which are somewhat crude. However, the analysis does show that if a leak equivalent to a hole about 0.31 inch in diameter should occur downstream of the orifice, the flow through the tube downstream of the leak would fall below the rate experimentally shown to be safe, but the total flow through the tube would increase to only about 102% of normal. A high flow trip set this close to normal operating conditions would undoubtedly result in many spurious shutdowns. If the leak size were as large as about 0.56 inch, the total flow would increase to about 122% of normal and backward flow through the tube would be sufficient to provide adequate cooling.

The range of leak sizes which could result in reactor damage and which would be difficult to detect with a high flow trip is not large and the probability of their occurring may be small. However, protection must be provided, and several protection schemes are under consideration.

PRTR Project Management and Design

Phase III PRTR Contract. The Phase III contract is estimated to be 65% completed versus a scheduled 65%, based on the revised contractor's schedule. Over-all PRTR project is estimated to be 82% complete versus a scheduled 82%.

The pre-placed heavy aggregate concrete work has been completed. The thermal shield blocks have been installed in the reactor core assembly, and the cooling coil connections are being made.

Core Components. Helium sniffer leak testing of the moderator vessel portion of the calandria has disclosed five leaking weld seams. Arrangements have been made for the Phase III contractor to repair the defective welds. The reflector vessel has not been leak tested yet. Halogen sniffer leak testing of the bottom primary shield disclosed no leaks.

The shot has been installed in the core region of the bottom shield prior to installation. Remainder of the chilled iron shot filling will be added to the annular region of the shield after it has been placed in position because the reactor building crane cannot lift the shields when completely filled with shot.

The water softener tanks are being installed. Installation of the fuel handler rails is in progress.

PRTR Stack Addition. The PRTR stack contract has been completed.

Process Piping. Structural support drawings for the steam generator were revised to incorporate (1) grouting of the main support assembly ceiling attachment pads for uniform bearing, (2) pre-stressing of ceiling attachment bolts, and (3) substitution of heavier duty constant-force support hangers acting to counterbalance the weight of the unit during thermal expansion movement. Design modifications were completed for installation

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of a rupture disc in the wedge of the 14-inch motor operated gate valve in the main inlet piping to the steam generator. This modification is intended to avoid any possibility of isolating heat sources from pressure relief devices and cooling equipment, while retaining necessary sealing for maintenance and emergency light water injection.

Design Development and Research Contract DDR-79 with Electric Boat Division of General Dynamics Corporation was modified to include a dynamic (earthquake shock) analysis of primary coolant system piping.

Bids were received during the report period for PRTR ion exchange resins and portable disposable ion exchange units. The low bid of Illinois Water Treatment Company for bulk resin was accepted, and an engineering review and analysis of the submittal on portable units is in progress at month's end.

Process tubes and nozzles are being assembled and tested by the contractor. ATP's on hydrostatic testing and helium leak testing have commenced. The assemblies all indicate a small amount of leakage on the helium leak test but usually not enough to interfere with checking welds on the nozzles.

Instrumentation and Control. The specifications of the rupture monitor shielding and sampling system (mechanical portion) were sent out for bids. These bids are due during the second week of April.

The vendor building the rupture monitor electronics system has requested a delay in delivery date. Delivery is expected about the middle of April on his revised schedule. This delay is expected to present no problem since the rupture monitor system is not being installed by the Phase III contractor.

A blower was placed on order for use with the gas moisture detection system to replace one offered by the Phase III contractor which was not satisfactory for use in this system.

Connectors and cable for attachment to the shim control units have been received. Assembly procedures for the special cables and connectors have been prepared and submitted to the Phase III contractor.

Fuel Handler. New shrouds are being made for the fuel handler because of damage incurred during various testing operations. Electrical components are being procured for an alternate power supply to the discharge hoist. Blower speed has been reduced 10% to prevent overloading when handling a fuel element and process tube together.

Fuel Element Examination Facility. All the cast iron shielding blocks and all the plugs except one viewing plug have been received. The wall blocks have been installed. A minor amount of concrete chipping was necessary before the wall blocks could be lowered through the floor opening.

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The W. F. and John Barnes Company is experiencing difficulty in securing sound aluminum castings for the frame and gear housings of the primary manipulator. Selected areas of the main frame are being machined to determine the feasibility of obtaining the specified finish. If the selected areas can be successfully finished, the remainder of the frame will be machined. If not, it may be necessary to recast the frame.

The difficulties with the aluminum castings have resulted in an extension of the scheduled completion dates. The new completion date will depend on the solution to the surface finish problem.

The first test of the second air duct with the movable outlet (zipper) has been completed. The test showed the necessity of additional bracing to withstand the internal pressure.

Load-Out Cask. Additional drawings were received for comment and/or approval. The drawings were reviewed and returned to the vendor. Certain minor changes were made in the drawings at the request of the CPD representatives in order that the cask be more compatible for use in Redox. The vendor has been requested to submit a quotation for any additional charges resulting from the changes.

PRP Critical Facility (Project CAH-842). The project proposal for the PRP Critical Facility has been forwarded to the AEC for approval.

The detailed design for the Critical Facility building is being approved. CE&U has submitted an estimate of $30,000 and four months to complete Title II services for the equipment design, installation specifications and ATP's. The fuel transfer lock, periscope, and control rods will be provided on a design and fabricate basis.

Scoping of an adjustable weir overflow for the reactor tank, a storage tank, addition pump, and associated piping and valving to permit level control of the reactor was completed.

Fuel Element Rupture Test Facility (Project CAH-867). The project proposal has been prepared and is being circulated for approval. In order to meet fund limitations of $1,500,000, it was necessary to eliminate non-essential equipment items. The items eliminated included:

1. One circulating pump, reducing the number of pumps to two half capacity units.
2. One of the two sets of make-up system ion exchangers.
3. One of the two decontamination chemical mixing tanks.
4. Pump isolation valves and other valves throughout the system which could be eliminated because of the removal of above equipment items.

A rough draft of the design criteria (HW-63863) was issued for comments. It is expected that the design criteria will be completed early in April 1960.

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The problem of swelling fuel elements after failure has required a means for detecting tube bulging. The present detection system design will use an insulated outer tube which will close an electrical circuit whenever it contacts the inner tube or the reactor shroud tube.

The high pressure (2100 psig) high temperature (600 F) bellows design on Test Section "B" appears feasible. After inquiries to various vendors, at least three companies feel they can make the bellows for a price of less than $500 each.

Design and Component Testing

Design Test PR-1, Discharge Operation Mockup. Testing of the PRTR Fueling Vehicle continued during the month. Component tests are summarized below:

(a) Air Cooling System. The speed of the compressor was reduced from 3520 RPM to 3140 RPM. Compressor suction pressure with a process tube containing the Pu-Al prototype element in position on the seat was 8.9" Hg gauge at 3140 RPM. The compressor discharge flow rate was 350 CFM with the above conditions and the compressor ran 21 minutes without overloading (compressor drive was switched off after 21 minutes).

The shroud halves do not engage properly at the top and the shrouds leak along the mating surfaces. Attempts to correct the above condition were unsuccessful. The shrouds are being redesigned.

During one of the test periods the shroud halves stuck on the discharge hook housing and the operator attempted to raise the hook without retracting the shrouds. The shrouds were lifted off the shroud supports and one of the halves fell from the vehicle into the test pit. An interlock was added to the discharge hoist circuit to prevent movement of the discharge hoist when the shrouds are in the "in" position.

(b) Process Tube Discharge. The centering device on the seat was revised to give the maximum height and pitch to the positioner plates but attempts to place a severely bowed tube (0.250 inch) on the seat were unsuccessful. The process tube was removed, straightened to specified tolerance (0.100 inch), and replaced. Further attempts to discharge the process tube-fuel element assembly into the cask and lower the assembly on the seat were successful. The assembly was placed on the seat 20 times without incident.

(c) Charge-Discharge of Prototype Pu-Al Fuel Element. The fuel element was successfully discharged from process tubes with maximum bows of 0.25", 0.80", 1.15", and 1.55" over the tube length. The end brackets rubbed against the tube wall during discharge attempts from the bowed tubes and the wire wraps were flattened where the

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wraps rubbed against the tube wall. Maximum discharge hook tension during the discharge trails from the 1.55" bowed tube was 230 lbs. Normal tension during discharge attempts was 100 lbs. Minimum time required to discharge the fuel element, engage the seat and shrouds, and place the compressor in operation was 36 seconds.

(d) Water Spray System. Flow rate of the water spray system is 2.35 GPM.

PR-10, Primary Loop Mockup. The spare PRTR mechanical seal pump assembly was disassembled on February 24, 1960, after 310 hours of operation using a new lower balanced seal. The same pattern of excessive wear was found. A factory representative present recommended several minor changes and inspection checks during seal assembly but could not find a definite cause of the premature failure. The spare pump was reassembled and run for two short periods while a detailed evaluation of the vibration was made. The analysis revealed about 10 mils maximum vibration with the pump cold and five mils hot with a frequency of 1775 RPM. The maximum amplitude was measured at the pump volute. A later vibration analysis performed with the impeller running in air, resulted in only one mil at the volute. This possibly points to a hydraulic imbalance and further investigation is under way. The pump vendor is preparing a program to correct the imbalance if the operation of the reactor pumps verify that the imbalance is hydraulic.

The first of the three PRTR primary pumps was hot tested, starting on March 11, 1960, following complete pump disassembly and renovation. This unit was found to vibrate a maximum of six mils both hot and cold. After 69 hours of operation, the high pressure mechanical seal was inspected and found to have worn 0.002 inch. The amount of wear and the appearance of the seal face indicate that the seal was wearing excessively.

The second PRTR primary pump was placed in service on March 22, 1960. The vibration analysis has shown a maximum vibration of 1.4 mils. This unit will be disassembled for inspection on March 28, 1960.

The high pressure seal of the prototype continues to operate satisfactorily after 3200 hours of operation and 45 pump starts. The leak rate is approximately 0.1 gph at equilibrium conditions although the pump is routinely cooled and shut down each week day.

During the past month the single tube prototype has operated at temperature 540 hours with 24 complete thermocycles during this time. The fuel element was removed once while changing the gasket on the nozzle to process tube connection. No measurable wear was noted on the fuel element supports.

The nozzle to process tube (NTPT) connection with the thinner shim was operated for 16 thermal cycles and 430 hours. Leakage during this test averaged 5.7 ml/hr. The gasket during this test was compressed 0.025 inch. The shim was removed and the NTPT connection reassembled on March 16. Since

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that time the connection has operated 185 hours with nine thermal cycles and an average leakage of 1.7 ml/hour. (It was found that after eight cycles the bolt torque had dropped from 75 ft-lbs to about 45 ft-lbs. Retorquing the bolts cut the leakage which had increased to about 4 ml/hr back to 0.6 ml/hr, which was about the same as the leakage during the first five thermal cycles.)

Cap leakage from the period February 18 through March 15, averaged 0.9 ml/hr during 16 thermal cycles and 430 operating hours. Leakage during the nine thermal cycles and 185 operating hours since March 15 has been quite erratic due to impingement of the inner metal rings of the gasket between the metal seating surfaces. Minor modifications to the gasket retainer are being tried to correct this problem.

Leakage at the inlet connection has been about 0.02 ml/hour during 400 operating hours and 18 thermal cycles since March 2.

A test piece with two simulated nozzle-to-process tube connections is now being operated and thermocycled to 500 F and 1200 psi. One of the connections has been made up using shims to prevent metal-to-metal contact between the Zircaloy tube end flange and the stainless steel outlet nozzle flange.

Gas leakage with the solid copper gas seal gasket between the process tube and ring flange was found to be essentially zero during 15 thermocycles and 150 operating hours. This test was made with a metal shimmed NTPT connection. Leakage without the metal shim in this connection should be no problem due to the resulting higher compressive forces on the solid copper gas seal gasket.

PR-40, Shim Control Mockup. The prototype test facility for investigating possible corrosion between the inconel shim rods and the aluminum tube extensions is now being installed.

Two motors from the vendor supplying the reactor shim rod order are scheduled for further testing. The motors received on the reactor order have had a high rejection rate due to an insulation breakdown between phases. New stators are being furnished with a glass supported silicone rubber phase insulation. One motor will be operated in the shim rod mockup and the other will be operated in a known radiation field.

PR-70, Helium Compressor Test. The German manufacturer submitted a piston and seal system for the high pressure compressor oil pump. This piston and seal system was tested and found unsatisfactory.

The Vickers' oil pump, formerly tested without suction pressure, was tested with a 15 psig positive feed as recommended by the vendor; however, it would not operate. It is concluded that this multipiston aircraft type hydraulic pump is not applicable to our service on the high pressure helium compressor.

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Further evaluation of Hanford rebuilt oil pumps using hardened steel pistons and liners is under way. It is now believed that reliable operation for 1000 hours and more can be obtained with Hanford rebuilt pumps.

Rebuilt gas outlet check valves have been prepared for the low pressure helium compressor, using a stellite seat and flapper disc. It is proposed that these valves be tested in the PRTR helium compressors. Gas check valves for the high pressure compressor are being fabricated from 17 - 4 PH stainless steel.

PR-80, Air Cooling Duct Test. The high pressure duct was installed and preliminary tests performed. Excessive leakage and deformation of the carriage rail section prevented completion of the tests. Modifications have been started to correct these problems. The high and low pressure compressors have been delivered to the reactor contractor for installation.

Special Tools. Two new cutting edges for the core saw have been fabricated and are ready for testing.

The cut-off saw was adapted to the fueling vehicle and tested. It cut through a work hardened zirconium tube in 38 minutes. A new loading device is being prepared to shorten the time required to cut through a tube.

Reactor tools for removing jumpers, nozzle caps and hold-downs, shim rod electrical connectors, and inlet flange bolts have been tested. Improved reactor models are now being fabricated. Additional special tools for the reactor and load-out facility are continually being added.

Silicone Foam and Sealers. A new silicone rubber was used to treat all wires and the structural opening interior surface prior to pouring foam and a following non-foaming silicone cap. Leakage from this arrangement and from the wire ends which were capped with silicone were still excessive.

Fiberglass resin was used to fill the top inch of an opening, with sand used as a filler material. This arrangement sealed well but was brittle.

An epoxy cement has exhibited the best properties for sealing the structural opening and also the ends of the wires. Further tests will be completed on this material and a report issued.

PRTR Instruments. The infrared sensitive lens, arsenic trisulphide, being irradiated at 10^6 R/hour absorbs 10^8 R with little change but attenuates 70% of the incident energy after having received 10^9 R. This lens is being evaluated as a candidate component for the temperature detector in the Fuel Examination Facility.

A precision servomanometer is to be obtained for measuring moderator level of the PRTR during criticality studies. The resolution expected is to the nearest apparent hundredth of an inch of moderator level.

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Several designs have been proposed for monitoring in-pile movement of the high pressure tube in the gas loop relative to the calandria shroud tube during operation.

Final evaluation of the instrumentation for measuring the first two feet of moderator fall for the calandria dump rate tests has been completed. The instrumentation may be used to measure the time of moderator fall when using any valve individually or any combination of valves as well as measuring the time lag between the time the power to the valves is interrupted and the time the moderator begins to fall. Measurement of the time of fall for this first two-foot interval is accurate to ± 0.01 second.

Design Analysis

Physics Analysis. The remainder of the Critical Test descriptions were completed and presented to the Startup Council. A final review of the test descriptions was also completed at which time changes suggested by the Startup Council were incorporated. Final arrangements have been completed with Chemical Research and Development Operation to carry out experiments to demonstrate the feasibility of poisoning the moderator with boron for Critical Test 15. Power test planning is continuing in cooperation with the Power Test Subcouncil. An initial list of experiments has been prepared and outlines are being written.

Consideration is being given to performing two-dimensional neutron flux distribution calculations utilizing an IBM-709 code, ANGIE, which has just been received. The code has provision for either x-y or r-z geometry and will accommodate up to 2000 mesh points and eighteen energy groups. Thus, a fairly detailed calculation of the PRTR core should be possible. A test case is being prepared to check the operability.

Effort is continuing to determine the reliability of control rod reactivity worths calculated using the RECON computer code. The code employs a two-group diffusion theory neutron transport model and obtains solutions for control and reactivity worths in a reflected core. Comparison of results with hand calculation indicate that the code is debugged (performing correctly all intended operations). The major radial buckling and radial distribution of statistical weights are being formed properly. Calculation of the worth of black rods in the EGCR is under way; these values will be compared to experimental results obtained in the PCTR. A similar comparison is also planned for K Reactor rods.

The FLUX-WEIGHT code is now debugged and operational. Initial use of the code is being made to determine the PRCF core design and to obtain critical loadings, flux distributions, radial statistical weights, and an evaluation of moderator level worth.

Work is continuing on the SNG Transport Code, and a successful test run on a slab geometry case has been completed. At present, a comparison of the SNG (Hanford version) Code with the SNG (North American version) Code is under way.

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The PRTR xenon program is complete and running. A report will be issued in the near future.

PRTR Process Specifications. Progress on writing process specifications remains at about thirty percent written in rough draft form. The outline of process specifications to be written and three of the proposed specifications have been reviewed by the Startup Council. Revisions requested by the Startup Council have been incorporated in the specifications.

Safeguards Analyses. Preparation of the report of the final safeguards analysis for the PRTR gas-cooled loop was started this month. A comment draft of the report will be issued early in April. Analyses have revealed no feature of the design or operating plans which would result in decreasing the safety of the PRTR.

Writing of the PRP Critical Facility Preliminary Hazards Report was begun. Studies of the effects of various coolant system failures were conducted. Investigations of the reactor physics and of nuclear accidents were initiated.

Reviewing of preliminary PRTR critical test descriptions was completed. The writing of a hazards and restrictions summary section for the critical tests was begun.

Plutonium Fabrication Pilot Plant

Construction is estimated to be 90% complete at month end. Preparation of the Construction Completion Report has begun.

The relocation of transferred capital equipment from Building 231-Z is proceeding essentially on schedule. The plastering subcontractor commenced erection of partitions in the second floor process area. Slow progress was made in painting the floor of Room 131. It is planned to accept this room for operations use early in April.

The cross-push mechanisms were received from the sintering furnace vendor in partially complete condition. The work of completing these units is nearly finished at month's end. The atmosphere and furnace gas pressure control panels have been completed and installation is nearly complete. After the limit switches for the various feed movements are installed and adjusted, the units will be ready for startup.

The etch facility is nearly complete. It was discovered during the month that the small monobed water demineralizer, scoped before the extent of demineralized water usage in zirconium etching had been determined, is already overloaded. A rush requisition was placed for a 1000 gal/hr unit, with the intention of completing its installation in time for the etch facility startup.

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Final inspection of the 20-inch rolling mill has been completed. The mill appears to be well made and only minor adjustments were required. It is scheduled for shipment April 4.

PRTR Operations Planning

Forty-one operating procedures were issued during the month. The tentative outlines for PRTR Operating Standards were up-dated and reissued. A number of procedures were prepared for the PRTR Sample Program. The PRTR Electrical Manual is 70% complete; it will be completed and issued during April.

A document, HW-64322, "Power Calculation in the PRTR," by E. D. Jones was issued during the month. A study of excess reactivity versus reactor periods was completed. A report will be issued by April 1, 1960.

A complete list of PRTR valves was prepared. The list gives identification, function, and print reference for each PRTR valve and includes schematic diagrams. The valve list will be issued early in April to all interested persons.

Industrial Medical Operation was requested to obtain noise level measurements near the operating diesels. The results of their study have not yet been received.

A sample respiratory mask with voice amplifier was obtained and tested. FPD Maintenance is investigating the cost and availability of parts.

Spare parts procurement continued. Availability of funds for spare parts was reviewed with HLO Financial. Estimate of spare parts expenditures during FY-60 is presently $40,000.

Calibration of instruments has been discontinued for several weeks at the request of the contractor. Calibration manpower requirements were reviewed with FPD Maintenance.

Final operational and design review was completed for 18 PRTR design tests during the month. Design Test No. 39, "Flux Monitoring System," was written and circulated for comments. It will be presented to the PRTR Startup Council in early April. A cost code was established to accumulate the cost of special equipment for the design tests. Procurement of special equipment began.

An outline of the proposed PRTR power tests was prepared and presented to the PRTR Startup Council. Discussion of the outline is scheduled for early April. The tests, as prepared, would require approximately ten weeks, with design power being achieved five weeks after start of the tests.

All PRTR critical tests have been presented to the Startup Council. Formalization of the Introduction to the Critical Tests which includes instrumentation, hazards, and restriction summaries will be presented to the council in the near future.

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Rupture monitor system electronic prints were reviewed and returned with a request that additional information be furnished. Also, comments were issued for the rupture loop instrumentation and control equipment. The PRTR Maintenance and Mockup Area tracings were reviewed for operational approval. The complete rough draft issue of the Rupture Loop Design Criteria was reviewed and comments issued.

Sessions I and II of the Radiation Training Program were conducted. Review and study of the qualification questions, operating procedures, and special training assignments continued. One Shift Engineer spent the month in the 100 Areas to become more familiar with reactor operating problems. Six Engineering Assistants were assigned to the 314 Building Equipment Development Laboratory for training and assistance to MEDO. This portion of the engineering assistant training program will be completed on April 4. Two information meetings were held to familiarize PRTRO personnel with the purposes and equipment layout of the CO_2 gas loop.

A report was prepared which defines the data processing input, report requirements, calculation requirements, forms design, and estimate of data volume. The report was designed primarily to assist machine programming by EDPM Operation. It will be documented and issued early next month to acquaint all interested persons with the PRTR data service which will be available.

2. PLUTONIUM CERAMICS RESEARCH

To determine the effects of sintering time on densification rates of UO_2-PuO_2 mixtures, pellets of UO_2 containing 15, 25, 40, 60, 75, 90, and 95 w/o PuO_2 and also pure PuO_2 were heated in hydrogen for 44 hours at 1500 C, 22 hours between 1400 and 1500 C and eight hours between 1300 and 1400 C. This was the same composition series which exhibited the marked density decreases with even slight additions of PuO_2 after one and eight hours at all temperatures up to 1500 C. The specimens were found to have undergone dimensional changes during the sinter, the extent of which increased with PuO_2 concentration. Beginning with UO_2-40 w/o PuO_2, there was evidence of flow, the bottom of the pellets assuming the contour of the molybdenum boat, and the pure PuO_2 pellet was almost spherical in shape with a glazed appearance. However, the densities of all compositions as determined by water immersion were 90 percent of theoretical or greater. The cause of this apparent flow is being investigated.

In a continuation of an investigation of the discrepancy between Hanford Laboratories and AERE data on the stability of PuO_2 in hydrogen, PuO_2 was obtained by calcining plutonium oxalate at 150, 300, 500, 800, and 1000 C. These powders were heated in hydrogen at 1500 C for eight hours and subjected to x-ray diffraction analyses. Only a single PuO_2 phase was found on the patterns obtained from the 150 C and 300 C calcination treatment. Those calcined at 500, 800, and 1000 C showed PuO_2 and 15, 25, and 15 percent alpha Pu_2O_3, respectively. Since HLO PuO_2 is normally obtained by calcining the oxalate at 300 C and AERE calcines at 600 C, it is concluded that the stability of plutonium dioxide in hydrogen is definitely influenced by the calcination treatment.

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Melting studies on plutonium dioxide have continued. The following table shows the melting point and lattice parameters of fused PuO_2 for the atmospheres indicated.

Sample	Atmosphere	MP	Lattice Parameter
C 19-2	Helium	2280 C	5.4168 ± 0.0005 Å
C 26-1	"	2270	5.407 ± 0.002
C 26-2	Vacuum	2255	5.402 ± 0.002
C 26-3	Argon	2280	5.401 ± 0.003
C 27-2	½ He - ½ H_2	2310	

The diffraction data were obtained by the Debye-Scherrer method with copper radiation. A sub-oxide was not detected on any of the patterns. All of the lattice parameters are greater than the 5.3960 Å found for as-received plutonium dioxide, indicating a loss of oxygen during melting. The amount of this loss is apparently time dependent since all of the samples, with the exception of C 19-2, were melted rapidly. Unfortunately, the times at elevated temperatures are not available; however, the larger lattice parameter of C 19-2 over that of the sample melted in vacuum illustrates the time effect.

Samples of PuO_2 and UO_2-60 w/o PuO_2 were melted in helium and polished for metallographic examination. A very small quantity, approximately 2-4% of a second phase was observed at 500X. This quantity is so slight it is beyond detection by x-ray diffraction techniques.

In connection with PuO_2 volatility, vapors of two samples were collected on a copper condenser which was hung about one-half inch above the specimen. In one experiment the PuO_2 was heated to 2135 C at 10^{-3} mm Hg for eight hours. The lattice parameter of the condensed PuO_2 was 5.408 ± 0.001 Å and only a very slight trace of alpha Pu_2O_3 was present. The other sample was heated to 1000 C at 10^{-3} mm Hg for 48 hours. A bluish-black condensate, probably an oxide of tungsten, was present on the copper, but no plutonium was detected.

X-ray diffraction charts have been obtained on pellets of MgO, Al_2O_3, ZrO_2, and stabilized ZrO_2, each mixed with two w/o and eight w/o PuO_2. MgO showed no sign of reaction with PuO_2 when sintered in either hydrogen or helium at 1500 C for eight hours. In hydrogen at these conditions an unidentified reaction did occur between Al_2O_3 and PuO_2, and the diffraction patterns are being re-run to obtain better resolution of the lines. The reaction is possibly the formation of the perovskite-type compound, $PuAlO_3$, reported by L. E. Russel et al, AERE-R 3044. In order to determine if the perovskite compound can be formed, a pellet containing stoichiometric amounts of Al_2O_3 and PuO_2 was pressed and sintered at 1500 C for eight hours in hydrogen. The pellet evidenced signs of a reaction by severe bloating, pitting, and plastic flow and is presently being analyzed by x-ray diffraction.

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Pure ZrO_2 pellets crumbled or severely cracked when sintered at all temperatures from 1100 C to 1500 C for eight hours, but it was found that as little as two w/o PuO_2 in the ZrO_2 made the pellets dimensionally stable when sintered at these same temperatures. X-ray diffraction showed a retention of about 3.5% of the high temperature tetragonal phase at room temperature in the pellets containing eight w/o PuO_2 and 10% in pellets containing two w/o PuO_2.

Pellets containing 15, 25, 35, 50, 65, 80, and 92 w/o PuO_2 with ZrO_2 have been pressed and sintered, and are being examined by x-ray diffraction. The melting point furnace is being adapted to heat and quench small specimens of ZrO_2-PuO_2 and will be used to determine portions of the ZrO_2-PuO_2 phase diagram.

A literature survey on the physical and nuclear properties of various ceramic materials including BeO, MgO, Al_2O_3, ThO_2, and SiC is being published.

Previous experiments in which oxides of Pu and U were heated with graphite to form the respective carbides were repeated using a mixture of the two oxides as a starting material. The amounts were chosen in three samples so as to yield 25, 50, and 75% PuC in UC, respectively. As had been noticed previously, the products formed at 1800 C showed strong x-ray diffraction lines of Pu_2C_3, presumably due to a loss of plutonium during reaction. Vaporization of PuO_2 at 2100 C has been observed, and vaporization tests will be made at 1800 C on PuO_2 to determine if this is sufficient to account for the formation of Pu_2C_3. Other strong lines of PuC, UC, or a solid solution of the two, were also found in all three samples, but no satisfactory metallographic technique has been found as yet to distinguish these phases under the microscope. Another run was started in which a surplus of PuO_2 was added to graphite, but furnace troubles required the equipment to be shut down for repairs.

Evaluation has been completed on the Blaine air permeability fineness testers which were purchased with the hopes of rapidly and inexpensively determining the surface areas of ceramic powders, particularly plutonium dioxide powders. Comparisons of the surface areas of alumina, magnesia, zirconia, and urania obtained on the air permeability apparatus with the surface areas of the same powders obtained on a B.E.T. nitrogen absorption apparatus indicate that a different calibration exists for each material; therefore, the air permeability apparatus is useless in obtaining true surface areas of plutonium dioxide powders until a plutonia sample of known surface area becomes available for use as a standard. There is no hooded B.E.T. apparatus presently available with which to standardize a plutonia sample. A good degree of reproducibility can be obtained on the air permeability apparatus, and the instrument should be useful when a standardized plutonia sample can be obtained.

3. URANIUM DIOXIDE FUELS RESEARCH

Fuel Evaluation

Swaged UO_2 capsules have attained an estimated maximum exposure in excess of 14,500 MWD/T during irradiations in MTR-ETR. No failures of these or other swaged capsules or fuel elements have occurred.

Hot swaged UO_2 capsules were successfully irradiated to 2250 MWD/T. The irradiation continues.

Post-irradiation examination of an irradiated, purposely defected, Zircaloy-2 clad, swaged UO_2 fuel rod revealed evidence of zirconium hydride formation, even though the specimen was irradiated only 90 minutes in 40 C water coolant. Concentration of the hydride in the Zircaloy-2 cladding increased uniformly from ~150 ppm at the 0.005 inch diameter hole to ~250 ppm at a 0.4 inch radius from the defect. Beyond this radius the hydride concentration was ~150 ppm.

A second, defected Zircaloy-2 clad, swaged UO_2 rod was irradiated for 125 minutes in the MTR at a maximum surface heat flux of 685,000 BTU/hr/ft^2 (33 percent higher than in the previous defected element irradiation). The fuel element was power cycled twice. No unusually high fission product activity was evident, nor was any particulate matter released. This element is being sectioned.

The rapid hydriding evident on the first Zircaloy-2 test indicates the desirability of another test, using a Zircaloy-4 clad fuel rod. The fuel rod has been fabricated.

Sixteen, three-foot long, swaged UO_2 fuel rods having PRTR end caps were fabricated and shipped to ORNL. These rods will provide material for comparison with material swaged at ORNL.

Basic Studies

Autopsies of irradiated UO_2 specimens still provide most of our information regarding the thermal conductivity of UO_2 at high temperatures. A tantalum bulb, helium gas thermometer has been fabricated to use in measuring UO_2 core temperatures during irradiation. A method of braze-joining small diameter stainless steel and tantalum tubes without the use of filler metal was developed. A read-out system for recording temperatures measured by the thermometer was assembled and tested.

Microscopy studies of UO_2 at temperatures up to the melting point are being extended to include irradiated samples. The high temperature microscopy furnace has been modified and shielded accordingly.

A compact hydraulic lift for the lid of the high temperature hot cell was fabricated, a remotely operated specimen dispenser was constructed, and pyrometer calibrations are in progress.

Samples of impact formed UO_2 are being prepared for irradiation testing and thermal conductivity studies.

Micronized UO_2 was compacted in the Dynapak (high energy impact) equipment at various temperatures. A maximum UO_2 density of 94.5 percent T.D. was obtained in the temperature range of 900-1200 C. The high density UO_2 thus produced has an extremely fine grain structure, as revealed by electron micrographs.

Single crystals of UO_2 are being fabricated into specimens for irradiation experiments, thermal conductivity determinations, and other fundamental studies.

Approximately 100 pounds of large crystals were selected from 700 pounds of Norton arc-fused UO_2. A pole figure x-ray scan of a representative single crystal revealed a single angle of reflection for the (111) plane. Although the peaks were slightly broadened, indicating a defect structure, this effect was not pronounced. Some microscopic pores and inclusions are evident in photomicrographs of the crystals.

4. BASIC SWELLING STUDIES

Irradiation Program

Two types of capsules for irradiating uranium at a constant temperature are currently under construction: a metallographic specimen swelling capsule for insertion into either the MTR or the ETR, and a general swelling capsule. Three of the metallographic specimen capsules have been completely assembled, and a fourth is in the final stages of construction while five general swelling capsules have now been fabricated.

Of the four assemblies of the metallographic specimen swelling capsule being assembled, one is for heat transfer evaluation and bench testing, one is for ex-reactor comparison to the in-reactor tests, and two are scheduled for irradiation in the ETR. Two of the three capsules already assembled contain pre-characterized specimens ready for irradiation while the third capsule contains only a dummy specimen. The laboratory evaluation tests on this latter capsule are in progress. The control instrumentation for the other two capsules is being installed at the ETR reactor. A prototypical unit of the ETR instrumentation has been tested at HAPO and found to operate satisfactorily for control at specimen temperature at any constant value from 200 to 700 C.

A general swelling capsule containing four one centimeter diameter uranium spheres was charged into a reactor in the latter part of February. The capsule is operating satisfactorily at a temperature of 550 C which is maintained while the reactor is down as well as when it is up. When the reactor is down, there are essentially no thermal gradients throughout the capsule, but when the reactor is up, there is

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a gradient from the center to the end of the capsule and also from the center to the edge of the spheres. By controlling the temperature at the surface of the end sphere, all temperature changes that occur when the reactor is shut down are minimized. This should tend to decrease the effects of the thermal cycling on the swelling behavior. The control temperature is precisely maintained when the reactor shuts down in a normal fashion and undershoots by only 10 C when the reactor scrams.

The experience gained from observing the operation of this capsule suggested several modifications to be made in future capsules of this general configuration. The fifth capsule that was assembled contained only three spheres (two natural and one enriched) so that less of the required heat comes from the fissioning process. The capsule has slightly larger heat dissipating fins to increase the heat input necessary to maintain any particular temperature. This will allow more efficient operation of the control system. The fifth capsule is now undergoing bench tests and will be charged if the tests prove successful.

Pore Size and Distribution

Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. A formal report, HW-63848, "Metallographic Studies of Swelling in Irradiated Uranium - Effect of Burnup, Irradiation Temperature, and Post-Irradiation Annealing," is being prepared.

Five non-instrumented capsules containing pre-characterized uranium irradiated to burnups as high as 0.2 a/o are in Radiometallurgy and post-irradiation examination is about to begin.

Statistical analysis of distortion associated with the replication of pores in synthetic plastic specimens is continuing. Measurements of pore diameters and depths of pores, as revealed by replicas, indicates that pores are distorted if they are cut above their centers. Three synthetic specimens each containing pores with diameters of 1.17, 0.81, and 0.56 microns, respectively, are being analyzed, and the results will be used to help formulate a mathematical model for quantitative metallography.

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. It is not at all certain that mechanical property changes measured after irradiation will be indicative of the changes induced during the period of irradiation. The retained defects associated with residual damage may have entirely different effects on the creep properties than will the instantaneous effect of a high neutron flux.

The irradiation of an in-reactor creep capsule 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. Last month, an average in-reactor rate of 1.69×10^{-6} in/in/hr was measured which compared with the ex-reactor rate of 1.5×10^{-7} in/in/hr at a test temperature of 500 F (260 C) and a stress of 30,000 psi. As the in-reactor transducers are not as sensitive nor as accurate as the ex-reactor transducer, the data have been analyzed statistically to place the confidence limits on the above rates. The analysis shows that the creep rate of the in-reactor specimen is of the order of ten times that of the ex-reactor specimen.

The laboratory tests are now completed on the study of the thermal balance within the prototypical creep capsule. The thermal balance of the capsule was upset as the helium pressure was increased to provide the stress on the specimen. A test cell was constructed which incorporated a one inch diameter heat source centered in a 2-1/2 inch ID stainless steel pressure vessel. The test assembly was cooled in flowing water while the heat transport by helium gas was measured at steady state temperatures as a function of helium pressure. Under the test cell conditions the heat transport was measured over the range of 100 C to 600 C at 15 psi to 600 psi helium pressure. The amount of heat required to reach 500 C at 500 psi was 4.5 times that necessary at 15 psi. Four arrangements of convection baffles were tested, the most efficient being two concentric aluminum cylinders insulated on the ends and providing about one-eighth inch space between them. These baffles reduced the amount of power necessary to reach 500 C at 500 psi to only 1.35 times that needed at 15 psi. The results of this heat transport study are now being incorporated in the capsule under construction to reduce the drastic change of thermal balance as the capsule is pressurized with helium.

The same test cell that was used for the thermal balance studies is now being used to measure the arc-over voltages as a function of helium temperature and pressure so that suitable insulation will be provided in future capsules to prevent premature failure of the transducers, heaters or signal leads by electrical arc-over.

Ex-reactor creep measurements are being performed on cold worked and annealed Zircaloy-2 ex-reactor. Creep activation energies have been determined for 25 and 45 percent cold worked Zircaloy-2 after second stage creep rates were well established. In the method used the temperature was increased in 25 C increments and each new creep rate was measured. The logarithms of these rates were then plotted as a function of the reciprocal of the absolute temperature. The data were found to conform to the equation:

$$\dot{E} = Ae^{\frac{-Q}{RT}}$$

where $\dot{E}$ = the creep rate at temperature T
A = frequency factor, a stress dependent structure factor

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Q = activation energy in calories per gram mole
R = gas constant
T - absolute temperature.

An activation energy for creep of 59.7 K cal/gm-mole was determined. The data for two 25 percent cold worked specimens and one 45 percent cold worked specimen displayed no differences in the activation energy. The value of A does vary with the amount of stress on the specimen. It is interesting to note that the activation energy appears to be independent of cold work level. The primary reason for determining the activation energy on this series of specimens was to provide a basis for tests on creep in-reactor. These rates, activation energies, and frequency factors will be used as a comparison between in-reactor tests and ex-reactor tests.

6. GAS-GRAPHITE STUDIES

EGCR Graphite Irradiation

Designs for three possible EGCR graphite sample configurations have been completed which employ four one-quarter cylinder, four-inch long samples held together as a unit. Mockup tests of these designs have been initiated to aid in confirming heat transfer calculations made for the three configurations.

Cemented Graphite Joints

Tensile test specimens of graphite containing joints cemented with National Carbon Company "F" cement have been irradiated to 3.9×10^{19} nvt ($E > 1$ Mev) at about 550 to 600 C. Prior to irradiation cracks developed in the cement of one sample heated to 500 C. After irradiation, similar cracks appeared in the samples which were not heat treated prior to irradiation; however, they were sound enough to survive an inadvertent three-foot drop during discharge from the test-hole. A tensile strength of 783 psi was determined for one sample. Rupture occurred at the cemented joint. In unirradiated specimens the cement was stronger than the graphite. The diameters of the cemented joints contracted an average of 0.12 percent. Remaining specimens will be given further irradiation and studies will be made of pre-irradiation heat treatments in an effort to eliminate cracking in the cement.

Radiation Damage Annealing

Very recent work shows that the contraction of graphite which occurs during high temperature irradiation can be altered by annealing at higher temperatures. The dimensional changes during annealing may be associated with a removal of interstitials from between the lattice planes with a resulting further contraction in the C_o lattice direction but a growth (recovery) in the A_o direction.

One possible interpretation of these data leads to the conclusion that contraction in the parallel extrusion direction is caused primarily by distortion of lattice planes within crystallites and can potentially

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be removed by annealing. This same line of reasoning points strongly towards the less-graphitic graphite formed from binder material as being primarily responsible for contraction in the transverse extrusion direction.

Thermal Oxidation

Samples of British nuclear grade graphite have been oxidized in flowing CO_2. At 750 C, the specimens lost weight at a rate twice that of CSF graphite. It was noted that the material was coarse in structure, evidently with large coke particles.

Metallograph Studies

Typical samples of each available raw coke have been polished after impregnating with epoxy resin. Pictures at 50X and 250X are being made on the metallograph with bright field, polarized light and sensitive tint plates to reveal characteristic details. Samples of CSF, TSGVF, and GL-10 (needle coke) graphite have been prepared with polished surfaces parallel and transverse to the whole-bar extrusion axis. No outstanding characteristics have been found which might distinguish between areas related to coke particles and areas of graphitized binder. Samples of calcined coke have been prepared for comparison with the raw cokes and graphites.

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

A meeting was held with Bristol-Siddeley and Struthers-Wells representatives to discuss the problems occasioned by the late delivery of the primary gas blowers. As it now stands, the June 1 shipment date of the Phase A package is still firm, but the third blower may be shipped directly to Richland for assembly and installation.

Fabrication of the in-reactor section is approximately 20% complete. About 55% of the required material has been received.

A package is now under preparation for negotiation of installation of certain portions of the gas loop by the PRTR Phase III contractor.

The design criteria for the backup emergency power source from 384 Building power plant to PRTR loop installations was completed. Specifications and requisitions for the electrical gear to complete the intertie were issued.

Gas Loop Component Testing

The new nozzle closure assembly which had the sealing faces and body made of Hastelloy "X" was completed and put under test. This assembly, which leaked slightly when cold (one cubic foot per day), had no leakage when heated to a temperature of 1500 F and a pressure of 500 psig. Instrumentation used in this test is capable of indicating a leak of 0.001 cubic foot per day. The test was continued for 48 hours under full pressure and temperature. Again, difficulty was experienced in disassembly of the

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seal. This was caused primarily by growth and oxidation of the stainless steel parts. Modifications were started to increase clearances where possible.

The hot test of the flexible hose furnished by Avica was stopped after the hose developed a major leak. The flexible hose lasted about twenty hours at 1200 F and 500 psig with no flexing. Testing of the hose after failure showed many pinhole leaks besides the major leak.

Testing of the outlet helium bellows is complete. Bellows obtained from Parts Engineering and Arrowhead Products were tested. Both bellows assemblies were tested at 600 F for 10,000 cycles. The bellows from Arrowhead Products developed a slight leak after 8000 cycles. The bellows from Parts Engineering passed the test with no leaks evident.

Capsule irradiations of Inconel, Inconel-702, Hastelloy-X and Hastelloy R-235 are in progress to provide information on candidate gas loop materials in respect to effects of irradiation on mechanical properties.

Gas Loop Design Analysis

A number of gas loop transient thermal problems were investigated and are discussed below.

1. Maximum Shroud Tube Temperature Following Loss of Helium Coolant. Previous calculations have shown that it is necessary following the loss of helium coolant flow to inject emergency water to prevent the shroud tube temperature from exceeding 600 F. Those results indicated that if the helium flow were lost during normal full power operation the shroud tube temperature would increase to about 840 F when the loop is cooled at 900 F/hr. The consequences of water injection are extremely severe; therefore, calculations were made to determine the maximum shroud tube temperature when the loop is cooled at the most rapid rate possible by the CO_2 primary coolant.

   The most rapid cool down rate could be achieved by maintaining the 15,000 lb/hr CO_2 flow rate, bypassing the regenerative heat exchanger, turning off the heater and unbypassing the cooler. The loop operating conditions were 1500 F maximum CO_2 temperature, 500 KW tube power, and equilibrium operation. It was assumed that the reactor was scrammed following the loss of helium

   The results of this study show that the maximum shroud tube temperature is about 735 F and will occur about 7.2 minutes after the loss of helium. The shroud tube temperature was also found to remain in excess of 600 F for about 11 minutes. The maximum rate of temperature change in the 3.50" Hastelloy-X piping at the outlet of the test section was about minus 17,350 F/hr or minus 290 F/min.

2. Minimum CO_2 Flow To Prevent Clad Melting

   Following the loss of the CO_2 primary coolant flow the minimum flow of CO_2 from an emergency supply required to prevent fuel element clad melting was determined.

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The loop operating conditions were as described above. In this case GHX-1 was not bypassed, instead it remained totally unbypassed. The CO_2 flow was assumed to decay hyperbolically from the initial 15,000 lb/hr to the minimum flow in one minute. A scram was assumed when the CO_2 was lost.

A minimum flow of 500 lb/hr was chosen as a lower limit. The results at this flow indicate the maximum cladding temperature is about 1970 F. The maximum temperature was seen to occur after about nine seconds or in the flywheel flow decay period. At one minute the cladding temperature was about 1860 F or 110 F less than the peak temperature.

These results indicate only a nominal CO_2 flow is necessary to prevent fuel element damage after the loss of the primary coolant.

3. Temperature Transient Following Simultaneous Loss of CO_2 and Helium Coolant. After a total loss of flow of both the helium and CO_2 coolants, the temperature transient was calculated. The operating conditions assumed were a 500 KW fuel element, 1500 F maximum CO_2 temperature, 15,000 lb/hr normal CO_2 flow and 200 lb/hr normal helium flow.

   Assuming that a scram occurs on loss of coolant flow, the shroud tube would be heated to 600 F at about 1.6 minutes and melt after about 3.3 minutes. The fuel element temperature would increase to 2480 F during this time, well below the melting point of the cladding.

4. Shroud Tube Temperature With No Gas Loop Coolant Flow. The maximum shroud tube temperature was determined for the condition of the reactor at full power when the gas loop was without fuel element, primary coolant flow, or helium flow. It was assumed that above the level of the moderator the gamma heating rate was 14 percent of the maximum rate for the two process and shroud tubes. The heat generated in these tubes is assumed transferred radially to the three adjacent normal process tubes only.

   At these conditions the adjacent shroud tube temperatures would increase to about 616 F, and the gas loop shroud tube temperature would be about 841 F. The inner and outer process tube temperatures would be about 928 F and 954 F, respectively.

   Therefore, a nominal helium or CO_2 flow is required when the reactor is brought to full power and the loop facility does not contain a fuel element.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

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

One hour isochronal annealing treatments at 25 C increments were initiated for copper, iron, and titanium specimens and were extended from 425 to 475 C for molybdenum, zirconium, and high-purity nickel specimens. Both the hardness and electrical resistance of irradiated copper showed practically no change upon annealing at temperatures to 150 C. On the other hand, pronounced drops in electrical resistance occurred between room temperature and 150 C, and hardness recovery occurred at 200 C for titanium specimens irradiated to both 1.0×10^{19} and 1.5×10^{20} nvt. Complete recovery of the electrical resistance for zirconium irradiated to 1.5×10^{20} nvt took place at about 475 C; whereas complete recovery for the lower exposure (4.7×10^{18} nvt) specimen was observed at 400 C. Significant hardness recovery for the 4.7×10^{18} nvt exposure of zirconium was observed above 450 C which constitutes the second recovery region above room temperature. Little change between 425 and 475 C occurred in the electrical resistance of both irradiated nickel and molybdenum; however, the hardness of molybdenum irradiated to 1.5×10^{20} nvt decreased slightly at 450 C. The hardness of both the unirradiated and irradiated molybdenum specimens which increased markedly between 200 and 375 C showed little change between 375 and 450 C.

Age hardening similar to that observed in irradiated molybdenum above 200 C was observed in unirradiated molybdenum which was solution treated at 1150 C and aged at 500 C for 4.8 and 24 hours. Overaging was not observed out to 24 hours. X-ray diffraction studies to determine structural changes in the specimens were started.

X-ray studies of titanium specimens both unirradiated and irradiated to 1.0×10^{19} and 1.5×10^{20} nvt were completed. A slight decrease in the c/a ratio and a line broadening exceeding 50 percent for the 1.5×10^{20} nvt specimen were observed.

An unirradiated molybdenum specimen and specimens irradiated to 1×10^{17} and 1×10^{18} nvt were pre-strained beyond the yield point, annealed for four hours at 350 C, and again plastically strained. Strain aging characterized by a return of the yield point was not observed in any of the specimens; however, a small positive displacement of the yield strength was observed after annealing. A specimen irradiated to 5×10^{18} nvt broke abruptly with practically no plastic strain and exhibited a cleavage-type failure.

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E. CUSTOMER WORK

Radiometallurgical Examinations

Routine Slug Examination (RM-403). Examination of 403-3, an internally and externally cooled Hanford production fuel element, was completed this month. The element exhibited a hot-spot directly opposite the rib marks on the female end. Rough handling of the element prior to irradiation was indicated by several dents which were observed on the surface of the can wall. The flow pattern visible at the female end of the slug indicated that the slug may have cocked slightly in the vertical direction. A pattern was seen both above and below the internal coolant channel. The slug was sectioned transversely at the midpoint and the two halves were sectioned longitudinally. The surface of the internal cooling channel was in good condition, and no unbonded areas were observed. No cracks or defects in the uranium fuel were observed.

Routine Fuel Element Examination (RM-403). Examination of sample 403-4 (KL 257D) was completed this month. This element had erosion-corrosion streaks and pits visible on the top side of the jacket. A scratch observed in the spire was located approximately 3/4-inch from the male end and extended for 1/2 inch. The depth of the scratch was estimated between two and five mils.

Bend Test Samples (RM-329). At the request of IPD personnel, four samples of fuel, each five inches long, were removed from an irradiated 0.020-inch thick wall, coextruded Zr-2 clad, natural uranium 7-rod cluster fuel element. The sectioned samples were shipped to IPD for subsequent bend testing.

Examination of Corrosion Coupons (RM-286). Five Zr-2 corrosion coupons were delivered to the Analytical Chemistry Operation for hydrogen analyses. Thirty-six corrosion coupons were weighed, with 18 being cleaned before weighing.

Lamprey. The lamprey drilling unit is complete and has been tested satisfactorily. A static vacuum of 8×10^{-5} atm was obtained before and after drilling a 9/16 inch diameter, sealed zirconium tube representing a ceramic fuel element. Fabrication of the portable gas collection and measuring system is partially complete. The target date for hot cell operation of the lamprey is June 1.

Radioactive Materials Receiving and Storage Addition (Project CGH-790). Installation of interior wall paneling was completed, and interior painting is about 95% complete. Minor construction forces are preparing for painting of the basin. Acceptance testing of the project equipment has been delayed pending receipt of several small equipment items which were not ordered by the contractor.

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

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Operation	Number
Samples into cell	30
Conveyor transfers	23
Photographs	12
Length measurements	0
Diameter measurements	8
Plastic mounts	1
Grinding	0
Samples sectioned	18
No. of standard cuts*	49

* One "standard" cut = one transverse section on a solid 1-1/2" diameter uranium element.

Metallography Laboratories

A new lapping surface plate was devised for use with the Syntron automatic polishers. It consists of 600 grit silicon carbide abrasive powder mixed into a cold setting polyester resin which is subsequently poured onto the lapping plate, allowed to harden and then machined flat. Preliminary tests show that this lapping surface serves very well as an intermediate step between fine grinding and polishing in the preparation of metallographic specimens. Used in conjunction with the Syntron automatic polishing machines, the new lapping plate prepares a specimen for fine polishing in a short time, although not as quickly as could be done manually. However, the advantages of the automatic grinding and polishing are flatter edge preservation of specimens and the number of specimens done simultaneously which reduces the operator time per sample quite markedly.

Replication and electron microscopy work for the month included the following examinations: irradiated uranium from a 7-rod cluster fuel element, irradiated UO_2-PuO_2 fuel elements, examination for particulate matter in D.O.P. oil, irradiated Al-Pu and Al-Si-Pu alloys, characterization of Spencer fused and Norton fused UO_2 particles, a carbon deposit formed in a loop at ORNL during a natural convection test, and irradiated UO_2 fuel elements.

The results and interpretations of these metallographic examinations will be reported in connection with the respective research and development programs.

Samples Processed During the Month.

Total samples	402
Carbon replicas	33

Photographs.

Micrographs	315
Macrographs	142
Electron Micrographs	219
	676

[redacted]

1252721

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Special Fabrications

Of the first 118 fuel rods processed through the ultrasonic bond tester, 80 percent met the specifications for acceptable rods. To be satisfactory, a fuel rod must not have a non-bond area over 0.125 square inch. It should be noted that the group included ten known, non-standard rods, eight of which were rejected by the bond test. The ten rods were assembled, outgassed, sealed off, allowed to cool, reheated, and extruded.

Normally the pieces are not cooled and reheated. Of the next group of 89 fuel rods subjected to the ultrasonic bond test, 88 percent were satisfactory. No rods have been rejected because of segregation in the Al-Pu core. The average can wall thickness of all rods has been about 0.085 inch.

Over one hundred billets have been cast with both end configurations, thus completely eliminating machining and scrap generation with the exception of chips from cutting off one end. This cut-off operation will also be eliminated by closer control of the tolerances on the mold. Fifteen of the cast-to-shape billets were extruded; one was rejected for end-thickening (dog-boning). This problem will be eliminated by removing the abrupt change of contour at one end. All billets for the fabrication are now being cast to shape.

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Manager, Reactor and Fuels Research
and Development

FW Albaugh:kb

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

MARCH 1960

FISSIONABLE MATERIALS - 2000 PROGRAM

FUELS

Nuclear Safety in the Fuels Preparation Department

The nuclear safety specification for the storage, handling and transporting of 0.96% enriched uranium fuel elements was revised to provide more operating flexibility. These revisions were based on data obtained since 1956 when the present specification was written. The changes are summarized below:

1) The storage of loaded pallets and shipping boxes was increased about 100%.

2) The permissible weight of 0.96% enriched uranium per unit area was increased from 106 lbs U/ft^2 up to 318 lbs U/ft^2.

3) The autoclave loading limit was increased 12%; the spacing required between stacks of autoclave baskets was reduced.

4) The "high lift" truck limit was increased 100-200%.

5) The spacing required between two 0.96% arrays was reduced from six feet down to three feet; a six foot spacing between 0.96% arrays and natural uranium is no longer required.

6) The inter-area truck limit was increased 50-100%.

7) The number of fuel rejects shipped offsite per railway car was increased from 250 to 1000; the number of barrels, each containing up to 200 lbs U scrap, were increased from six to twelve per car.

A talk was presented to 30 FPD engineers on the subject of "Nuclear Safety - Burst Characteristics, Accidents and Controls". Nuclear safety in FPD operations was also reviewed.

STUDIES RELATED TO PRESENT PRODUCTION REACTORS

Neutron Temperature Studies

The galley proofs of the two papers, "An Investigation of Effective Neutron Temperatures" and "Calibration of Lutetium for Measurements of Effective Neutron Temperatures", were received during the month. They have been proofread and returned.

When the spectral index of the thermal neutron distribution (i.e., the neutron temperature for a pure Maxwellian distribution) in a reactor spectrum is measured by lutetium, the measured activities must be multiplied by a factor which corrects

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the total activities to thermal activities. This factor is

$$\frac{CdR-1-\alpha}{CdR}$$

where α is the ratio of the epithermal subcadmium resonance integral to the epicadmium resonance integral and CdR is the cadmium ratio.

In order to obtain an estimate of the effect of α on the spectral index, resonance integrals were calculated for the lutetium isotopes. The calculations have been made under two different assumptions. For one assumption the "1/E" spectrum is joined to the Maxwellian distribution according to a joining function given by Hurwitz. The calculations were made for values of kT which equal 0.025, 0.040, 0.050, 0.075, and 0.100 ev. For the other assumption, the "1/E" distribution is assumed to cut off sharply at μkT. The calculations made under this assumption were carried out for values of μkT which equal 0.093, 0.1252, 0.133, 0.155, 0.186, 0.45, 0.55, and 0.600 ev. The calculations show that the resonance integral for epithermal subcadmium neutrons is approximately four times greater when calculated under the assumption of the Hurwitz joining function than under the "sharp-cutoff" assumption. The calculations made using the Hurwitz model were only for survey purposes and were not calculated as accurately as the sharp-cutoff resonance integrals. More exact calculations will be made with ACE (a program which numerically integrates according to Simpson's Rule).

In order to obtain some idea of how the different assumptions affect a neutron temperature measurement, the results from the Hurwitz model were used to correct the lutetium measurement made in the TTR internal column. The neutron temperature which was calculated with the "sharp-cutoff" model has been reported as 342°K. Using the Hurwitz model it is 325°K.

The program ACE was used to recalculate the five g factors for Lu-176 which were used to normalize the ratio of lutetium activities reported in HW-62777. The results agree with the previous calculations. Factors have also been calculated to compare with experimental data which is being analyzed. This data measures the relative thermal activities of the two lutetium isotopes between 210 and 273°C.

The spectrometer was operated successfully during the whole month. A source of Lu-176m was obtained by irradiation of Lu_2O_3 in the internal column of the TTR. The sample was irradiated in a cadmium capsule in order to minimize the amount of Lu-177 produced. The momentum distribution of the electrons emitted by Lu-176m were measured with the spectrometer. It was found that the more abundant beta particles have a maximum energy of 1.04 ± 0.03 Mev. The specific activity of the source was too low to observe more than one component of the beta spectrum. This preliminary data will be used to plan a detailed analysis of the distribution from a source with a greater specific activity. This source will be obtained from an irradiation at F Reactor. A Development Test has been written and all of the necessary signatures have been obtained for this irradiation.

Neutron Temperature Coefficients

Debugging of the nuclear data tape code has been completed. This code has been used successfully to update the previous nuclear data tape. In addition to the microscopic cross sections for 20 materials, the present tape has macroscopic cross sections for 8 materials. The tape can be easily updated as more data become available.

The nuclear data subroutine, NUDATA, which compiles the nuclear data needed in a reactor code, has been completed and is ready for use. A report on this subroutine and its use is being written.

Multimaxwellian Group Analysis

FIT-1 was operated almost daily during the month in an attempt to fit the epithermal flux data from the neutron rethermalization experiments. Several changes appeared desirable and were incorporated. None of these affected the basic logic of the program explained last month.

The limitations of the program, which had not been brought out in running test cases, are becoming apparent. If all but one of the neutron diffusion parameters are well known, the program will find a value for the unknown parameter quickly and calculate a theoretical traverse in good agreement with experiment. As the number of uncertain or unknown parameters increases, the program's effectiveness appears to decrease. As an example, an attempt was made to fit a set of experimental flux traverses, using a set of epithermal parameters from APEX-369 as first estimates from which to begin iterations. A particular order of parameters on which to iterate was selected, based on estimates of their accuracy. After repeated iterations, the program converged on a set of values of these parameters which differed significantly from the first estimates and for which the calculated flux traverses showed only fair agreement with the experimental measurements. Further tests are being run to determine the effect on convergence of the order in which the parameters are iterated.

Neutron Thermalization

Consideration has been given to the question of absorption hardening of a Maxwellian energy distribution of thermal neutrons in heterogeneous, neutron absorbing media. The neutrons absorbed out of the Maxwellian distribution are represented as a negative source of neutrons. The energy distribution of this source, called the absorption distribution, is that applicable in the limit of small absorption, $M(E,kT)\sigma(E)$, where $M(E,kT)$ is the Maxwellian distribution and $\sigma(E)$ is the total cross section of the medium. The negative source diffuses through the medium until it is rethermalized into the Maxwellian spectrum. The negative absorption flux is everywhere added to the Maxwellian component.

The cross section of a "1/v" absorber averaged over the absorption spectrum is 1.273 times larger than that for the Maxwellian spectrum. For a homogeneous medium the effective neutron temperature is higher than the moderator temperature T_m by an amount $T_m \left[0.546 + 0.075\ (\Sigma_m/\Sigma_{reth})\right] \left[\Sigma_m/\Sigma_{reth}\right]$ where Σ_m is the cross section of the medium and $\Sigma_{reth} \sim \Sigma_s\ \xi_{eff}$ is the cross section for rethermalization of the absorption distribution. The appropriate rethermalization cross section for graphite can be obtained from recent measurements.

Neutron Rethermalization Experiment

A limited description of the recent experiments on neutron rethermalization has been given in previous Monthly Reports. The analysis of these experiments during the past month has been directed towards two primary objectives: (1) to determine the temperature dependence of the rethermalization cross section of graphite between the absolute temperatures 140°K and 800°K, and (2) to compare neutron temperatures obtained from 1/v traverses with those obtained from lutetium traverses. The latter provides a means of checking the applicability of the group diffusion model employed in this analysis.

The analysis for the determination of rethermalization cross sections has been limited so far to the evaluation of the best parameters for the fast flux.

The analysis is a stepwise procedure with one independent step and three dependent steps. They are (1) evaluation of the best $\xi\Sigma_{12}/D_1$ in the two experimental regions, (2) adjustment of Σ_{12} and D_1 to yield the correct fast to slow flux while holding Σ_{12}/D_1 constant, (3) determination of the values of the rethermalization cross sections for graphite which minimize the sum of the squares of differences between the fitted and experimental curves (while holding constant the values found in steps one and two), and (4) determination of the sensitivity of the rethermalization cross section thus found to small uncertainties in known diffusion parameters. The first step is done with experimental values of the slowing down flux at 5 ev, as measured with cadmium covered Au and is essentially independent of the other steps. The last three steps are done with the Au data and traverses of the thermal activity of a 1/v detector (Cu). The precision of the last three steps is rather sensitive to precision of each preceding step. Work on step two is in progress.

Some time has been spent on the analysis of lutetium data for the determination of traverses of effective neutron temperatures. Two problems exist in these calculations. The first problem is that of deciding upon the best description of the energy dependence of epithermal neutron spectrum in the PCTR core. At least four spectra are possible or have been considered sufficient in past work. They are (1) a 1/E spectrum of epithermal neutrons with a sharp, low energy, cutoff at μkT ($\mu \approx 5$), (2) a 1/E spectrum with a Westcott cutoff function defined by μkT ($\mu \simeq 4.3$), (3) a slowing down spectrum based upon small source theory which falls off much faster than 1/E, and (4) a spectrum derived by Hurwitz, et al, which is a 1/E spectrum multiplied by a joining function, H(E/kT). The first two spectra are not significantly different so far as neutron temperatures are concerned. The latter two spectra are significantly different and give rise to temperature changes which may be as high as 20-30°K at 400°K.

The second problem in the determination of the temperature of neutrons with lutetium is one of calibrating the counting system for use with the curve of g^{176} vs. neutron temperature. It has been shown that the ratio of the thermal activities of Lu-177 and Lu-176 m is proportional to g^{176}. The constant of proportionality is a function of irradiation times and counter efficiencies and must be evaluated by each experimenter. The effect of irradiation time must be calculated. The calibration of the counter requires a single foil activated in a thermal column with a cadmium ratio of a 1/v detector $\geq 10^4$ for 1% accuracy, if cadmium ratios are not measured. The ITR thermal column has a cadmium ratio of

a 1/v detector of approximately this value. Data have been obtained for this calibration for these experiments. The analysis has not been completed.

Some calculations of neutron temperatures have been made using a calibration constant which is expected to be within a few percent. The results and experimental conditions are tabulated below.

NEUTRON TEMPERATURES[a,b,c,d]

REGION ONE				REGION TWO			
	Neutron Temperature				Neutron Temperature		
Radius in.	Westcott °K	Hurwitz °K	Uncertainty %	Radius in.	Westcott °K	Hurwitz °K	Uncertainty %
0.5	255	242	±5.2	9.4	341	307	±10.5
2.5	259	248	±4.3	11.4	366	325	±11.8
4.5	266	252	±5.4	13.4	369	324	±13.0
6.5	279	264	±5.5	15.4	395	328	±18.5
7.4	298	277	±7.5	16.8	409	318	±25.0

(a) Region one radii are 0 and 7.5 inches and the graphite temperature is 144°K.

(b) Region two radii are 8.25 and 16.6 inches and the graphite temperature is 290°K.

(c) The "Westcott" temperatures are based on a sharp cutoff of epithermal neutron spectrum at 4.3 kT.

(d) Hurwitz, et.al. Spectrum.

A Program for Analyzing PCTR Data

APDAC-I continued in limited production use, under the control of the programmer. About forty foil traverses and cadmium ratio measurements were analyzed for members of Reactor Lattice Physics. Cost of analysis is from two to three dollars per case. Errors in the input data may run the cost higher, depending on the type of error made.

One definite, and two suspected, program errors have been observed. The press of other work prevented location and correction of these. It appears that, once these errors are corrected, the program can be made available for production use.

Instrumentation and Systems Studies

The infrared radiation pyrometer for potential in-reactor graphite temperature measurements was demonstrated to interested Irradiation Processing Department personnel. Since the demonstration, a method of drift compensation has been tested and shown to improve the stability of the pyrometer. The unit has since

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been installed on a metallograph to read temperatures of Zircaloy specimens in the range of 500° to 1000°C. Preliminary tests at the installation show that the unit compares very well with the thermocouple temperature reading. Final calibration adjustments are now being made.

Investigations continued on methods of neutron/gamma discrimination based on differences in scintillation decay rates (output pulse shapes). A CsI(Tl) crystal and two unactivated NaI crystals were received for use in experimental measurements of the pulse shape effect. Development of a complete electronic system for the detailed study of fast pulses continued.

Circuits were developed for a complete FM magnetic tape unit to record the output of an in-pile radiation monitor. Using only transistor amplifiers, the system from recorder input to read output displays a linearity of + 0.25 percent over a pass band of d-c to 3000 cps. This will be used to obtain information relative to the transfer function of a reactor.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Exponential Pile Measurements of Large Diameter Fuel Elements

Preliminary and final material buckling values have been measured this month for several different fuel elements. The results are given 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	10 3/8 dry	+87	1.5	.305	--	25.03
2.5 x 1.6 with 1.17	10 3/8 wet	+9*	1.5*	.305	.631	25.03
2.5 x 1.6 I and E	10 3/8 dry	+102	1.5	.373	--	34.41
2.5 x 2.0 with 1.66 x 1.1	8 3/8 wet	-85*	1.66*	.493	1.102	21.12

* Preliminary values

The material buckling listed in Table I for the tube-in-tube fuel element was measured in a 6 x 8 foot exponential pile. The other bucklings were measured in 4' piles. The front-rear extrapolation length used in all cases was 1.03 inches. The λ in Table I is the side-side extrapolation length.

A front-rear horizontal traverse has been taken with the counter inserted from the side of the exponential pile. This traverse was taken in order to determine whether or not a possible displacement of the effective center of the BF_3 tube

from the physical center of the tube had any effect on the measured front-rear extrapolation length. The results gave a front-rear λ of 1.06 inches which, within the errors of the measurement, was the same as had previously been measured with the counter inserted from the front of the exponential pile.

Three side-side horizontal traverses have been taken in the 6 x 8 foot exponential pile, with the neutron sources placed at ($\pm$ a/4, 0) and (0, $\pm$ b/4); where a is the effective width and b the effective depth of the pile. The results are shown in Table II.

TABLE II

Cell Position	Points	λ (inches)
Edge	14	1.02" $\pm$ .1
Edge	13	1.14" $\pm$ .2
Between Tubes	7	.90" $\pm$ .05

Thus the side-side λ is essentially 1 inch with this source distribution compared to 1.70 inches in the 4' pile of the same width. Another series of measurements is being taken in the 6 x 8 foot pile with the sources clustered close to the axis of the pile as they are in the 4 foot piles. It is hoped that the results with the new source distribution will help in understanding the difference between large and small pile extrapolation lengths.

PCTR Measurements 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 a 10.5-inch lattice has been partially completed. Preliminary values for the lattice parameters for the dry lattice have been obtained. The k_∞ is 1.045, the 1/v-fuel utilization is 0.918, the resonance escape probability is 0.815 and the fast fission factor is 1.039. Preliminary values from the wet lattice for the k_∞ and the 1/v fuel utilization are 0.982 and 0.830, respectively.

The experimental work with the 2.5" x 2.0", 1.66" x 1.1" tube-in-tube element in an 8-3/8" lattice, with water coolant, has been completed in the PCTR. Analysis of the data is in progress. A preliminary value of k_∞ = 0.985 has been found for the infinite multiplication constant.

The preparation and fabrication of equipment for measurement of k_∞, f, p, and ϵ of a 2.5" solid fuel element in a 10-1/2" lattice is almost complete.

PCTR Measurement of k_∞ and f for Selected Cluster Elements

Refined analyses of the experiments to measure negative k_{ex} lattices have been completed. The lattice was a seven-rod (.925-inch diamter) natural uranium cluster, water-cooled, in a 7-inch graphite lattice. The results of the new analysis do not show quite as good agreement as the preliminary values reported in the December, 1959, Monthly Report. However, useful conclusions can still be drawn. The results are:

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Method	k_∞
Enriching with U-235 - Aluminum alloy	0.949 ± .002
Poisoning with copper	0.941 ± .002
Uniform enrichment of fuel to 1.007 weight percent U-235	0.939 ± .002

The result for the uniform enrichment method was obtained from the relationship

$$(k_\infty)_{nat} = (k_\infty)_{1.007\%} \frac{\eta_{nat}}{\eta_{1.007\%}} \frac{f_{nat}}{f_{1.007\%}}$$

where $(k_\infty)_{1.007\%}$ = 1.063 ± .002 from PCTR measurements

$$\frac{\eta_{nat}}{\eta_{1.007\%}} = 0.8949, \text{ calculated from Westcott cross sections}$$

$$\frac{f_{nat}}{f_{1.007\%}} = 0.9875, \text{ calculated from IPD survey code.}$$

It is seen from the table that the results for the alloy-enriching and copper-poisoning methods do not agree within specified errors. Part of the discrepancy can be attributed to the fact that in the copper-poisoning experiment, the lattice cell could not be placed in the proper spectral environment because of the impracticality of removing absorber from the lattice. The magnitude of the effect can be estimated from observations made in the alloy enrichment method.

It was found that by not enriching the buffer cells (compared to the proper procedure of enriching all 9 cells) a +6 mk error in the observed value of k_∞ resulted. This effect was coupled with a 14% change in the fast-to-slow flux ratio incident on the test fuel cluster. On the basis of the relative change in flux ratio to be expected upon removal of absorber, it is estimated that the spectral conditions prevailing in the experiment caused a minus 3 mk error in the copper poison method. When this estimated correction is applied, the value for the poison method is k_∞ = 0.944 ± .002.

At the present time, no reason is known for the 10 mk discrepancy between the results from the alloy and uniform enrichment methods. However, a change in the effective neutron temperature or uncertainty in the calculated ratios could enter into the difference. The discrepancy is a measure of the effect to be expected in analyzing concentrated versus distributed enrichment.

Improved Methods of Reactor Parameter Calculations

Some months ago, Selengut proposed a new method for calculating effective values of the diffusion coefficient and diffusion length for a heterogeneous lattice. At that time a numerical comparsion of Selengut's method with more conventional methods was begun, using a simple heterogeneous lattice consisting of a solid rod

of natural uranium in a graphite moderator. This work was described in HW-60846 B, p. 5.

Because of the termination of the physicist involved, the comparison was not completed at that time. The work was resumed this month and has now been completed, including several additional cases with rather artificial parameters, chosen to make the effect of the new method more apparent. The results can be briefly described as follows: Two reference methods were used, in which D was calculated from the flux and volume weighted average of Σ_{tr} and $1/\Sigma_{tr}$, respectively. For cases in which these two methods gave nearly identical results, D_{sel} was slightly less than either. For cases in which the two reference methods differed significantly, D_{sel} was an intermediate value. For the L^2 comparison based upon these D values, L_{sel} was somewhat higher than those of the two reference methods, when these latter gave nearly identical results. For cases in which the L^2 of the reference methods differed significantly, L^2_{sel} was again an intermediate value. A more complete description of these results is being prepared.

The fluxes needed in the above comparisons were calculated with the IDIOT program. In the process of this work, a subroutine capable of calculating these different D and L^2 was written and debugged. The subroutine was not incorporated into IDIOT, but this can readily be done if it proves desirable to do so. Subroutines have also been written to increase the convenience of calculating the lattice sums and solving the determinant encountered in the formulation of two-group small source theory for an infinite superlattice.

Exponential Measurements for N Reactor

The theory needed for the analysis of control rod measurements in an exponential assembly has been developed for a single rod case. Experiments with the rod in pure graphite and then in a lattice are considered to determine separately the thermal and epithermal extrapolation distances into the rod. Harmonic corrections have been neglected.

PCTR Measurements for N Reactor

The design of the graphite and tubing for the condensed lattice is essentially finished and working prints are being prepared. The foil holder design has been altered, so that the pieces of the holder are interlocking, for ease in positioning the foils in the holder.

The order for the graphite for the mock-up lattice has been placed at about 2/3 the price of earlier bids. Delivery is expected about the end of May.

Instrumentation and Systems Studies

Fabrication has started on the two-range, two-detector prototype Scintillation Remote Area Monitor for NPR. All design-development work is completed.

Because of modifications to the north gamma calibration well facility of the Calibrations Building for a portion of the month, the evaluation tests were not completed on the prototype experimental Logarithmic Scintillation Remote Area Monitor. However, about two weeks of continuous running stability tests were done with readings made every day at various gamma dose rates from 20 mr/hr to 5 r/hr. The reading variations at each check point for the two weeks was less than ± three percent.

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Fabrication was completed on the lead shield detector head for the prototype NPR Scintillation Beta-Gamma Air Monitor. The incorporated lucite light pipe and terphenyl-in-polyvinyltoluene detector was tested with a point beta-gamma source. Variations in geometry were less than four percent over the complete two-by-four-inch area. All of the circuitry for this instrument has been previously developed and tested; therefore, the circuitry merely needs to be fabricated to complete the instrument. An adequate air pump has been determined and will be ordered.

Continued progress was made concerning the prototype NPR Fuel Element Rupture Detection System. The detailed fast and slow-scan mechanical design was completed for the full-scale mockup. Mechanical fabrication of the full-scale mockup was started and is proceeding on schedule. It is scheduled for completion in two months. An interim status report is near completion.

An analog program has been prepared to determine the minimum number of vents needed in the NPR confiner. It is desired that pressures below 5 psi be maintained. Various types of incidents will be considered; e.g., a break in a header. This problem will be completed in April.

Results from the NPR Heat Exchanger (HX) program were obtained this month. The program gives the HX response, where the heat transfer coefficient is a function of the primary and secondary temperatures and flow rate. The HX was also sectionalized to provide a better description of the outlet temperature. The results included the HX response to various disturbances, such as inlet temperature variations, flow decay, and variations on the steam temperature. These results were forwarded to Reactor and System Design Analysis - IPD Design.

Analog computer solutions of the reactor kinetic equations were obtained. These are more consistent than the Litton DDA results and check the theory more closely. There is encouragement that the nature of the solutions can be predicted theoretically.

Mechanism of Graphite Damage

The linear differential transformer was used to measure length changes in KC graphite being irradiated with electrons. Most of the reading of the device was found to be due to thermal expansion of the transformer jig. This will have to be controlled or eliminated before the transformer can be used in experiments.

STUDIES RELATED TO SEPARATIONS PLANTS

Plutonium Critical Mass Facility

The current status of the project as reported by Construction Engineering Operation is as follows:

The total project is 78 percent complete versus a scheduled 87 percent. That portion of the project covered by the fixed price contractor is 95 percent complete versus a scheduled 93 percent. The total project status reflects the continued delay during the month in delivery of the instrumentation and control system. On March 30, however, word was received that the complete system had been shipped with expected delivery at Hanford on April 4. Since it is not certain what effect the delay in delivery of the instrumentation will have on the completion of the facility, no changes have been made in the original date of completion which is June 30, 1960.

[redacted]

Bids were received and a purchase requisition let for fabrication of the in-hood reactor components. These include control and safety rod drivers, dump valves, and supporting structures, etc.

An order was placed for additional reactor vessels to be used in the initial series of experiments with plutonium solutions. This order includes two spherical vessels with nominal diameters of 12 inches and 13 inches, which may be used in both bare and reflected criticality experiments, and two cylindrical vessels with diameters of 11 inches and 13 inches, designed for unreflected criticality experiments. Design is proceeding on cylindrical vessels for reflected experiments.

Design is also proceeding on a split half critical assembly machine for use in criticality experiments with solid fuels (simulated precipitates) which are being developed to explore critical phenomena in the H/Pu range of 5 to 30.

Experiments for Nuclear Safety Specifications

Exponential measurements were continued for determining the quantity of neutron absorber which must be added to a water moderator in order to "safe" a heterogeneous system of enriched uranium. The buckling was measured with one percent enriched uranium rods of 0.925-inch diameter at an H_2O/U volume ratio of 1.37 (lattice spacing of 1.40 inches). The buckling for the unpoisoned lattice was $3040 \times 10^{-6} cm^{-2}$. The buckling for the case of 1.5 gm/L boric acid in the moderator was $1882 \times 10^{-6} cm^{-2}$.

Exponential experiments were conducted with natural uranium fuel elements in light water. The measurements were done in order, 1) to better evaluate the safe mass limits for natural uranium in light water, and 2) to obtain buckling values for the interpretation of planned experiments involving a three-percent lattice reflected by a natural uranium tamper; this type of system could be obtained if enriched uranium were inadvertently placed in a dissolver containing natural uranium. The fuel elements for these experiments were 0.925 inch in diameter and were positioned in thin Lucite tubes. The buckling was measured for two lattice spacings. With this fuel rod diameter the buckling should have been near the optimum value for natural uranium in light water (as predicted from calculations and offsite measurements). The results for the two lattices are summarized below. In both cases the buckling was negative. However, the error limits for this kind of measurement are relatively large.

Buckling for Natural Uranium Water Lattice

Lattice Spacing	H_2O/U Volume Ratio	Buckling
1.5 inches	1.89	$-24 \times 10^{-6} cm^{-2}$
1.6 inches	2.29	$-367 \times 10^{-6} cm^{-2}$

The error limits in both cases are estimated to be about $\pm 250 \times 10^{-6} cm^{-2}$.

An exponential experiment will also be made with a 1.4-inch lattice which should permit a better estimate of the maximum buckling for the natural uranium light water lattice.

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Data Correlation - Development of Nuclear Codes for Criticality Calculations

The initial reduction of the P-11 plutonium criticality data to an empirical-one-group representation has been accomplished. It appears evident that not enough data were taken at any given H/Pu ratio to give much confidence to the parameters which are derived, namely, buckling and reflector savings. Some further analysis is possible and work on the data will continue.

Seven nuclear codes, which involve both diffusion theory and transport theory, were obtained for the 709 Computer from Atomics International Division of NAA. These codes can be used for calculating, 1) flux and power distributions, 2) criticality parameters, 3) perturbation effects, and 4) reactor kinetic behavior.

The IDIOT code has now been modified to compute parameters for water-moderated systems, including systems fueled by Pu-Al alloy fuel elements; this code is now operable on the monitor system.

Work was continued during the month on the Monte Carlo code for infinite homogeneous systems with principal attention being given to the cross section data for the data tape.

Critical Hazards Specifications

1. Nuclear Safety in Hanford Laboratories Operation

a. The nuclear safety of a metal box designed for shipping 7.4 wt. % Pu-Al alloy fuel rods offsite was reviewed. The approved box (SK-3-9345) is 24" x 18" x 65" and holds 12 rods on a 3" center-to-center spacing. The rods are 6" from the outer edges of the box which assures a 12" spacing between the rods in any two adjacent boxes. The specification requires that each rod be at least 0.9" in diameter; the plutonium content must not exceed 88 grams. For the mass and spacing limits specified, any number of loaded boxes would be safe if flooded with water.

b. The nulcear safety of the Redwood Car was revised to include the shipping of 7.4 wt. % Pu-Al alloy fuel rods in the same car with plutonium metal. The revised specification permits the Redwood Car limit of 225 Kg of plutonium (the same mass limit as previously used) to be made up of plutonium metal in birdcages (4.5 Kg Pu/birdcage, maximum) and 7.4% Pu-Al alloy fuel rods in approved shipping boxes (1.1 Kg Pu/box, maximum).

c. The nuclear safety specifications for Hanford Laboratories, which are being prepared in accordance with HLO Nuclear Safety Bulletin No. 1, are about 60% complete. Rough drafts of the primary specifications have been sent out for comment to each of nine operating components. It is estimated that a total of 26 specifications will be prepared to cover present operations in HLO. To date, three of these have been approved and issued. In many cases, the specifications currently in effect are being revised to include recent process changes.

2. Chemical Processing Department

a. A nuclear safety specification for the transporting of plutonium metal masses between Task III and the storage vaults in 234-5 Building was reviewed. A special cart is to be used for these transfers. The specification requires that, 1) the storage positions on the cart be limited to 2.5 Kg (max.) of plutonium metal on at least 12" centers, 2) the plutonium be fastened in place on the cart while in transit, and 3) the spacing between the plutonium on the cart and plutonium passed in transit be at least 3 feet. Interaction calculations show that the loaded cart would at least be safe if two storage positions were inadvertently double-batched.

b. The nuclear safety of the design proposed for the feed make-up facility for the critical mass laboratory (CMF Facility, 234-5 Development Operation) was reviewed. This facility will utilize 13 vessels in four primary hoods. Each vessel will be shielded with 1" of lead and 8" of concrete. Each vessel is therefore fully reflected; however, interaction between vessels is essentially nil. In the "Solution Tank Hood", four of the five vessels proposed are safe by geometry (5.3 I.D., less than 275 g Pu/L); the fifth vessel (also 5.3" I.D.) may not be safe at the proposed 700 g Pu/L (maximum). A recommendation was made that this vessel diameter be reduced to 4.9". In the "Ion Exchange Hood", a 2-1/2" thick slab tank is proposed. This tank is not "infinitely" safe for all conditions, but will be safe at the proposed operating limits on volume and concentration. In the "Concentration Hood", three 4" I.D. vessels are geometrically safe and one 6" I.D. vessel will be safe by limiting plutonium concentration. Sumps and enclosures around the vessels that might be a hazard in the event of a leak, will be evaluated when further design information is obtained.

c. A nuclear safety specification for the RMC Fabrication Line was reviewed.

d. A nuclear safety specification proposed for the storage vault in Room 190 in 234-5 Building was reviewed. This vault will contain plutonium as metal, powder, and solution. The unit mass limits will be 2.5 Kg for metal and powders and 400 g for slag and crucible fragments and solutions. All units will be 12" or more center-to-center. The proposed array of about 30 units is safe. As an added degree of safety, it was recommended that the lower of the three cabinet shelves be used for solution storage and the top be used for metal; the center shelf would then be used for slag and crucible fragment storage.

e. A design proposed for the metal solution storage tank (SK-2-18185-Cell 13) to be used in the NPF Reprocessing Facility was reviewed for nuclear safety. This tank is made up of six parallel slabs connected at the ends to form one continuous slab. Each slab is about 9 feet wide and 13 feet high. Two slabs are 4" thick throughout; the other four are 4" thick in the lower 12" of height and 9"-10" thick in the upper 11 feet. Solution level will be at about 10 feet (2500 gallon working volume). For 3.4% enriched uranium, the 4" slab thickness is critically safe at all solution concentrations; the 9"-10" thick sections, however, are only safe up to a concentration of about 600 g U/L. A final evaluation of this tank will be made when the design changes are complete.

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Critical Mass Theory Studies

Debugging of the RKE program, which numerically integrates the reactor kinetic equations with time varying reactivity, was continued during the month. Several errors responsible for discrepancies in the program calculations for an analytic test case were located and corrected. Agreement within the accuracy of the convergence criterion has now been obtained for this case. For more representative cases the flux calculations appear to be adequate but the time increments required are often undesirably short. These short time intervals are caused by mathematical transients introduced into the solution by the numerical integration technique. Encouraging progress is being made in increasing the time steps by reducing these transients.

A short program for calculating the extrapolation length of spheres, cylinders, or slabs has been written and debugged. The program solves an empirical formula by an iterative technique.

Mass Spectrometry

The difficulties which have been encountered in the past with high voltage breakdown in the ion source of this mass spectrometer have been remedied for the present by a thorough cleaning of the system. In addition, a liquid nitrogen cooled copper trap was added to the source region to maintain a lower source pressure and reduce the time necessary to outgas a sample preceding an analysis. The performance of this system was satisfactory.

The use of a shaped filament to obtain an improved fraction of metal ions from uranium samples was studied for several different sizes of V-shaped filaments. Improved metal ion yields were obtained for the shaped filament but an optimum shape has not yet been determined.

Monoenergetic Neutron Age Experiment

At the suggestion of a referee of the manuscript entitled "Age of Na-Be Neutrons in Water and Kerosene" an attempt was made to fit the observed asymptotic flux distributions with a function of better theoretical basis. The data have now been reanalyzed and a consistent fit obtained to the functional dependence of the asymptotic flux. This analysis has led to slightly revised values of the experimental age. The resulting best values for the age to indium resonances of Na-Be neutrons are (13.88 ± 0.22) cm^2 in water and (13.84 ± 0.21) cm^2 in kerosene. These values are in better agreement with the calculated values of $(13.90 \pm .14)$ cm^2 and $(13.94 \pm .08)$ cm^2, respectively. The measured thermal migration areas become (21.5 ± 0.4) cm^2 and (20.6 ± 0.4) cm^2 compared with calculated values of (22.2 ± 0.5) cm^2 and (21.8 ± 0.5) cm^2 for water and kerosene. The paper describing this experiment has been rewritten.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Scattering Cross Sections

Three aluminum single crystals grown in aluminum oxide crucibles were examined for perfection by neutron diffraction using the 105-KE spectrometer. All three crystals were grown such that the heat loss of the liquid was conducted through the liquid-solid interface. One crystal grown in a short freezing time in an

air atmosphere contained many bubbles and holes. The diffraction pattern showed structure which persisted over 1.5 degrees. The diffraction patterns observed from a crystal grown with a long freezing time in air and one grown in a short freezing time in vacuum showed higher efficiencies and narrower reflections. Reflections from different parts of the crystals indicate a more perfect structure near the beginning of the growth. Both crystals contain regions which may be suitable for construction of a composite crystal for use as a high efficiency monochromator.

Subthreshold Fission

The fission cross section measurements of the 5.2 ev resonance in the target nucleus U^{234} have been completed and final resonance parameters have been obtained. The measured fission peak height was corrected for resolution and doppler broadening to give a true fission cross section of (49 ± 9) barns at the peak of the resonance at (5.20 ± 0.04) ev. The fission width of the resonance obtained from this result and the listed parameters for the total cross section is $(2.0 \pm {}^{2.2}_{1.0}) \times 10^{-5}$ ev.

The resonances in Pa^{231} could not be seen in fission with the neutron intensity available with the present collimation system.

The preparation of foils enriched in the isotopes U^{236} and U^{238} has been completed. These foils are being mounted in the multiple plate fission chamber for fission cross section measurements on these nuclei.

Fast Neutron Cross Sections

The new chamber for the Van de Graaff analyzing magnet is essentially complete and its attachments are under construction. Assistance was rendered to Radiological Physics in establishing a permanent baseline for the accelerator and in correcting the misalignments which arose during the extended outage which began in December.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

PRTR Startup Experiments

The approach-to-critical experiment for a Pu-Al annulus surrounding a UO_2 core has been modified so that the PRTR is allowed to go critical first with the moderator at full height rather than at half height as was originally planned.

The Critical Facility of the PRP

The content of an experimental program for the Critical Facility has been outlined. This was done in the preparation of a recommendation concerning the program.

Multichannel Analyzer

The bids for the analyzer have been reviewed. The recommendation was made that the quotation by Radiation Counter Laboratories be accepted on the bases that

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improvement in resolution of this method is anticipated.

A survey of methods for detecting micro-displacements of metal surfaces for use with the eddy current ultrasonic transducer has been completed and has been summarized in Physical Measurements Memorandum 60-7. The most promising method found in the literature of the field is a capacitance bridge radio frequency carrier system with which the Bureau of Standards detected vibrations having amplitudes less than 10^{-9} cm.

The input noise level of the amplifier system for use with the infrared detector head being used in the thermal bondtesting program has been reduced to about 0.3 microvolt. Dark noise generated within the photoelectromagnetic infrared detector now being used could not be detected above this level. Tests of the sensitivity of the present infrared pyrometer system to changes of the surface temperatures of autoclaved X-8001 aluminum alloy cans show that 1/2°C changes within an area of about 4 square millimeters can be detected at temperatures between 30 and 50°C. Since the sensitivity is still limited by the noise generated within the pre-amplifier it would be possible to obtain even greater sensitivity by further reducing pre-amplifier noise. Comparison of the sensitivity of the instrument to temperature changes of various aluminum surfaces shows that autoclaving greatly increases the emissivity of X-8001 alloy.

An experimental power printing circuit, for use with an Alden Helix recorder to produce area-temperature maps, has been fabricated and tested. This circuit provides a 1000 cycle rectangular wave output having a positive half cycle duration proportional to the amplitude of the 2000 cycle output of the detector system. The negative half cycle is maintained at ground potential. When applied to the Helix recorder, this output produces an area covered with broken lines, the length of each line segment being a function of the temperature at the corresponding point in the area scanned by the detector. Tests have shown that a larger Helix recorder, than the 5-1/2 inch Helix borrowed for evaluation, will be needed for reliable quantitative maps of fuel element surface temperatures at 1/8 inch intervals.

A single turn work coil has been used with the 10 KC, 50 KW induction heater. Only 1 KW could be coupled into the test piece due to the poor impedance match. An eddy current concentrator type work coil, which should be more efficient, is now being fabricated.

Arrangements have been made to borrow an infrared Model TD-1 Thermdot Radiation Thermometer from the manufacturer (Radiation Electronics Corporation) for evaluation on site during one week in April.

Several developments to improve general eddy current test methods continued. Work has begun on a modification unit to be used with the General Radio (Type 1005-A) Impedance Comparator. A circuit has been designed, and is awaiting fabrication, which will make it possible to effect a 360° shift in the phase of the Z and θ reference voltages of the comparator and will also provide for the present 90° angle between them to be varied. The unit will also house a low-noise preamp stage, a null-balance circuit for use with eddy current probes, and a crystal stabilized oscillator to improve the frequency stability of the instrument.

The delay line type, pulse stretching circuit, described last month, is being modified for direct application in the automatic gain control input network to be used with the Inductive Thermometry Instrument. By proper selection of parameters it has been found that a 0.13 microsecond pulse can be stretched into a pulse having almost constant amplitude and 22 microseconds duration, due to the effect of reflected waves in a six section network. This represents a stretching ratio of approximately 170.

During the investigation of the variables encountered in the laboratory in measuring the PRTR process-tube-to-shroud-tube distance using an eddy current method, it has been found that spacing changes within the required accuracy can be detected by employing conventional techniques. The long term reproducibility requirements constitute the major problem at the present time. This is particularly true in view of the fact that the indications are extremely sensitive to variations in spatial orientation of the probe.

GAS COOLED REACTOR PROGRAM

Lattice Parameter Measurements

Data analysis of the EGCR stainless steel loop experiment has been delayed due to a failure on the part of the computer program (APDAC) to properly calculate the specific activities needed for determination of geometric correction factors and cadmium ratios. The program did handle successfully, however, a calculation of specific activities, geometry corrected, based on geometric correction factors obtained from an alternate machine code. The analysis is continuing with these data. Calculations of the average flux in each cell component are being made.

Most of the preparations for the next EGCR experiment have been completed. Plans have been made to measure k_∞ and f for 2.6 w/o UO_2 fuel. Special graphite spiders and end caps have been fabricated which will be used to measure the flux peaking which can be expected in spiders and end caps with low absorption and high moderation characteristics. A measurement of the r, θ power distribution within the fuel tubes is also planned as part of the experiment.

A report for Allis Chalmers has been completed on the measurement of k_∞, f, p, and ϵ for the 1.8 w/o UO_2 fuel elements. The report is presently being prepared for distribution.

Variation of Doppler Coefficient with S/M Ratio

Experiments are in progress in the PCTR to measure the Doppler coefficient of a 1.92 inch diameter solid natural uranium fuel element in a dry 8-3/8 inch graphite lattice. The lattice parameters, p and ϵ, for this configuration are also being measured, with air coolant and with H_2O coolant.

Measurements of PCTR reactivity as a function of test cell fuel element temperature have been made over the range 100°C to ~ 750°C. The test element was heated to ~ 950°C, but handling operations and reactivity transient decay times caused the loss of ~ 200°C before beginning data recording.

Several incidents have marked this first experiment. The quartz envelope was fractured while the slug temperature was ~780°C. Use of the helium dump system to flood the element with an inert atmosphere prevented any uranium fire and any

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gross oxidation. Warping of the fuel pieces upon passing through the two phase transitions caused a loosening of the shrunk-fit joints in the 20 inch element.

Several auxiliary experiments have been performed. The PCTR pressure and temperature coefficients of reactivity were measured for the 1.92-inch lattice configuration. The pressure coefficient was found to be -0.0407 cents/millibar. The temperature coefficient data has not been analyzed yet.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Two field experiments designed to measure the dispersive capacity of the atmosphere during unstable temperature gradients were completed on March 11 and March 15. Dosage data were obtained to a distance of 3200 meters from a ground level source, utilizing both the horizontal and vertical sampling grids. Preliminary analysis of the vertical dosage data indicated that the profiles were much flatter during unstable than during stable conditions--a result predicted earlier from theoretical considerations.

Perfection of the phosphorescent technique for assaying ZnS loadings on the membrane filters exposed during the summer experienced another setback and recovery this month. The transistorized automatic gamma counting equipment was found to be so sensitive to environmental conditions that it was decided to return to a Tri-Carb system similar to the one on which the original development work was done. Certain sample handling and automatic timing features were incorporated into the new equipment to improve the accuracy and ease of operation. Thus far, the stability of the system has proved satisfactory and counts on given samples can be duplicated within acceptable limits. Work toward complete calibration of the system, required before routine reanalysis of samples can be scheduled, was in progress at month's end.

Preparation of individual chapters and data compilations for the Geophysics Research Papers, comprising the general report on the past summer's dispersion and transport experiments, continued according to agreement with the Air Force. The chapter titled, "Wind Prediction for the Green Glow Program", by C. L. Simpson, was reviewed by the Air Force and returned with editorial comments. The machine compilation of the Portable Mast data was completed in a form suitable for direct reproduction in final reports. The summaries were edited and corrected in preparation for transmittal to the Air Force. Analyses of streamlines, trajectories, tracer arrival time, and transport speeds were essentially completed and the numerous charts required were prepared for publication. Rough drafts of other sections of the report were started.

DOSIMETRY

A cooperative experiment was begun with Dr. C. L. Finch of the University of Washington. The purpose of the experiment is to measure the uptake of orally administered Fe^{59}. Three subjects were given iron salt and three were given a hemoglobin solution at the University of Washington. Two weeks later they were brought to the whole body counter and counted. They were compared with two subjects from Richland who were given intravenous injections of Fe^{59}. Our part of

the experiment is done but the results cannot be calculated till Dr. Finch has finished some of his calibrations. Incidental to the experiments we obtained an Fe^{59} calibration for our counter. It was very close to a value we extrapolated from data for Na^{22}.

The calibration of the whole body counter for Zn^{65} was improved but more work remains to be done. There appeared to be rather large differences in the calibrations obtained with different people. Some of this may be due to different distribution of the Zn^{65} in the body. The distribution in one subject was studied for one month. Initial deposition was in the area of the liver. Later counts showed a spread into the legs and head.

Counts were made of individuals lying on a table with the big crystal at a fixed distance above them and moved along their body in four-inch increments. It was found that for K^{40}, Fe^{59}, Zn^{65} and Cs^{137} the total count obtained in this way by scanning from head to toe was 95% or more of the count that would be obtained by moving the counter well beyond both extremes of the body. Theoretically, the latter procedure is necessary for an ideal count. The experiment shows that the restricted scan is quite adequate for our purposes.

Tests of a shadow shield counter showed that below 0.5 Mev there was a large increase in the radiation spectrum due to the scattered gamma rays. It was found that 90% or more of this scattered spectrum could be removed by lining the wall of the cell being used to create the shadow with 1/16 inch sheet of lead. This was considered adequate. When sacks of sugar were put in front of the counter to simulate a person, considerable scattered radiation was again introduced into the counter. Attempts are being made to reduce this through use of more lead shielding.

An employee was found to have an unusually high Zn^{65} burden (36 mμc). His diet, his wife, and his fellow workers were examined but no reason for the high burden was found.

Other Activities in Whole Body Counting: Another de-bug run was made on the IBM system. The system now appears to work all right. A bed was fabricated and installed for use in the scanning counting. A new, more rigid and durable chair is being fabricated.

Precise optical methods were used to align the positive ion accelerator to eliminate the beam striking obstructions in the machine and in preparation for very accurate experiments with the precision long counter. The deposition of carbon on targets in the accelerator was found to be very substantially reduced as a result of the cleaning and the substitution of untreated "O" rings during the recent shutdown of the accelerator.

The National Bureau of Standards is sending us their precision long counter. It and one from CPD will be compared with ours in an experiment in which it is hoped reproducibility of 0.1% will be achieved.

A technique was developed for depositing carbon targets for the Van de Graaff with a carbon arc. Targets ranged from 140 to 1300 micrograms/cm^2 and were quite hard surfaced. Bombardment of these targets with deuterons was used to provide a high intensity source of monoenergetic neutrons for calibration of the criticality dosimeters being installed at Hanford.

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Fabrication of one of the molds for the production of tissue equivalent chambers was completed. In correspondence with Dr. W. Snyder, of Oak Ridge, it was found that he is going to make neutron penetration calculations for a phantom 30 cm in diameter and 60 cm long. We plan to make depth dose measurements in a similar phantom. He has offered to calculate the depth dose for distributions of source energies below 10 Mev.

The gamma ray calorimeter water bath was connected adiabatically in order to improve the reproducibility of the system. The noise and drift in the calorimeter were reduced to one-fifth by the change.

INSTRUMENTATION

A miniature phototube detector was received for the personally-carried personnel alarm dosimeter. Minimum signal-to-noise ratio was determined to be better than 2:1. The final mechanical-physical arrangement of phototube and the ionization chamber was determined. Only some transistor circuit design remains to be done to complete the "breadboard" layout for use in extensive tests. Minimum continuous operation is being designed to exceed 100 hours. Selectable alarming to ± 10 mr accuracy will be available from <20 mr to about 200 mr.

All of the experimental transistorized circuitry was completed for the alpha air monitor using coincidence counting techniques to eliminate radon-thoron background effects. All the circuitry is on plug-in printed circuit boards and the circuitry is now driving the recorders. Extensive testing will now be conducted to determine the ultimate available sensitivity.

The experimental circuitry for a portable scintillation beta-gamma dose-rate meter was extensively revised during the month. The instrument uses a semiconductor chopper input and all transistorized circuitry. Several commercial semiconductor choppers were investigated, tested, and found to be useless for the temperature range and input current requirements of the instrument. A chopper circuit, using inexpensive germanium transistors, was developed and tested quite satisfactorily during the month. This works correctly from minus 20°F to plus 140°F with an output noise-level equivalent to about 0.05 microamperes input signal current. Thus, the system can perform properly for input currents of 0.1 microampere to 10 microamperes. The complete instrument reading error due to temperature variations is less than ± 10 percent for minus 10°F to plus 140°F using zinc cell batteries. Mercury cell batteries cannot be incorporated as they are useless below plus 15°F.

Investigation was made of several mixed plutonium-americium sample sources used for animal experimentation at Biology. The sources are used to generate aerosols for the animal inhalation experiments. It was determined that the americium component contributed from 46 percent to 79 percent of the total counts obtained from lung deposition.

Due to ambient temperature effects, portions of the circuitry for the transistorized logarithmic count-rate meter were redesigned. Attempts are being made to obtain proper operation from 0°F to plus 140°F.

Further development progress was obtained on an alternate miniature personally-carried approximate dose-rate integrator alarming device. Improvements were made in the drive mechanism to the miniature integrator.

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An investigation was started concerning possible magnetic tape recording of gamma energy pulse height spectral data from several simultaneously operating scintillation detectors. An eventual possible use of such a system will be the Total Body Counting Facility and an additional use would be for the Biology Operation. Such a system would eliminate the requirement for using a multichannel analyzer for each detector. Using a linear amplifier and a coded analog-to-digital converter, simultaneous spectral information could be taped and then leisurely inserted into a single multi-channel analyzer at a convenient time.

Continued operational success was achieved during the month with the experimental transistorized alpha monitor (110 VAC-operated) which uses either, as desired, the old air proportional alpha probe or the new non-gamma sensitive (to 10 r/hr) scintillation alpha probe. The unit was successfully used three weeks at Redox and now is in constant use at the 308 Building. Geometries with the new scintillation probe exceed the air proportional probe geometries by five percent, and the scintillation probe geometry variation is less than about ± two percent over the two-by-four-inch and two-by-seven-inch active detector areas. Plant drawings of the new probes are being made so that the probe can be obtained in quantity.

The necessary parts have been ordered for the electron beam deflection and control system for the electron Van de Graaff. The instrument will be assembled after all of the parts arrive.

Some investigative effort was started concerning the use of high purity silicon P-N junctions for use as alpha detectors, alpha particle energy analyzer detectors, neutron detectors, etc. This program will accelerate when the proper silicon ingot material is received so that the detectors can be fabricated.

The use of glass dosimeters is being investigated; however, later information concerning the detector materials and fabrication is awaited from the U. S. Naval Research Laboratory. It appears, with the new CaF_2 detectors, that accumulated gamma doses as low as one to five mr may be read out easily.

Two transistorized audio power amplifiers of 1.5 and six-watt output capabilities were designed and one was tested. These will be used with aurally-indicating radiation monitors under high ambient noise conditions.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Research and Development

The mass spectrometer for this program operated at about 90 percent efficiency during the month. Two days were spent in cleaning the source region to eliminate uranium backgrounds and on general spectrometer maintenance. About half of the available operating time was spent in determining the possible effects of chemical solvents used as the carrier for sample material. From the standpoint of sample sensitivity and the required outgassing times the carriers HNO_3 and $NaSiO_3$ gave clearly better results than four other solvents tested.

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TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month. There were four unscheduled shutdowns due to electronic failure.

The 8-3/8-Inch Lattice Tube and Tube k_∞ and f Experiment was completed during the month.

The Fuel Temperature Coefficient Experiment with 1.92-inch natural uranium fuel was started during the month.

Installation and testing of a special fine control rod was completed. For reactivity changes of four cents or less, rod changes can now be determined to 0.001 cents.

The core mockup jig was completed and installed. Test cores up to the maximum usable size can now be set up and checked without sacrificing reactor time.

In the TTR seven days were used for lutetium thermometer calibrations. For the remainder of the month, the Critical Mass Experiments utilized the TTR facilities.

There were no unscheduled shutdowns during the month.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	85.9
24-Hour General	62	83.9
Special	152	92.1

March, 1960, produced a wide variety of meteorological conditions. Temperatures ranged from a low of 13 on the 4th to a high of 83 (an all-time record high for March) on the 25th. The over-all monthly average of 45.1 was slightly below normal.

Weather during March included rain, snow, hail, and one rather severe thunderstorm. In Richland, but not at the station, sleet and freezing rain also occurred. Total precipitation of 0.67 inch was nearly twice the normal. Still there was a long dry period with no measurable precipitation from the 8th to the 26th.

Nine consecutive days of the above-specified dry period, including 5 straight clear days, had an over-all average wind speed under 5 mph. For the month as a whole, however, both cloudiness and wind speed were above normal.

Instrumentation

The Scintillation Detector Mask Monitor for the Laundry Operation was delivered and is being field-tested by radiation monitoring personnel. The background at the Laundry Building was determined to vary from the mean by at least twice the

standard deviation. Such large variations in background effectively reduce the ultimate instrument sensitivity. It appears that background checks will have to be made about every ten minutes to assure proper mask reject level.

A slip-ring assembly for use with GM tubes was designed, fabricated, and delivered to Redox. The unit will be used for shallow well monitoring in the 200 Areas. The unit operated satisfactorily.

A scintillation transistorized shoe and clothing monitor was calibrated, tested, and delivered to the Chemical Research Operation, HLO. The unit was fabricated in the 328 Electronics Shop to our specifications. In addition, three portable transistorized scintillation alpha, beta, gamma instruments were calibrated and delivered to the same customer.

Three Scintran alpha monitors and one scintillation transistorized alpha hand counter were calibrated, modified, and delivered to the 308 Building. The units were fabricated to our specifications by the Instrument Laboratory of Seattle.

Advice was rendered to the design draftsman doing the layout work for plant-type electromechanical drawings for the Scintillation Transistorized Alpha-Beta-Gamma Hand and Shoe Counter.

A portion of the probe design was completed for a large area, thin NaI crystal, Pu^{239} X-ray detector to be used by Radiation Monitoring and Industrial Medicine Operation for the detection of Pu^{239} in wounds. All necessary commercial parts have been ordered.

The 328 Building Electronics Shop is fabricating two advanced model (Model II) Scintran alpha monitors which will incorporate special features desired by field monitoring personnel. These will be evaluated and field tested when completed.

An in-cell monitoring system was designed for the Chemical Research Operation, HLO. This incorporates a high-level ionization probe and a low-level scintillation probe--both with beta-gamma sensitivity. The probes will be used in hot cells for dose-rate measurements. The complete instrument will be fabricated to our design by the 328 Electronics Shop.

An air filter monitoring system was designed by us for exhaust filter monitoring by the Chemical Research Operation, HLO. The unit will be of a gamma detecting scintillation type incorporating alarming circuits for dose-rate alarming.

Evaluation of a "Fido" pocket, gamma, aurally-indicating monitor was completed with unsatisfactory results. Satisfactory acceptance tests were completed on two more scintillation transistorized gamma energy analyzers for the Radiation Protection Calibrations Operation.

The specifications for the POTR automatic data recording system were revised and forwarded to Reactor Lattice Physics (HLO).

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Development was initiated on a part of the PRTR process tube inspection probe. Several manufacturers were consulted about instruments to measure the tube's inside diameter. One linear variable differential transformer system appears to be well adapted to the proposed equipment.

Several of the process controller circuits to be used in studying autoclave temperature control systems have been simulated on the Donner analog computer. These circuits are different from the normal controller simulations in that they include the effects of "reset windup" and controller limiting during process startups. These controller circuits and other circuits which will represent the autoclave process dynamics will be combined and programmed into the GEDA analog computer early in April. Modifications to the existing autoclave control system are being made to allow the use of proportional control with manual reset. It is expected that these changes will allow the existing equipment to provide satisfactory control on startup and during normal processing operations.

Considerable difficulty has been experienced in determining whether the vibrations measured during the 326 Building extrusion press deceleration tests are primarily due to accelerometer resonances or actual mechanical vibrations in the press. Difficulty in precisely synchronizing the scope trace with the moment of impact has made it difficult to use scope writing speeds fast enough to accurately determine the origin of the resonances. It appears that the frequency spectrum of the measurement signal is considerably wider than was originally expected, thus making it difficult to differentiate between the desired signal and resonance conditions. Further progress on this problem will depend on the customer's decision as to whether additional funds can be made available. A letter outlining the results obtained to date, and a proposal for further study, will be sent to the customer.

The work required on Project CGI-839 has been completed except for review of comments on drawings and acceptance test procedures which may be received from various interested parties.

An IRE Standard on Nuclear Techniques was reviewed and comments forwarded to Instrumentation Design (CEOUO).

Optics

The 600 manhours of optics shop work for the period February 28 to April 3 consisted of 18% for IPD, 26% for CPD, 45% for HLO, and 11% for CEUO. This work included:

Aluminizing two mirrors, repair of a borescope, and repair of the 105-H and 105-KW underwater viewers for IPD.

Repair of crane periscopes for Redox and Purex and fabrication of glass bearings for CPD.

Testing the PRTR wide angle viewer and profilometer, modifications to a radiation ratio pyrometer, fabrication of parts for an infrared radiometer, design and fabrication of a pyrometer for Ceramic Fuels, and miscellaneous other work for HLO.

Fabrication of parts for the PRTR Examination Facility Viewers for CEUO.

Analog Computer Facility Operations

The major problems on the analog computers this month included a study of NPR heat exchanger characteristics and a study of reactor kinetic equations.

Out of a total 168 hours of possible operating time with the GEDA computer during March, there were 6 hours of scheduled down time and 22 hours of unscheduled down time. Replacement of the patchbay contacts in the GEDA is delayed pending resolution of legal difficulties between the computer and contact vendors.

Acceptance tests of the new EASE computer proceeded throughout the month and are now about 90 percent complete. Sources of difficulties or failures to meet specifications have been identified and action is under way to effect corrections. Considerable difficulty has been experienced with the digital voltmeter and with excessive air temperatures in the equipment. Some modifications will likely be required in the air conditioning system for the facility.

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Chemical Research & Development

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATIONS PROCESSES

Decontamination of Reactor Components

Laboratory tests of solutions for decontamination of rear-face piping of existing HAPO reactors were continued. The most satisfactory solution tested was 0.9 M H_2SO_4 - 0.3 M $H_2C_2O_4$ containing one g/l phenylthiourea. Decontamination factors in excess of ten were obtained for both process tubing and pigtails after ten-minute contacts with the solution at 60 C. Carbon steel, stainless steel, Zircaloy-2, and aluminum all corroded at rates less than 0.05 mils/hr in the solution.

Stellite-6 and Stellite-12 have relatively poor corrosion resistance to 0.23 M $KMnO_4$ - 5.4 M NaOH, one of the solutions in the APACE procedure proposed for NPR decontamination. Hardenable stainless steels, 17-4 PH, 17-7 PH, and AM-350, might possibly serve as substitutes for the Stellites as valve seats. These three steels corroded at rates of about 1/6 those for the Stellites in the APACE alkaline permanganate solution.

Uranium Oxidation and Fission Product Volatilization Studies

The design, fabrication and installation of fused silica apparatus to replace the stainless steel furnace and sections of the off-gas train neared completion. In addition, the equipment for direct counting of xenon-133 was modified to assure a counting error of less than 1% for any single measurement. The pellitized caustic trap for iodine and tellurium was replaced with a liquid trap.

A third experiment was completed on the penetration of Zircaloy by aluminum-clad uranium. The test assembly, exposed for 24 minutes at 1182 C, produced an aluminum-uranium alloy between the uranium and Zircaloy. No penetration of the Zircaloy took place and no aluminum or Zircaloy diffused into the uranium.

NPR Effluents

Additional laboratory experiments were performed to study the ability of precipitates formed in typical permanganate decontaminating solutions to scavenge radioisotopes from solution. The precipitates result from the reduction of permanganate ion when solutions from various treatment steps are mixed. It was found that the scavenging factors for radioiron, radiocalcium, and radioiodine in case of decontamination solution mixtures containing a "peroxide-carbonate" cleaner were significantly greater than were obtained in earlier experiments. Contrary to previous indications, significant change was indicated in the degree of calcium scavenging as a result of the accelerated permanganate reduction caused by the presence of peroxide. These later experiments gave Ca^{45} decontamination factors up to 3.5×10^3, which is nearly ten times those previously measured. The new data display greater consistency and precision than did earlier results.

Reactor Effluent Treatment

Specimens of candidate aluminum and AlSi for reactor effluent treatment beds were suspended in flowing reactor basin effluent for long range corrosion and film area studies. The data are needed to assist selection of bed material. Specifications were prepared for the physical form of the bed packing and a market survey initiated to determine possible sources of supply. Interest in the problem was shown by one aluminum supplier and suggestions and samples were offered. The problem of procuring relatively inexpensive bed material in the quantity required must be solved before aluminum bed effluent treatment for reducing radioisotopes discharged to the Columbia River can be considered feasible.

SEPARATIONS PROCESSES

New Solvent Studies

The series of dialkyl phenyl phosphonates under preparation has been completed with synthesis of the di-t-butyl compound. Continuing studies have shown that of all of the dialkyl phenyl phosphonates prepared in this study, only the t-butyl compound has an appreciable hydrolysis rate. The undiluted compounds containing 1.5 M HNO_3 showed unmeasurable hydrolysis in twenty-four hours at 60 C. After ten days, solubility measurements indicated about 4 ± 3 percent decomposition as compared with about 5 percent for TBP. In contrast, t-butyl compound hydrolyzed measurably in three hours at 25 C. It apparently forms a solid hydrate which melts at about 27 C.

Purex C Column Studies

The process behavior of water from the ion exchange unit in the Purex plant was compared with that of steam condensate from the 321 Building using a three-inch C test column. The column was operated at 1250 gal/hr-sq ft sum of phases, at an aqueous-to-organic flow ratio of 1.1, and with 0.02 M HNO_3 in the aqueous stream. Both old (nozzle plates pointed down) and new (nozzle plates pointed up) plant cartridge types operated unstably at all pulse frequencies with water taken from the ion exchange unit just after cation bed regeneration. Water taken from the ion exchange unit in the period just prior to cation bed regeneration showed a region of stable operation below 40 cycles/min. Water taken upstream from the anion bed (between the cation and ion beds) just prior to cation bed regeneration gave no region of stable operation.

With steam condensate, a wide region of stability was obtained. For example, with the new plant cartridge and 1.0-inch amplitude, cycling occurred only above 70 cycles per minute. Further tests showed that the Purex sanitary water which feeds the ion exchange unit is nearly as good as the 321 steam condensate in the new plant-type cartridge.

Purex 3A Column Studies

A nozzle plate cartridge using the same geometry as that currently installed in the Purex HA column (23 percent free area, 3/16-inch-diameter holes, two-inch plate spacing) was tested for suitability in the proposed 3A Palm column.

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The flowsheet for this column differs from the HA column flowsheet primarily in that the feed contains only 0.2-0.3 M $UO_2(NO_3)_2$ but 5-8 M HNO_3, and the flow ratio is adjusted to give a uranium concentration in the product of 0.2 to 0.3 M The performance of the cartridge with this flowsheet was highly satisfactory. The following results, all obtained at room temperature, were determined:

1. The flooding frequency at a one-inch pulse amplitude ranged from 115 cycles/min at a volume velocity of 700 gal/hr-sq ft to 77 at a volume velocity of 2300. Flooding started in the top half of the extraction section and rapidly propagated through the scrub section.

2. The HTU's at frequencies about 10 cycles/min below the flooding frequency were 1.1 to 1.2 feet. Uranium waste losses were on the order of 0.002 to 0.009 percent in the 12-foot extraction section. These losses may be on the high side because of uranium contamination in the solvent. Mistron added to the scrub (at about 0.1 g/l) had no effect on the waste loss.

3. Aqueous entrainment in the organic overflow during HTU runs ranged from 0.1 to 0.3 volume percent of the organic flow, and appeared to be independent of variations in the organic holdup times in the disengagement section for the range of 0.4 to 0.9 minutes.

4. Sodium ion tracer was added to the feed of two runs to determine the amount of entrainment in the organic product which originated in the extraction section. Analytical results are incomplete, but a tentative sodium decontamination factor of about 7000 was obtained for one run across the six-foot scrub section plus disengagement section.

Although not separately investigated, the scrub section cartridge (which had the same geometry as the extraction section cartridge) seemed to be an excellent match for the extraction cartridge with respect to dispersion characteristics and flooding. The scrub section was observed to operate stably at a frequency of 68 cycles/min and a volume velocity of 1850 gal/hr-sq ft. Since the 3A column scrub section flowsheet is quite similar to that for the HA column scrub section, a unidiameter HA column using 23 percent free area nozzle plates throughout appears to be feasible.

Processing Nickel-Coated Aluminum-Clad Fuels

Fuels Preparation Department personnel are currently fabricating and testing aluminum-jacketed uranium metal fuels having a 0.5 mil nickel coating on both the inner and outer surfaces of the aluminum jacket. In studies of the dissolution of these fuels (nonirradiated), the outer nickel coating dissolved readily in boiling one molar nitric acid but was not rapidly attacked in 0.3 M acid. After removal of the outer nickel coating, the aluminum jacket and inner nickel coating were removed by the usual sodium hydroxide-sodium nitrate procedure. The inner nickel coating was not dissolved; it was undercut and sloughed off as a solid. A reddish brown material adhered to the uranium metal even after prolonged (10-hour) exposure to the boiling decladding solution. Investigation of the nature of this material and its effects in dissolver solutions is in progress.

Statistical Analysis-Photometer Calibration

A statistical analysis of the midcolumn photometer calibration data has shown that the instrument will measure the uranium concentration in the aqueous phase of a mixed-phase sample over the range from 0 to 100 g/l and 18 to 60 C with an accuracy of ± 0.5 percent or ± 0.3 g/l whichever is greater.

Interfacial Area Monitor

A particle counting and classifying instrument was described at the Pittsburgh Analytical Conference. A device which uses this principle and which could count and classify the size of organic bubbles that exist within an operating pulse column has been envisioned. The method is based on electrical conductivity measurement in a small diameter tube. Preliminary laboratory tests have shown the principle as sound, and have guided the design for a prototype instrument. The proposed monitor has the potential to measure the aqueous-organic interfacial surface area per unit volume within an operating pulsed extraction column, a measure that has not been obtainable in the past. Of lesser importance, it has the potential to measure the organic-to-aqueous hold-up ratio that exists in an operating pulse column to a higher degree of accuracy and in a lesser time than the present method of sampling and measuring the volume of the two phases after disengagement.

An electronic bubble counting system has been fabricated to operate in conjunction with the interfacial area detector. The circuitry consists of an amplifier, a time-to-amplitude converter, and an electrical register driver. A calibration system, also being tested, consists of a free-running multivibrator and a coincidence amplifier. The system will feed a signal to an existing 20-channel analyzer which will serve as the bubble size read-out system.

WASTE TREATMENT

Semiworks Fluid-Bed Waste Calciner Prototype

Two successful runs and one run resulting in excessive bed caking were completed during the month. The feed composition was changed to one simulating a high iron, high sulfate, high acid Purex waste stream.

No feed nozzle pluggage occurred as a result of nozzle lump formation during operation with the ANL type nozzle, even though the atomizing air flow rate was reduced. (The "ANL" nozzle is one patterned after the extended-tip nozzle designed at ANL. The liquid tip of this nozzle extends 3/16-inch beyond the air nozzle, which, in turn, extends 1/8-inch beyond the inside calciner wall.) However, at the end of the run, a small lump was observed on the nozzle, probably indicating a potential serious buildup during extended operation. A moderate amount of agglomerate formation in the calcine (one percent by weight) confirmed the fact that nozzle lumping was occurring to a small extent. The reduced tendency to lumping is a definite improvement over that of the standard nozzles used so far.

The severe bed caking which occurred in the one short run was primarily a result of poor atomization in a malfunctioning "standard" nozzle. The nozzle

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was found to be out of alignment and also improperly assembled. The resulting caked bed consisted of lumps, from "cornflakes" to hard fused fist-sized "rocks", on the heaters. The bed was cleaned out by a combination of chipping, slurrying with dilute nitric acid, and fluidizing a bed of garnet sand.

Feed solution of the composition tested this month has a considerably greater tendency for sintering and fusing at lower temperatures than the feeds tested previously. This sintering tendency became manifest by scaling on the heaters (about 1/16-inch thick) at measured heater temperatures of 700 C, and by complete fusing at temperatures of 800 C. The greater fusing tendency for this feed solution (with a sulfate to salt nitrate ratio of 1.6, and a sodium-to-iron plus aluminum ratio of 0.8) confirms data obtained for comparable solutions in batch calcination work. If solutions of this composition are to be successfully processed in fluid bed equipment, it appears that conditions must be altered to:

1. Adjust the solution composition (e.g., reduce sodium and/or sulfate concentrations, etc.) or

2. Reduce operating and/or heat source temperature.

Another objectionable feature to feed of this composition is the excessive quantity of fine calcine entrained in the calciner off-gases. This entrainment was 25-30 percent of the total calcine compared with less than five percent in the previous Purex type waste tested.

Observation Wells

Project CAH-885 (CET FY-1960 well drilling) was combined with the well drilling portions of project CAC-840 and CGI-791 (CPD and IPD projects). The work was scheduled to begin by June 1 and to be completed during calendar year 1960. Further use of the core barrel method of drilling and aquifer tests during drilling are expected to provide more and improved information on the geologic features affecting waste disposal.

There were no significant changes in ground water contamination patterns in the vicinity of the 200 Areas. Uranium was detected in a well monitoring the 216-U1 and U2 cribs at a concentration of 1.5×10^{-6} uc/cc. These cribs received miscellaneous U-Plant wastes from 1951 through 1956 and now receive infrequent small batches of decontamination wastes.

The trailer-mounted scintillation probe was calibrated to measure its capabilities for detecting Ru^{106} in monitoring wells. The calibration was performed by submersing the probe inside a short section of well casing in a tank of water to which was added various concentrations of ruthenium spike. The probe was found to respond to concentrations as low as 2×10^{-6} uc/cc.

Disposal to Ground

Seven samples of Purex silica gel regeneration waste were submitted for analysis to evaluate ground disposal problems. This waste is discharged to the 216-A-3 crib. Only one of the samples contained detectable concentrations of Cs^{137} (8×10^{-5} uc/cc) and none contained detectable concentrations of Co^{60}. The

total radiostrontium concentration averaged 1.8×10^{-6} uc/cc with an average Sr^{90} content estimated to be less than 2×10^{-7} uc/cc. These low concentrations do not warrant special laboratory study of this waste.

Scouting studies were started to examine the potential for decontaminating higher level chemical processing plant waste with clinoptilolite. Initial experiments involved aged Redox high-salt waste. A synthetic waste solution spiked with the aged waste was passed through a 120 cm mineral column at a flow rate of 40 gal/hr-sq ft. The radioactive material in this 6-year-old, alkaline waste was found to be greater than 99 percent radiocesium for which clinoptilolite has a high specificity. Preliminary analytical results indicate an initial decontamination factor of 2×10^{7} for Cs. The results indicate that a still higher D.F. would be obtained with a longer column. The capacity of the bed for decontaminating these wastes is estimated to be about 50 column volumes. Thus, the cesium in 50 gallons of this waste could be contained on one gallon of the mineral bed. The waste was found to contain very low concentrations of radiostrontium and none was detected in the initial effluent from the column (D.F. 100). Ruthenium broke through the mineral column very quickly.

Arrangements were made for laboratory soil column evaluations of wastes from the Coolant System Decontamination Test Facility in the 242-B Building. Analytical data indicate that the waste contains neutron activation products with lesser quantities of rare earths, Zr-Nb and Ru. About 500 gallons per week is now sent to underground tank storage in the 200 East Area.

Special Geological Studies

The difficulty in predicting the percolation rate in cribs even only a few hundred feet from an existing crib from which information is available was emphasized during construction of the 216-U-12 crib. Early excavation disclosed extensive silt beds up to six inches thick at the proposed site. Correlation of this information to data from the 216-WR crib excavation obtained in 1950, suggested that a better site lay about 100 feet westward. Completion of the pit at the new site confirmed the situation. The replacement crib will be five to ten feet higher in altitude than the original crib and will lie within a series of coarse sands separated by silt partings up to about two inches thick. The WR crib lay largely beneath these silt partings in a permeable silty sand.

Five silt partings were noted in a 10-foot vertical distance, the lowermost of which lies a few inches below the pit bottom. Another silt bed apparently lies about two feet deeper and was found in one test hole dug for the purpose. Others may lie deeper. Flow of waste out of the crib probably will be laterally for some distance because the silt beds, although thin, are quite continuous.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium Recovery

Studies were continued to develop practical methods for dissolving strontium-lead sulfate precipitates accumulated in centrifuge equipment. Successive

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centrifuge washes with 6 M HNO_3 gave inadequate removal, but 4 M sodium acetate followed with nitric acid worked efficiently and also gave a separation of strontium from the rare earths. Thus, the first four centrifuge washes removed 99 percent of the cerium with two percent of the strontium. The next four removed 97 percent of the strontium with the remainder of the cerium. It appears, however, that the best way to solubilize the strontium is to slurry the cake from the centrifuge and treat, in-tank, with acidic oxalate solution. This treatment dissolves the strontium and converts the lead, cerium, and rare earths to insoluble oxalates.

Strontium Purity Determination

Complexiometric titration (for calcium) and polarography (for strontium and barium) have the advantages of remote operation, use of aqueous samples, and acceptable detection limits. Experiments with a Sargent Model XXI polarograph using tetraethyl ammonium bromide as supporting electrolyte showed that strontium and barium could be detected down to about 10^{-4} M and that a barium content as low as one percent (in otherwise pure strontium) could be measured.

Mass spectrophotometry was successfully tried (E. B. Street) as a method for determining the isotopic purity of recovered strontium. Results obtained on 15 μg and 1 μg samples of natural strontium indicate that reasonable accuracy is obtained with samples as small as one microgram. A combination of the result of mass spectrophotometric analysis with radiochemical determination of strontium-90 would afford a way of determining total strontium.

Technetium Analysis

Analytical methods suitable for the determination of technetium in a wide variety of Purex streams are being developed. Anion exchange, as a preliminary purification and concentration step, shows promise. The technetium, presumably as pertechnetate, loads readily onto Dowex-1 from 1 M HCl and is easily eluted with 4 M HNO_3. Decontamination factors from beta and gamma activity are about 40 to 60, respectively, but decontamination from ruthenium is very poor (DF 3.8). Solvent extraction is being explored as a second step for added decontamination.

Preliminary experiments indicate that polarography may be an attractive method for determining technetium. It has the important advantage over radiochemical methods that complete decontamination from the other fission products is not required. A precision of ± 10 percent was obtained with samples containing 0.3 μg Tc/ml and ± 4.8 percent at 1.0 μg/ml. By using micro cells, samples containing as little as 0.2 μg of technetium would yield adequate precision.

Fission Product Packaging Prototype

Four final runs were made with the hydrolyzer to complete the studies on the conversion of $Cs_2ZnFe(CN)_6$ to mixed oxides by the hydrolysis method. These runs were made to evaluate the following: (1) effect of a restrictor baffle at the rear of the hydrolyzer tube, (2) characteristics of steam hydrolysis in the absence of air, and (3) effect of iron oxide additives on slurry calcining properties.

The true value of the restrictor baffle was indeterminate under the conditions of the runs. However, two improvements were observed; namely, a greater residence time for the process material and a better temperature distribution in the reactor zone.

Sensitivity to tar formation was more pronounced in the hydrolysis of $Cs_2ZnFe(CN)_6$ with steam alone than with a mixture of steam and air. The tar starts to form when the reaction zone temperature exceeds 350 C. It is believed to be a polymer formed during the partial decomposition of the cyanide radical.

The addition of iron oxide, in equal weights of Fe_2O_3 to $Cs_2ZnFe(CN)_6$, significantly enhances the over-all process. The following five outstanding advantages were observed:

1. An absorption mechanism improves many fold the initial separation of the $Cs_2ZnFe(CN)_6$ precipitate from its mother liquor.

2. Flow characteristics of the slurry within the hydrolyzer are improved.

3. The nitrate-cyanide reaction in the hydrolysis-calcination step is negated.

4. Conversion to the mixed oxides is significantly improved because of the catalytic effect of the ferric oxide. No tar formation was observed at temperatures in excess of 400 C.

5. The filtration characteristics of the product discharged from the hydrolyzer are greatly improved.

In addition to the continuous processing methods being studied in conjunction with the fission product packaging prototype, studies are being made on batch (or semi-continuous) methods of converting fission product brines and slurries to suitable products for off-site shipment. A three-inch-diameter agitated pot is being designed. The final boil-down, drying and/or calcining operations will be performed in the pot. Ideally, the calcining pot would be removed from the agitator assembly and would serve as a component of the product shipping container.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Analysis of Lead by Controlled Potential Coulometry

Lead down to 0.002 g/l concentration was measured coulometrically with a ± 2 percent error. Separating from sample interferences (except bismuth, cadmium, and tin) was done by a -0.65 volt reduction to lead metal which dissolved in the mercury pool cathode. The electrolyte was discarded. After adding 0.1 N potassium sodium tartrate, the lead metal was oxidized at -0.25 volt, with incidental transfer of the lead to the new electrolyte. The oxidation was used as a measure of the lead present. Any bismuth, cadmium, or large amount of tin would interfere. The colorimetric dithizone method had occasionally yielded erratic results.

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Isotopic Analysis of Strontium

Microgram strontium in molar nitric acid was analyzed isotopically by the thermal ionization mass spectrometer. Tantalum filament was used because its strontium work function exceeds that of conventional tungsten filament. With 15 micrograms of natural metal, 82.68 ± 0.43 percent of Sr^{88} was observed; precision was poorer for a one microgram sample which showed 82.00 ± 0.70 percent Sr^{88}. Similarly, 0.54 ± 0.04 percent and 0.46 ± 0.04 percent were observed concentrations of Sr^{84}, the least abundant isotope (literature value: 0.55 percent).

Analysis of Ce-Pr^{144} in the Presence of Ce^{141}

Cerium-Pr^{144} was more accurately measured in the presence of Ce^{141} by increasing the gamma energy spectrometer gain. Its increase from 10 Kev per channel (Cs^{137} in channel 66) to 5 Kev per channel (Cs^{137} in channel 132) moved the Ce-Pr^{144} - rich 80 Kev region out of the instrument noise area. Secondly, the increased gain reduced the effect of instrument drift. Thus, the 80 Kev region became useful for measuring Ce-Pr^{144}. The small Ce^{141} contribution was deducted by measuring Ce^{141} in the upper half of the peak centered at 140 Kev. The upper half was selected to minimize a Ce-Pr^{144} contribution centered at 134 Kev. By so doing, however, the Ce^{141} measurement became more sensitive to instrument drift. Duplicate Ce-Pr^{144} measurements showed a standard deviation of ± 6 percent. Previously, Ce-Pr^{144} values came from measurements of total cerium activity at the 135 Kev peak corrected for Ce^{144} contribution by 'a priori' assumptions of Ce^{141} to Ce^{144} ratios. The method suffered from the fact the Ce^{141} counting efficiency is ten times greater than that of Ce-Pr^{144} at 135 Kev.

EQUIPMENT AND MATERIALS

Purex Organic Treatment Pump Mixer

Additional studies have been completed on the Purex G-1 organic pump-mixer. Recent studies have been made in an attempt to devise simple methods for recirculating settled organic back through the pump-mixer for remixing with aqueous treatment solution. Installation of an eductor in the organic inlet line permits the required recycling.

Pump for Purex Recovery Installation

A special five-stage deepwell turbine pump has been designed for possible use in a proposed Purex Plant recovery facility. The pump, because of special process and design layout limitations, will be a maximum of four inches in diameter and 30 feet long.

Recuplex Pulsers

A test installation is being fabricated for testing various pistons and rod-seals which are candidates for use in pulse generation equipment of the proposed new Recuplex facility. With the test installation, it will be possible to simulate simply the hydraulic pulsing conditions which could be encountered in the 50-foot-long Recuplex columns.

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Non-Metallic Materials

Samples of polyethylene cut from a spare Purex HA column plate have been irradiated in the presence of Purex HAX and simulated HAW and then tested for flexure life. Samples which have received a total dose of 5×10^8 r have been tested. There is no clear indication that the presence of the solutions during irradiation has any appreciable effect on the flexure life of the plastic. The test is being continued to higher exposure levels.

Several gasket materials which were found resistant to phosgene at room temperature were tested in phosgene gas at 500 F. Of the materials tested, only Teflon felt and Hypalon rubber (both products of duPont) remained intact at the end of the test. The Hypalon rubber became stiff while the Teflon felt shrank in one dimension and became thicker. The Teflon felt was otherwise unaffected. Either material would make an adequate gasket for phosgene at 500 F.

Corrosion of Decontamination Operation Waste Storage Tanks

Samples of 1020 steel were exposed to liquid and vapor phases of solutions taken from the 4, 8, 12, and 16-foot levels in the 118-TX tank to determine if Decontamination Operation wastes present a corrosion hazard in the tank. During a ten-day exposure, corrosion rates in all liquid phases were less than 0.01 mil/mo. Results on the vapor phase samples were erratic. Pitting attack ranging from negligible to ten mils/mo was found. Further exposures with freshly polished samples will be made.

Continuous Slag and Crucible Dissolver

A survey to determine appropriate materials of construction for a continuous slag and crucible dissolver is in progress. In boiling simulated dissolver solution, annealed Hastelloy F (low carbon), Ni-o-nel, 309 SCb stainless steel and 347 stainless steel corroded at rates of from four to eight mils/mo. As-welded Hastelloy F and Ni-o-nel corroded at rates of 11 and 16 mils/mo, respectively. Haynes 25, as-welded 309 SCb stainless steel, and 309-L stainless steel are currently under test. Also, a welded and annealed 347 stainless steel pot is being exposed to the dissolver solution under conditions permitting study of heat transfer effects and vapor and interface corrosion.

Examination of Failed Purex F-6 Tube Bundle Section

Tube bundle 17, which developed leaks after 20 months' service in the east position of the F-6 waste acid concentrator, has been removed and decontaminated. A section was cut from the bottom of the bundle and examined in detail. While the tube sheet and some of the tubes are severely corroded, the failures occurred at tube-to-tube sheet welds and appear to have resulted from improper placement of the weld bead.

Purex 1WW Interim Acid Waste Storage

Coupons of 304-L stainless steel were exposed to boiling solutions simulating Purex 1WW waste which would be produced if an iron-free flowsheet was followed.

Nitric acid content of the solutions ranged from zero to six molar; all solutions, except that at six molar, simulated 60 percent concentration of 1WW. Corrosion rates in the solutions one molar or less in nitric acid were essentially the same as those previously observed in solutions simulating the present iron-containing wastes and containing the same free nitric acid. At nitric acid concentrations above one molar, the corrosion rates were significantly higher than those previously noted in iron-containing wastes.

Containers for Calcined Wastes

Stainless steels 304-L and 347, and carbon steel 1020 were exposed to synthetic calcined wastes representing (1) batch calcined neutralized Purex waste, (2) batch calcined acidic Purex waste with sulfate addition, and (3) fluid bed calcined acidic Purex waste (from ANL). Exposures were made at 400, 600, and 800 C in a normal furnace atmosphere. At any given temperature, corrosion was the most severe for (1), intermediate for (2), and lowest for (3). Penetration rates at 400 C were less than 0.1 mil/mo for all three metals in all three wastes. At 600 C, penetration ranged from less than one mil/mo for the stainless steels in (3) to 60 mils/mo for the carbon steel in (1). At 800 C, penetration ranged from 15 mils/mo for the stainless steels in (3) to 1000 mils/mo for the carbon steel in (1).

PROCESS CONTROL DEVELOPMENT

Integrated Plutonium Output Redox 3 BP Stream

The integrator on the 3BP plutonium monitor operated satisfactorily for a month. Since there is presently no 3BP flowmeter in the Redox Plant, the unit was returned to the laboratory and a solid state 0 to 50 millivolt power supply with Zener diode regulation was designed and built to simulate the Redox 3BX flowmeter reading. The simulated flowmeter reading will be multiplied by the counting rate meter output of the plutonium concentration monitor. The resultant product will then be integrated over a process cycle to give the amount of plutonium processed during that time. Cycle times as long as 270 hours can now be integrated without exceeding the capacity of the integrating register. The over-all system accuracy is about two percent.

Purex E-3 pH Probe

A new pH probe unit using "Swagelok" fittings installed in Purex E-3 tank has operated satisfactorily since February 23, 1960. Provision is being made to include a temperature compensator on the next replacement for the E-3 pH probe.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

Shear Basin Modification. Modifications to the shear basin and installation of a new 40-ton hydraulic shear (Model II) in 321-A Building are approximately 75 percent complete. Startup is expected during the first week of the coming month. The new equipment will permit more extensive shear blade tests and demonstration of a wet shearing system for shear dust control. It will be a scale model (i.E., contain the essential engineering components) of the shear system considered for incorporation in the Hanford NPF mechanical cell.

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Yankee Fuel Disassembly. Disassembly studies of Yankee fuels continued during the month. The bands used to hold subassemblies together (about 3/64-inch-thick by 1/2-inch-wide stainless steel bands) were cut with a "draw" knife. Various thickness bands with the ends held in various ways (ranging from slight initial tension to both ends free) were successfully slit. Over 60 cuts per knife have been made, indicating a knife cost well below $5/ton of uranium.

Three band cutting methods are currently considered practical: milling cutter, slitting knife, and high-speed saw. Testing of a high-speed saw will be initiated during the coming month.

Mechanical Cell NaK Handling. Tests are being made on a mockup of the NaK handling system contemplated for the NPF mechanical cell if sodium or NaK containing fuels were processed at Hanford. This system includes a saw hood where sodium is reacted with water at a controlled rate and a scrubber (Peabody) for the treatment of gaseous reaction products. A test made reacting 3.5 grams NaK/min, under three inches of water, resulted in an over-all removal efficiency of greater than 98 percent. Only about five percent of the total NaK reacted left the hood as fume; the remainder formed caustic with the water in the hood.

Feed Preparation

Orlon Filters. Orlon felt filters can be solubilized in hot 10 M HNO_3. It is suggested that Orlon felt be used to filter mechanical treatment cell water, and that filter and collected uranium dioxide be dissolved along with a charge of fuel. Dissolver solutions obtained by codissolution of Orlon felt filter cloth and uranium dioxide pellets in 10 M HNO_3 exhibited normal uranium distribution and decontamination under Redox solvent extraction conditions. Fine hair-like particles of felt in these solutions produced interfacial scums and poor disengaging behavior.

Zirflex Process Modifications. Study was continued of a Zirflex process modification in which reaction-generated ammonia is neutralized by addition of hydrofluoric acid instead of being removed by volatilization. Zircaloy-clad uranium dioxide fuel elements simulating those expected in the PRTR were obtained. These fuel pieces had been autoclaved to produce a "black oxide" coating. They were declad in a solution initially 2 M NH_4F - 0.5 M NH_4NO_3. At pH 7.6, rapid attack on the Zircaloy-2 did not occur until after an induction period ranging from 50 to 90 minutes. Dissolution then proceeded by pitting attack and undercutting characteristic of Zirflex dissolution of oxide-coated Zircaloy-2.

Acid Fluoride Dissolution of Zircaloy-2. An alternate process for dissolving Zircaloy-2 cladding in hydrofluoric acid-nitric acid solutions is being studied. This process seeks to take advantage of low corrosion rates observed for nickel-base alloys and relatively high Zircaloy-2 dissolution rates in nitric acid-hydrofluoric acid solutions at low temperature (25-50 C). Preliminary data indicate satisfactory Zircaloy-2 (unoxidized) dissolution rates (10-15 mils/hr) can be achieved with 2 M HF - 0.25 M HNO_3; corrosion rates for alloy 11 B (BMI experimental alloys) of less than one mil/mo were obtained under similar conditions. Higher hydrofluoric acid concentration (3 M) was required to penetrate oxidized Zircaloy in reasonable times.

Attack of uranium dioxide core materials by typical terminal decladding solutions (0.25 M HNO_3 - 2 M HF - 0.44 M Zr) was relatively high — ca. 0.1 weight percent per hour for the sample studied. The attack was reduced markedly by addition of sulfamic acid to the decladding solution.

Recirculation Dissolver Studies. The attractiveness of using a steam sparge as the motivating force for recirculation during Zirflex dissolutions was further demonstrated in the pilot plant dissolver. Zircaloy-2 tubing was dissolved in 5.5 M NH_4F - 0.5 M NH_4NO_3 with an F/Zr mole charge ratio of seven. An air sparge was used for motivation during initial heating, but was replaced by a superheated steam sparge (350 F) when the dissolvent reached the boiling temperature. A steam sparge of 2.6 lb/min provided a boilup of 0.277 lb-mol/hr-sq ft and a recirculation rate of 8 gpm. A maximum dissolution rate of 43 mils/hr and an integrated dissolution rate of 27 mils/hr were attained.

A second Zirflex run was made to dissolve Zircaloy-2 cladding from swaged UO_2 rods. The unexpected thickness of the cladding resulted in decladding only 18 of the 27 rods charged. The run was carried out under the same conditions as the previous run, and the maximum and integrated dissolution rates were essentially the same at 43 and 28 mils/hr, respectively. Uranium losses to the decladding solution were approximately 0.02 percent and were adequately predicted from laboratory data. Uranium dioxide fines apparently settled out during the dissolver cool-down period with a very small percentage carrying over to the centrifuge step.

Flooded Tray Dissolver. An alloy of U-3 w/o Mo was dissolved in 0.86 M $UO_2(NO_3)_2$, 0.068 M Mo, 0.95 M $Fe(NO_3)_3$, 0.86 M HNO_3. Conditions in the dissolver tray were carefully controlled to try to prevent precipitation of solids and still represent terminal dissolution conditions. However, as soon as the hot dissolver solution contacted the alloy, solids containing about 35 weight percent uranium precipitated. The dissolver solution had been made up from a previous uranium-molybdenum alloy dissolver solution, butted with uranyl nitrate and ammonium molybdate solution. The penetration rate during the run was the expected 32 mils/hr.

The dissolver solution and precipitate were treated to redissolve the solids. Digesting for three days at 0.88 M $UO_2(NO_3)_2$, 0.051 M Mo, 0.9 M $Fe(NO_3)_3$, 0.55 M HNO_3 did not dissolve the precipitate. Nitric acid was added to 3.9 molar at which point the precipitate dissolved. The acid concentration was successfully lowered without the formation of a precipitate to 1.8 molar by boiling while adding water to maintain a constant volume of solution. The waste condensate volume was one-half the original solution volume. As a terminal step, the solution was slightly concentrated to a 2.2 M HNO_3 acid concentration.

In laboratory scouting studies, formaldehyde was used successfully to destroy the acid in this solution. After the initial addition of formalin to boiling dissolver solution, brief induction periods up to two minutes were required before the first brown fumes appeared. No induction period was required for solutions which had previously reacted with formalin. The reaction was vigorous and increased as the formalin addition rate increased; decreased as the nitric acid concentration decreased; and stopped when the formalin addition stopped. The froth from the reaction broke quickly in the small freeboard above the solution surface. Dark brown fumes were produced by the reaction, even in the absence of air sparging.

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In the pilot plant, an initial 50 ml charge of 37 percent formaldehyde - 12 percent methanol in aqueous solution was added to the cold 2.2 M HNO_3 dissolver solution. After the solution had been brought to a boil, further additions of formalin solution at rates as high as 0.3 l/min produced instantaneous reactions. Addition of 21 liters of formalin solution with simultaneous concentration reduced the acidity in 350 liters of dissolver solution to 0.2 M in 250 liters of solution. Formaldehyde use ratios of 2.5 H^+ per HCHO were attained in the combined destruction-distillation operation, compared with 2.0 H^+ per HCHO predicted in AERE-CR-1739 for destruction alone, and 3.0 predicted in HW-58587 for combined destruction-distillation.

Five runs made last month in which 2S aluminum was dissolved in mercuric nitrate catalyzed nitric acid confirmed the effect of recirculation rate on dissolution rate. The data shown below gives recirculation rates and corresponding dissolution rates for various nitric acid concentrations with 0.005 M $Hg(NO_3)_2$ as catalyst:

Recirculation rate gpm/sq ft charge:	0.25	0.5	1.2	0.6	1.6
Penetration rate percent of batch rate:	35	75	95	160	120
Range of nitric acid concentrations, M :	0 to 5.0	0 to 5.0	0 to 5.0	5.5 to 7.5	6.4

Sulfex Studies. A series of laboratory scale Sulfex runs were made on type 302 stainless steel to determine initial differential penetration rates as a function of sulfuric acid concentration. When sulfuric acid concentrations varied from 3.0 M to 8.0 M, the penetration rates, R, expressed in mils per hour, are described by the expression:

$$R = 0.59(M\ H_2SO_4)^{2.33} .$$

When the acid concentrations were below three molar, a black residue was always observed. Although this residue amounted to only 1.1 weight percent of the stainless steel present, its formation was accompanied by some 25 percent increase in penetration rates over those predicted by extrapolation of data obtained at higher acid concentrations. According to Swanson (HW-61842), the uranium losses to Sulfex decladding solutions are significantly decreased by the presence of this black residue. A sample of this residue has been submitted for chemical analysis.

Preliminary studies with types 304-L and 347 stainless steels gave no black residues when dissolved in sulfuric acid at concentrations of 2.0 M and greater. It appears that type 347 stainless steel dissolves about fifty percent more rapidly, and type 304-L about fifty percent less rapidly, than does type 302 in initial Sulfex solutions.

Qualitative experiments have demonstrated that nitrate in 4 M H_2SO_4 can be destroyed with formalin to the extent that active stainless steel is not passivated by the solution.

Modification of 222-S High Level Cubicle. It is planned to equip the high level cubicle in the 222-S Bldg. for further studies on decladding and dissolution of nonproduction fuels. Arrangements have been completed for obtaining most of the irradiated fuel pieces desired. Equipment for removal and burial of apparatus now in the cell is being fabricated. Design of the dissolver and associated equipment is near completion. It is planned to modify an existing cask, available from the Radiometallurgy operation, for transport of fuels from 327 Bldg. to 222-S and to provide for getting the fuel pieces into the cubicle.

Support of Criticality Studies UO_2 Cake Densities. HW-64421 entitled "Density and Hydrogen Content of UO_2 Cakes and Slurries" was issued. As was indicated last month, these studies provided information used to evaluate the critical mass safety of various equipment pieces and process vessels included in the NPF reprocessing complex.

"In Process" Neutron Absorptiometer.

Nuclear poisons may be added to certain streams in the Redox plant to assure nuclear safety when processing enriched fuels. A prototype of an "in tank" neutron absorptiometer probe has been fabricated to aid in establishing suitable geometries for measuring boron concentration in the 2EX, 1BX, 2DA make-up tanks and the F-2 and F-5 concentrators. A design and calibration curve for the 2EX monitor has been determined. The monitor utilizes a plutonium-beryllium neutron source with the process solution serving as moderator. Thermal neutrons are measured with a BF_3 tube adjacent to the source.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt-Cycle Process

Preparation of Electrolytic UO_2. Further studies have verified that an important variable influencing the crystal habit of UO_2 electrolytically deposited on a graphite cathode out of molten NaCl-KCl eutectic at 700 to 800 C is the degree of exposure to chlorine which the UO_2 deposit is permitted. The dendritic type of deposit which had been considered "typical" of the process in the early work is formed when the exposure to chlorine is limited. More elaborate precautions are required to obtain dendritic deposits the greater the chlorine evolution rate, i.e., the greater the current passed through the cell. For example, in a very simple apparatus in which both the graphite anode and cathode were immersed in a single pot provided with a vented cover, a dendritic deposit could be obtained at a current of 12 amps if the cell cover was completely removed but not if the cover was left on the cell. The deposit in the latter case was smoother and much more adherent. Similarly, at 20 amps, a smooth adherent deposit was obtained even with the cell cover off. However, if the anode was provided with a shroud tube and a helium sparge was supplied at the bottom of this tube to expel chlorine, a dendritic deposit was optained at 20 amps.

The uranium(VI) content of UO_2 deposits formed in various ways has been determined by dissolving the samples in 85 percent phosphoric acid under anaerobic conditions, spiking the solution into dilute sulfuric acid and performing a

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controlled potential coulometric titration. It should be noted that there is some hazard associated in extrapolating the uranium(VI)/uranium(IV) ratio to an oxygen/uranium ratio for samples of UO_2 such as the Salt-Cycle product, where there is a possibility of included uranyl salts. However, measurements of chloride content on such Salt-Cycle samples indicate that the relative contribution of salts such as UO_2Cl_2 to the total measured uranium(VI) content must be quite low. Accordingly, uranium(VI)/uranium(IV) ratios so measured are recomputed and reported as oxygen/uranium ratios. Varying conditions in the electrolytic deposition have resulted in UO_2 products in which the oxygen/uranium ratio varied from ca. 2.005 to as high as 2.18. The trends are not so clear-cut as to allow an unqualified conclusion as to conditions which will result in a high or a low oxygen/uranium ratio. However, there is some suggestion that relatively higher oxygen/uranium ratios may be associated with dendritic deposits than with smooth adherent deposits. Leaching studies with dilute sulfuric acid have shown that the uranium(VI) in these samples is only slowly and incompletely dissolved, suggesting that the higher oxygen content is not a result of mere surface oxidation of UO_2 deposits.

Among the unattractive aspects of employing graphite as the electrode material in generating electrolytic UO_2 is the demonstrated tendency for accumulation of carbon to a concentration of as high as 1500 ppm in the recovered UO_2. Accordingly, some work has been done in a search for a suitable cathode material. Hastelloy B and C appear of doubtful value because of excessive corrosion and resultant contamination of the melt. Platinum cathodes appeared usable in small-scale experiments, and platinum and noble metal alloys will be further tested for use in future work.

Small-scale experiments seeking to further define the effects of deposition variables on the character of the UO_2 produced further confirm the importance of interaction of the UO_2 deposit with chlorine in determining the crystal habit of the UO_2. When the anode was housed in a shroud tube closed at the bottom by a quartz frit and access of chlorine to the cathode thereby limited, the results essentially confirmed those previously mentioned, in that the UO_2 deposits were dendritic and relatively nonadherent. However, the deposition ceased after a short time. Rapid conversion of uranyl to soluble uranium(IV) species occurred during the attempted deposition, and cessation of the deposition is, therefore, tentatively attributed to rapid depletion of uranyl via the deposition reaction and the following side reaction, which is known to occur at graphite anodes:

$$UO_2CL_2 + C + Cl_2 \longrightarrow UCl_4 + CO_2$$

When the same cell was used but the anode compartment was filled with U_3O_8 powder, the chlorine generated at the anode was consumed by reaction with the suspended U_3O_8 powder (to yield soluble uranyl species) and the deposition could be continued for substantial periods. The deposit in this case was likewise dendritic in character and poorly adherent. There was little difference in deposits obtained at 6 and 12 amps/sq-dm. At current densities of 15 to 20 amps/sq-dm, however, the deposits were brown in color, fine, and adhered very poorly to the graphite electrode. In this work there was some indication that higher current densities produced powders having a somewhat lower oxygen/uranium ratio, less than 2.01 for current densities greater than 12 amps/sq-dm, vice 2.015 at 6 amps/sq-dm.

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Since uranium(IV) appears to be rather potent reductant in the molten NaCl-KCl eutectic, an experiment was performed to determine the feasibility of removing "excess" oxygen from UO_2 by exposure to molten NaCl-KCl eutectic containing uranium(IV). The results obtained were somewhat encouraging in that this ratio was reduced from 2.020 to 2.011 in a three-hour exposure, although some reduction in particle size likewise occurred.

Determination of Oxygen/Uranium Ratio in UO_2. Measurements of oxygen/uranium ratio (more properly uranium(VI) content) on a substantial number of samples of varying history indicate that for samples having oxygen/uranium ratios near 2.01, the controlled potential coulometric titration is good to ± 0.0003 in the ratio. With samples having oxygen/uranium ratios near 2.1 the method appears good to ± 0.0006 in the ratio. Although probably good enough for practical purposes these precisions are somewhat poorer than customary for the controlled potential coulometric titration method. The problem is believed to stem from oxidation to a somewhat nonreproducible extent occurring when the solid sample is powdered before dissolving. The best reproducibility has consistently been obtained with samples which required little or no powdering prior to dissolution. Thus, it is probable that the reproducibility of this determination cannot be further improved except by using tedious "dry box" techniques for preparing the samples, or adopting a partial dissolution approach which avoids the necessity for powdering samples prior to dissolution.

Recrystallization of UO_2. The + 60, - 32 mesh fraction of a sample of electrolytically produced UO_2 was equilibrated for five hours with a NaCl-KCl eutectic melt containing initially about 5.9 weight percent uranium as UO_2Cl_2. A material balance after this equilibration showed that about 46 percent of the uranium initially present as uranyl chloride had precipitated as UO_2, presumably via the thermal decomposition reaction

$$UO_2Cl_2 \rightleftharpoons UO_2 + Cl_2$$

The final solid phase (UO_2) had gained 85 percent in weight and the relative proportion of fines had increased. Further, the residual + 60, - 32 mesh fraction (which amounted to about 60 percent of the initial charge) had undergone a marked change in crystal habit. The material charged was a typical dendritic deposit, each particle consisting of an agglomerate of a multiplicity of cubes. The coarse fraction of the recovered powder following this digestion was composed mainly of flat plates each one fairly large in two dimensions and each one presumably representing a single crystal.

Thus, it appears that UO_2 has a finite solubility in the NaCl-KCl melt and that a tendency exists for UO_2 to crystallize in a preferred orientation which leads to formation of plate-like crystals in the foregoing experiment. This tendency is apparently effectively thwarted when UO_2 is formed by electrolytic deposition.

Not only does this observation open room for speculation as to the importance of post-deposition interactions in determining the nature of UO_2 deposits made electrolytically, it also suggests that altering the shapes and sizes of UO_2 particles may be possible by "aging" treatments.

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Determination of Chloride in UO_2. A satisfactory method has been developed for determination of chloride in UO_2. This method depends on use of a microphotometer to measure the light scattered by a suspended silver chloride precipitate. Conditions which gave the best results entailed forming the precipitate at room temperature by addition of relatively concentrated silver nitrate (e.g., 0.5 ml of 1.0 M rather than 5 ml of 0.01 M), to a solution containing about eight percent ethanol. The light-scattering ability of the precipitate tends to increase with time up to about 50 minutes but measurements made after this time proved quite reproducible. The suspensions can be stabilized immediately after formation by addition of a very small amount of a detergent ("Tide" was used in this instance).

This method has proven quite reproducible for measurement of chloride in a wide variety of electrolytically produced UO_2 samples. Duplicate analyses on the same solution of UO_2 showed, in three instances, deviations from the mean of only ± 1.2, ± 1.2, and ± 1.1 percent. Duplicate and triplicate dissolutions of UO_2 samples in the same size range showed an average deviation of ± 7 percent.

However, the measured chloride contents show no systematic correlation to other properties of the UO_2 For example, the measured chloride contents of the +100, - 20 mesh fraction of UO_2 powders were respectively 175, 140, 163, and 179 ppm for powders which showed oxygen/uranium ratios of 2.15, 2.08, 2.03, and 2.01. Chloride contents of the + 20 mesh fraction of the same powders were, in the same order, 68, 130, 91, and 96 ppm. Powders which ranged in particle density from 10.58 to 10.80 and in surface area from less than 0.01 to 0.18 gram/sq-m showed chloride contents varying in random fashion from 25 to 128 ppm.

Plutonium Behavior in Salt-Cycle Process. Mixed crystal UO_2-PuO_2 (roasted to U_3O_8) can be dissolved with dried HCl-Cl_2 gas to yield a molten salt solution from which the plutonium is only inefficiently deposited. Addition of ca. 0.1 percent powdered graphite to the melt before the last hour of dissolution facilitates formation of difficultly deposited plutonium species. Use of this dissolving technique (to prepare a solution containing uranium and plutonium in 300/1 ratio) and then sparging the melt with dried HCl gas before initiating electrolysis has enabled as much as 39 percent of the uranium to be deposited with only 0.3 percent of the plutonium carrying with the uranium. These are all measures designed to limit the water and oxygen content of the melt and this is believed to be the key problem in avoiding codeposition of plutonium with UO_2.

Per contra, codeposition of plutonium with UO_2 is favored if oxygen is present. Thus, following the above experiment, the melt was sparged with air and further deposition carried out with an air sweep across the top of the melt. Under this condition, plutonium codeposited with UO_2 and the recovered UO_2 in the second deposition was enriched in plutonium to the extent of an enrichment ratio of 1.4.

Thus, it appears that the potential exists for altering the uranium/plutonium ratio in UO_2 recovered from irradiated UO_2 over a wide range by simply controlling the conditions under which the electrodeposition is made.

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Stability of Uranyl Chloride in NaCl-KCl. In further studies of the stability of uranyl chloride in NaCl-KCl eutectic at elevated temperatures, it was found that both uranium dioxide and uranium(IV) could be identified when the reaction mixture was dissolved in 4 M H_2SO_4. With increasing reaction time and higher temperatures, the amount of UO_2 relative to uranium(IV) increased. Thus, the simple decomposition of uranyl chloride appears to be more important than the postulated reaction to produce UO_2, UCl_4 and O_2. It is still highly probable that the latter reaction occurs, but to what extent is not known.

Materials of Construction for Salt-Cycle Process. Various nonmetallic materials are being tested for possible use in construction materials for the Salt-Cycle process. Initial screening tests are being conducted in a 50 mol percent sodium chloride - 50 mol percent potassium chloride bath at 800 C. After ten days, there was no appreciable change in the weight of a Norton A-402 alumina crucible, a Morgan Refractories XR-20 recrystallized alumina crucible, or a Morgan Refractories XN-100 Crucible. A sample of AJT 82 high density carbon produced by National Carbon Company exhibited no dimensional change after being totally immersed in the same bath for ten days.

A one-inch O.D. by 1/2-inch I.D. rod of Coors high density alumina was heated to 800 C, allowed to cool rapidly in air, then reinserted in the furnace. After several cycles the rod was not noticeably affected.

Processing Al-Pu-Si-Ni Alloy

It was reported previously that the Al-Pu-Si-Ni alloy fuel currently being prepared for the PRTR dissolves rapidly in $Hg(NO_3)_3$ - HNO_3 solutions of low (1-3.5 M) acid concentration, but slowly at higher acid concentration. Off-gas analyses show that hydrogen evolution is negligible during slow dissolution, but about 0.3 mole-per-mole of aluminum dissolved during rapid dissolution. It was also reported that Redox process feed solutions, prepared by way of rapid dissolution of the alloy, formed stable emulsions when contacted with hexone. Attempts to apply the ICCP gelatin treatment to these solutions to overcome emulsion formation were not successful. Emulsion formation did not occur when Mistron-25 was added to the feed solutions in concentrations of 100-150 ppm. However, interfacial scums were formed. The effects of these on plutonium loss will be investigated.

Data obtained to date on the loss of plutonium from the core to the Zirflex decladding solution are not adequate for quantitative estimates. Qualitatively, attack on the core is increased by increased pH and free fluoride concentration and by the presence of mercuric nitrate (possibly present due to incomplete removal of core dissolvent).

Continuous Ion Exchange Contactor Development - Jiggler Contactor

The quantity of scrub acid required as slip water has been substantially reduced through addition of a separator in the air lift resin recycle line. The resin slurry issuing from the air lift passes through a nozzle into a screened vacuum line which removes the small quantity of "excess water" that reaches this point. The remaining acid that wets the resin is estimated to be less than 15 percent by volume of the resin and is recycled to the top of the apparatus where it is removed in the product stream.

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Raising the level of the raffinate take-off line appears to be a reliable means for preventing the downflow of eluant from the strip column to the extraction column. An appropriate design of the intermediate section between "C" and "A" columns can, on the other hand, keep the raffinate from getting into the "C" column above. This was demonstrated in a 2.5-hour run using barium nitrate tracer in the feed (not absorbed on the anion resin). At a feed rate of more than one liter per minute (180 gal/hr-sq ft) and an eluant flow of more than 100 mls/min, no barium was detected in the product stream.

Two significant "flowsheet" runs using thorium nitrate feeds have been completed since the changes described above were made.

The first run at a feed rate of 500 ml/min appeared to have reached steady state with satisfactory thorium removal, viz., 97.7 percent. However, the two-foot-long strip column is apparently too short to effect the desired stripping. The feed rate, 900 ml/min, in the second run apparently was too great and fluctuating recoveries of 20-90 percent occurred.

RADIOACTIVE RESIDUE PROCESSING DEVELOPMENT

Radiant Heat Spray Calcination

Ten runs were made during the month in the demonstration spray calciner. Two types of waste not previously tried, Darex waste and Purex coating waste, were successfully calcined. Studies were also made on post-calcination evolution of noncondensable off-gases from high-sulfate Purex calcines, on equipment changes to minimize back-mixing in the nozzle region, and on gasketing materials for ceramic filter service.

Darex waste (2.9 M HNO_3, 0.68 M Fe, 0.12 M Al, 0.16 M Cr, 0.075 M Ni) was calcined both "as-received" and after neutralizing with ammonia. Operation was very smooth in both cases, and hold-up on the walls of the column was negligible. Feeding and atomizing the neutralized waste were not problems despite the presence of a thick slurry. Density of the product was 0.81 g/cc for the acidic Darex waste and 1.3 g/cc for the neutralized material.

Purex coating waste (209 gal/TU) was mixed with 1WW (37 gal/TU) and calcined with addition of 125 grams sugar per liter. The product was a fine white powder with a density of 0.65 g/cc. Addition of 40 weight percent boric acid to this material followed by heating to 850 C produced a clear amber glass (density 2.3 g/cc) similar to that obtained from TBP-25 waste. Volume of the glassy product is about 3.8 cu ft/ton, equivalent to an over-all volume reduction factor of 8.6. Cost of reagents (boric acid and sugar) is about $19/ton. Attempt to calcine coating waste without admixture with 1WW was less successful due to the low bulk densities and deliquescence of the products.

Laboratory studies were initiated to determine the volume of noncondensable gases which might be evolved from calcined wastes during storage. Samples of calcined powders, from high-sulfate 1WW, were heated in a tube furnace to 850 C and the off-gases, mostly SO_2, collected and measured. Volume of off-gas was as great as 30 liters/kg and imply that it is not safe to assume that wastes calcined in continuous-type calciners can be safely stored unvented

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and allowed to self-heat to 850 C simply because they have been subjected to this temperature during calcination.

Induced back mixing in the nozzle region of the spray calciner has been a troublesome problem and is believed responsible for much of the observed build-up of solids on the walls. A lucite model has been constructed to allow study of this phenomena, and testing of methods for its alleviation by recycle of a portion of the gas from a point further down the column. Preliminary results, using a permanganate colored spray, indicate that the model will be a useful tool and that the recycle idea has merit.

Several materials have been tested for gasketing the ceramic filter units. Viton-A was unsatisfactory. Glass-filled tetrafluoroethylene flowed in two hours at 260 C. Durabla, an asbestos-based gasket material, remained soft and flexible at 400 C. It changed color at 450 C but still passed an air leak test and is probably satisfactory for the project service.

A paper, Continuous Calcination of Aqueous Radioactive Waste Solutions by Radiant-Heat Calcination, by R. T. Allemann and B. M. Johnson, was prepared for presentation at the Nuclear Congress in New York, April 6, and was released locally as Hanford Report HW-63822.

Mineral Reactions

The radiostrontium in boiling tank condensate wastes was removed from solution by a 22 cm column of clinoptilolite with a D.F. of about 10-100, compared to the D.F. of 10^3 - 10^4 achieved for radiocesium. Increasing the length of the column produced no additional strontium removal. In addition, it was found that some radiostrontium was removed by passing the solution through a bed of activated carbon while none of the radiocesium was thus removed. These results indicate that part of the strontium is associated with the organic material dispersed as a colloid in the condensate. This strontium is in nonionic form and can be removed from the solution only by filtration of the organic phase.

The effect of clinoptilolite grain size on cesium adsorption was measured at several column flow rates. The measurements were performed for clinoptilolite grain sizes of 0.15 - 0.25 mm, 0.42 - 0.52 mm, 0.84 - 1.0 mm, and 1.2 - 1.4 mm. The larger grain sizes are desirable because of the low pressure drop across these beds, but a considerable loss of bed capacity for cesium adsorption was evident for these cases. This effect is most pronounced at high flow rates.

The equilibrium distribution coefficient for cesium between a 0.01 M CsCl solution and clinoptilolite was determined to be 1.60 at 24.5 C. The same coefficient was measured using clinoptilolite samples that had been subjected to irradiation by a Co^{60} source up to dosages of 2.9×10^8 R. No measurable change in the distribution coefficient was found for these irradiation levels.

Condensate Streams

The aqueous phase of the Purex Tank Farm condensate was sampled and analyzed weekly for several months. A number of fission product isotopes

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were found to be present in concentrations that remained relatively constant. The major nonradioactive constituent present was tri-n-butyl phosphate in concentrations varying from 30 to 190 mg/liter.

The first scouting run in the 271-CR Building Micro Pilot Plant treating this waste was completed. The mineral bed, through which the waste was passed downward, had a clinoptilolite particle size of 0.6 to 1.7 mm, a bed height of 18.4 inches and a bed diameter of one inch. At a temperature of 16 C and a flow rate of 1.9 gpm/cu ft cesium was removed with a D.F. of 330 and strontium with a D.F. of 2.3. Increasing the temperature to 22 C and decreasing the flow rate of 1.3 gpm/cu ft increased the cesium D.F. to 1200 and strontium D.F. to 8.5. The TBP concentration in the effluent was essentially the same as in the influent. Zirconium, niobium, ruthenium, and cerium radioisotopes were not removed by the bed (D.F. less than 2 in all cases).

Plutonium Recycle Test Reactor

Work was completed on the large area scintillation counter designed for measuring fuel rod low level uranium contamination. The instrument was demonstrated on several suspect fuel rods. Above-background measurements were recorded for several rods examined with two rods showing significantly greater alpha particle emissions (assumed to be from uranium) than the others. The two rods showing well above average were also the two identified earlier using spot checks with nuclear track film. A report of this work was prepared, HW-64273, "PRTR Fuel Rod Surface Contamination Measurements."

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

Samples of basalt and interbeds between basalt flows were examined by X-ray diffraction to search for significant mineralogical differences. The technique will be used to attempt identification of basalt flows exposed at different locations. Considerable data will be needed to permit correlation between locations.

A study of the ground water flow pattern near and beneath points of ground water recharge (mounds) was continued. The study is intended to permit evaluation of the ability of mounds to divert the movement of ground water and also to estimate their influence on monitoring results from wells. A numerical analysis technique was used to develop the flow pattern in the vicinity of such a recharge point. The resulting pattern appeared to conform with the pattern of flow lines observed in a laboratory model. This agreement tends to confirm the validity of the techniques and assumptions used in the numerical derivation.

To assist with evaluation of well sampling data, expressions were developed which estimate the vertical velocities produced in a completely perforated well as a result of initial small head differences between confined zones in an undisturbed aquifer. A typical situation would give a vertical movement of about seven ft/day for an initial head difference of about 0.12 foot of water. Movement of this magnitude could seriously distort the ground water monitoring data obtained from such a well.

A laboratory model was constructed for studying the influence of solution density on the movement of wastes in ground water. Preliminary tests with the model are encouraging and indicate the possibility of obtaining flow data for density effects in the specific gravity range from 1.0 to 1.2. The model will ultimately incorporate radioactive tracers to permit quantitative evaluation of the flow pattern.

Soil Chemistry and Geochemistry

A mineral reaction was studied whereby gypsum ($CaSO_4 \cdot 2H_2O$) is converted to barium sulfate when solutions of $BaCl_2$ are passed through a bed of the mineral. It was found that cesium is removed from solution by the reaction. The removal probably reflects the similarity in size between Cs^+ and Ba^{+2}. The incorporation of Cs^+ in the resulting $BaSO_4$ mineral is apparently permitted by some compensation of charge by anionic substitution. Cesium removal appears to be unaffected by the presence of gross concentrations of sodium.

Preliminary data were obtained from which the diffusion coefficient for cesium in clinoptilolite could be estimated. The effects of grain size, temperature, and sodium concentration confirmed those previously determined in column studies. Diffusion coefficients were measured for 0.2 M CsCl systems at pH 7. Measurements were made for clinoptilolite grain sizes 0.42-0.50 mm and 0.84-1.0 mm, for 25 C and 60 C temperatures, and for systems containing no sodium and 1.0 M sodium. The measured diffusion coefficients under these conditions ranged from $(1.7\text{-}4.8) \times 10^{-7}$ /sec-sq cm. This may be compared with reported diffusion coefficients for organic exchange resins of $(1 \text{ to } 2) \times 10^{-6}$ / sec-sq cm.

Laboratory experiments with oxalate-free solutions of Zr^{95}-Nb^{95} were performed to study the behavior of this material in soils. Trace concentrations of Zr-Nb were found to centrifuge in part from aqueous solutions in the pH range 2 to 10. The fraction removed by centrifugation was markedly affected by the pH. The greatest removal by centrifugation was found at pH 6.5, where 80 percent of the radionuclides were removed from solution by centrifuging at 1600 g. In the pH range from 6 to 10 more than 95 percent of the Zr-Nb could be removed by a 100 mu pore membrane filter. Below a pH of about 2 and above a pH of about 12 the radionuclides appeared to be mainly ionic and passed through the filter. The removal of Zr-Nb on soil was essentially unaffected by phosphate ion but adsorption by calcareous soils was strongly inhibited in the lower pH range by the presence of citrate ion.

Ground Waste Investigations

Three soil columns operating under unsaturated flow conditions were apparently performing satisfactorily. The interpretation of data obtained from unsaturated flow experiments is uncertain because to date these columns have not operated consistently enough to approach complete breakthrough. Improvements in research technique give promise of more reliable experimental results. The electrical conductivity of the soil was tested as a measure of the degree of moisture saturation in these unsaturated soil columns. A conductivity meter was used to measure the electrical resistance of the soil between two electrodes in a soil column. The resistance measurements were calibrated against gravimetric determinations of soil moisture content.

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Radiostrontium (Sr^{85}) apparently reached a maximum ground water concentration of 10 percent of the influent value in two wells near the Gable Mountain experimental crib. Normalized breakthrough curves prepared from sample data for these two monitoring wells appear to cross at the 50 percent breakthrough point, representing an influent volume of about 2800 gallons.

Field Apparatus Development

A gamma-ray scintillation detector was designed for improved monitoring of wells below the ground water table. Improvements should permit greater sensitivity, increased strength in the detector head support cable, and greater ease of handling. In situ gross gamma measurement of radioactive wastes in ground water should permit more rapid and economical identification of waste movement.

Another scintillation probe and collimator were designed for use in tracing gamma emitters in laboratory fluid flow models. Parameters determining direction and rate of flow should be more readily measured using the detector.

A single-unit well water depth sample was tested in nineteen project wells at depths of 40 to 550 feet below the water surface. These extensive tests proved the sampler to be useful and trouble free. For depths of submergence less than 100 feet the sample bottle is evacuated before use. This permits the bottle to fill when the inlet solenoid valve is opened. For use at greater depths, evacuation is not necessary. Seven additional units were ordered fabricated; these will be used in tandem and thus permit rapid sampling at pre-determined depths. Samples taken at several depths will provide data on stratification of wastes due to density differences, changing ground water velocity with depth, or other factors.

The samplings in the nineteen wells emphasized the generally poor condition of many wells. Sand has nearly filled some; debris and slimes are present in others. Well renovation is badly needed.

Micromeritics

Wall deposition was determined for 30u diameter glass beads carried in an air stream through a one-inch-diameter aluminum pipe. Extremely little deposition occurs for flow rates in the laminar flow region, whereas at a Reynolds number of 20,000, the deposition velocity is 22 ft/sec. At velocities greater than 11 ft/sec, re-entrainment is significant, much more so than for 20u crystalline ZnS particles. This suggests that shape of particles is an important factor in re-entrainment.

Equations were derived which express the length of a horizontal duct in which one-half the particles entering will be deposited in laminar flow. Variables are average fluid velocity, duct radius, and particle settling velocity. As calculated at a flow rate of one cfm in a one-inch-diameter pipe, one-half of the 4u particles of density 4.7 will deposit in about 25 feet.

The validity of turbulent deposition constants determined in the laboratory, and the calculation of sampling line deposition were tested using a

horizontal, 72-ft pipe simulating a sampling line. Preliminary data for a flow rate of 8 cfm showed that of the particles introduced, only 34 weight percent passed through the pipe. Calculations showed that about 26 weight percent should have passed through if turbulent deposition were the controlling mechanism. The agreement is considered satisfactory.

The results of these studies continue to emphasize the importance of short delivery lines in particle sampling.

Analytical Procedure for Strontium-90 in Milk

An ion exchange separation procedure was developed for removing metabolized strontium-90 from sheep milk. Quantitative removal was obtained on a strong acid cation exchange resin from milk buffered to a pH of 5.6 with acetic acid and ammonium acetate. Calcium is also quantitatively retained on the resin. The strontium and calcium were eluted from the column with 3 N nitric acid and separated utilizing the difference in solubilities of the nitrate in concentrated nitric acid.

Studies on Erioglaucine

In continuing studies of the effect of chemical structure on the free radical scavenging ability of erioglaucine, it was found that the sulfonate group at the ortho position strongly shields the central carbon atom from attack. For example, the reaction rate constant for attack by hydroxide ion on erioglaucine is only about 0.01 that for an analogous dye which does not contain this ortho-substituent. In order to determine the species of erioglaucine present in aqueous systems under various conditions, measurements of the protolysis and hydrolysis rate constants are being made. Very pure erioglaucine is needed for this and since commercial erioglaucine contains some quantities of other materials purification by treatment with Norit A charcoal and two recrystallizations from ethanol were found necessary. The product was judged to be pure since it gave one well-defined paper electrophoretic band instead of the many observed before purification.

Detection of Phosphorescent Particles

Automatic counting instrumentation for ZnS phosphorescence was set up and satisfactorily tested for application to the determination of ZnS particles on membrane filters. A detection limit of 10^{-9}g ZnS was obtained which is satisfactory for the Atmospheric Physics Operation application.

L. P. Bupp

Manager
Chemical Research and Development

LP Bupp:pc

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BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

John P. Herring was promoted to a Chemist II in the Biological Analyses Operation. Dr. Harold E. Dzuik joined the Pharmacology Operation.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

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

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

Columbia River Contamination

Concentrations of gross beta emitters in Columbia River organisms collected at Hanford were about the same as one year ago. Values follow:

Location	µc/g Wet Wt. Average	µc/g Wet Wt. Maximum	Trend Factor
Hanford minnows (entire)	9×10^{-4}	1×10^{-3}	- 3*
Hanford juvenile chinook salmon (entire)	3×10^{-4}	3×10^{-4}	-

* Values are compared with those obtained in December 1959.

Fallout Contamination

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

Sample Type	µc/g Wet Materials Average	Trend Factor
Bone	9×10^{-5}	+ 5
Muscle	3×10^{-5}	+ 6
Feces	2×10^{-5}	+ 2
Liver	1×10^{-5}	+ 3

Effect of Reactor Effluent on Aquatic Organisms

Routine monitoring of effluent from the 100 KE reactor was interrupted prematurely in the middle of the month as consequence of failure of the river water supply. At this time, mortality of young fingerling salmon held in concentrations of reactor effluent characteristic of those now existing in the Columbia River and anticipated for the future amounted to about 2% compared with a mortality among the controls of just under 1%. Since the fish in the dilute effluent water had developed more rapidly than the controls, owing to slightly warmer temperatures, careful analysis will be required in order to decide whether the slightly increased mortality among the fish in the effluent lots is meaningful.

The manner in which columnaris cells are cultured appears to modify their ability to kill fish. Cells cultured on a rotary shaker appear to have a lower virulence than cells cultured with a magnetic stirrer. The nature of this development is extremely puzzling since in both cases aeration and agitation are quite comparable. It may relate, however, to the observation that these organisms have flagellae. These flagellae may be important for virulence and one of these culture conditions made repress flagellation. Presence of flagellae has, to our knowledge, not been previously reported for this organism.

A variety of fish caught in the river were examined for the presence of columnaris organisms. To date no columnaris has been obtained from any of the samples tested.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Phosphorus

Cichlids which have been exposed to three levels of P^{32} in water for about six months continue to show an undesirably great variation in concentration of P^{32} between individuals. In virtually every case, however, the concentration exceeds that of the experimental design and some spawning has occurred at each level. The number of egg lots obtained thus far is insufficient for any conclusion as to the presence or absence of radiation damage.

Zinc

Studies on Zn^{65} transfer from ewes to their milk and to their lambs were completed and data are being processed. Autoradiographs of the kidney confirmed the previous finding of a much higher uptake of Zn^{65} in the cortex than in the medulla of this organ.

Previous data appeared to show a strong effect of foliar exposure on the uptake of Zn^{65}. Laboratory experiments with bean plants indicate only a four-fold increase of Zn^{65} in plants sprayed as compared with plants irrigated by application of the isotope solution to the soil. In both cases, Zn^{65} was applied as a solution in distilled water. Traces of clay particles added to the distilled water doubled the amount of Zn^{65} retained by the leaves as compared with water containing no particulates.

Reviewing our experience, it appears that a very strong effect of foliar application on Zn^{65} retention has been observed only in cases where a distinct root mat was present, as in pasture grass or lawn sod.

Strontium

Rainbow trout which have been force fed Sr^{90}-Y^{90} 5 days a week at three different levels (5×10^{-3} µc/g of fish, 5×10^{-2} µc/g of fish, and 5×10^{-1} µc/g of fish) have shown no significant differences in growth or mortality at the end of one month. There is an indication, however, that the growth rate of some of the fish receiving the highest level of Sr^{90}-Y^{90} is being depressed. The average sized fish in the high level group is now receiving about 85 µc Sr^{90}-Y^{90} each day Monday through Friday.

Experiments to evaluate the rate of uptake and translocation in plants of Sr and Ca with respect to water are presently underway. These experiments utilize Sr^{85}, Ca^{45}, and tritium to trace ion movement. Preliminary results suggest that short and long term build up may not directly coincide.

During the first six months of life, first generation offspring of the miniature swine on 25 µc/day of Sr^{90} have shown a general depression in appearance and body weights as compared with the offspring of the controls, the 1 µc and the 5 µc/day animals. At this time, however, there appears to be a slight tendency for recovery. Bizarre white blood cells, tentatively identified as large lymphocytes, have also been observed in some of the 25 µc/day offspring. Further pathological and histological evidence is necessary before these changes can be assigned to radiation damage. The dose-effect relationships are being evaluated.

Iodine

Lambs are being trained to nurse from the bottle in preparation for the comparative study on I^{131} uptake from milk labelled *in vivo* or *in vitro*.

Plutonium

A new chelating agent obtained from Geigy Chemical Company, designated RA-491, was compared with DTPA for its effectiveness in promoting the excretion of internally deposited Pu in the rat. Due to the limited available supply of RA-491 less than optimum amounts were employed and results are therefore quite preliminary. Although consistently less effective than DTPA in its overall effect, RA-491 was more effective than DTPA in promoting excretion by the feces, both following intragastric and intraperitoneal administration. This suggests that the two chelating agents may be operating in a somewhat different fashion and that a combination of the two might be more effective than either alone.

Two more miniature swine were utilized in the study on the effect of tourniquets on preventing the translocation of subcutaneously injected plutonium. In the animal on which a tourniquet was applied, the amount of plutonium deposited in the liver was one-eighth that of the control animal. It was noted that the blood concentration of plutonium in the tourniqueted animal was lower than that of the controls at 15 minutes but after one hour was higher than in the control animals, suggesting a flushing action at the time of tourniquet release. (On the next series of animals, special care will be taken to remove the entire injection

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site surgically before the tourniquet is released and local bleeding has been allowed to take place.)

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

Three one-year-old miniature swine were injected with Sr^{90} this month. This completes all groups in this experiment designed to test the comparative toxicity of Sr^{90}, Ra^{226} and Pu^{239} in miniature swine of varying ages (6 weeks, 6 months, and 1 year). After three months, the groups injected at weaning (6 weeks old) have shown an apparent initial reduction in the neutrophilic blood components as compared to the controls. Clinical data on the other groups have not been completed.

Radioactive Particles

Two dogs were killed this month for histology sections, one after 64 days post-exposure and another after 79 days post-exposure. Lungs of both dogs showed consolidation and fibrosis. The tracheobronchial lymph nodes were also swollen and consolidated.

At 16 weeks post-exposure, the lymphocyte values in the two groups of dogs that had received the highest doses of plutonium decreased to about 20 per cent of the control values.

Studies with inhaled phenolpthalein aerosols in rats have indicated that more deposition occurs at slower rates of breathing. With the depth of respiration kept constant, the amount deposited was greater at 60 respiratory cycles per minute (.26 mg/hr) than at 100 cycles per minute (.18 mg/hr).

Continued observations were made of five male beagles exposed to a single acute toxic dose of $Pu^{239}O_2$ by the pistol method. This consists of hematological determinations, fecal and urine excretion rates, and the calculation of body burden from dog-counter data.

Gastrointestinal Radiation Injury

The experiment to study the effect of chronic feeding of Y^{90} to rats has now been underway for about 450 days. Over a period of 60 days at the beginning of the experiment, 50 rats received 0.5 microcuries of Y^{90} per day; 50 received 0.1 microcuries of Y^{90} per day and 50 were maintained as controls with no Y^{90} in their drinking water. Forty-two animals from the 0.5 microcurie group, 24 from the 0.1 microcurie group and 11 from the control group have died or were sacrificed in a moribund condition. Only gross observations on pathology are available. No histological confirmation has yet been obtained. It is interesting, however, that there appeared to be cancerous involvement of the gut in only one animal from each of the experimental groups. Evidence of hemorrhage in the gut, tumors in the oral region, and in the reproductive organs, were much more frequent observations.

Microbiological Studies

The apparent protection against growth depression from tritium, as afforded to yeast cells by pre-irradiation with X-rays, was reinvestigated. The previously

reported results were calculated on the basis of viable cell concentration. Present data indicate that the total cell concentration is the determining factor in the combined effectiveness of tritium and X-rays. Apparently cells which are unable to divide are nevertheless effective in modifying the radiation damage.

Effects of Radioactivity on Populations

Cultures of grain-infesting moths, Ephestia, in media containing different concentrations of Sr^{89} have not eclosed as scheduled. No progeny are found in concentrations higher than 900 µc/300 g cornmeal; whereas, they are evident in lower dilutions. Although most of the progeny are still larvae, there are a few pupae. Evaluation must therefore be deferred until the control cultures have matured.

Palatability experiments to feed Habrobracon Pu^{239} were developed. Five different concentrations of Pu^{239} were fed to the wasps. Fertility, fecundity and longevity data are being collected.

Attempts to feed successfully $Zn\ Cl_2$ compounds are as yet not accomplished.

BIOLOGY OPERATION

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C. Lectures

a. Papers Presented at Meetings

W. J. Bair, "Deposition, retention, translocation, and excretion of radioactive particles," British Occupational Society Symposium on Inhaled Particles and Vapours, Oxford, England, March 29-April 1, 1960.

b. Off-Site Seminars

L. K. Bustad, "Hanford Biology," Puyallup Rotary Meeting, March 23, 1960, Puyallup, Wash.

c. Seminars (Biology)

R. F. Palmer, "Deposition in Rats of Reactor Effluent Radioisotopes," March 9, 1960.

B. J. McClanahan, "Flame Photometry", March 9, 1960.

D. G. Watson, "Zinc^{65} in Marine Organisms Near the Mouth of the Columbia River," March 21, 1960.

W. J. Bair, "Accumulation of Inhaled Plutonium in Tracheobronchial Lymph Nodes," March 21, 1960.

Dr. Richard W. Lawton, Missiles and Space Vehicle Department, General Electric, Philadelphia, "The Role of Biological Science in Space Exploration," March 29, 1960.

Dr. Lawrence J. Middleton, Agricultural Research Council, Radiobiological Laboratory, Wantage, Berkshire, England, "Agricultural Research Council's Radiation Biology Program," March 31, 1960.

Dr. E. L. Powers, Argonne National Laboratory, Lemont, Illinois, "Radiation Damage to Cells," March 25, 1960.

d. Seminars (local)

N. L. Dockum, "A Part Biology Operation plays in Hanford Safety," IPD Safety Meeting, 3/25/60.

D. Publications

a. HW Publications

None

b. Open Literature

George, L.A. II and G. S. Vogt, "Electron Microscopy of Autoradiographed Radioactive Particles," Nature 184, 1474-75 (1959).

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - MARCH, 1960

ORGANIZATION AND PERSONNEL

L. G. Waters transferred to Operations Research & Synthesis Consulting Service, Management Consultation Services, on March 31, 1960. He was replaced by Z. E. Carey who transferred to the Operations Research & Synthesis Operation effective March 1, 1960.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

Meetings were held with personnel from FPD and IPD in which agreement was reached as to the way in which Quality Certification data will be reported to IPD. Emphasis will be on control chart techniques. A proposal to reduce sample sizes in reporting on pre-irradiation dimensional data was accepted.

In connection with the utilization of IBM machines to process data, a revised definition of TFC (tube filling capacity) was developed. Although more difficult to compute by hand, it is more amenable to machine calculation than the present definition. Debugging of the program to calculate differences between post-irradiation and pre-irradiation dimensions is in progress.

Fuel Element Failures

Two methods of routinely analyzing rupture data to monitor fuel element quality by means of control charts were developed. The first method uses as the statistic the number of ruptures per two month period. The limits in this case are variable in that the potential for rupture is not constant due to varying reactor conditions. The second method uses as its statistic the adjusted length of time necessary to accumulate R ruptures where the adjustment removes the effect of reactor variables. The latter method is desirable because the limits are fixed, and operating personnel are accustomed to dealing with sequences of ruptures rather than the number of ruptures occurring during a fixed time period. In order to demonstrate the use of such charts, a sampling experiment was conducted in which 20 years of "rupture" data were generated. The types of apparent non-randomness which exist in a controlled situation when analysis is made after-the-fact are very illuminating. A report is being prepared.

A report was written on the amount of information concerning the effects of power on rupture rates that will result from a monitor program in which a central block of tubes will be run at higher power levels through the use of enrichment. This program is compared with one in which the power level of an entire reactor is raised.

Optimization of Reactor Operations

As discussed in the February report, the potential benefits that would result from an optimum allocation of supplemental crew personnel to perform charge-discharge work were to be investigated in order to build up a case for such a procedure. Although no time was available during March to pursue this, it

now appears that such a system of allocating manpower will be instigated without the need for this presentation. Attention will be diverted to other problems in this area as time permits.

Z-Plant Information Study

Liaison with Electronic Data Processing Operation and AEC representatives concern- the acceptance of on-line computational equipment continued during the month.

Reliability Studies

The K plant reliability study is nearing completion. A report summarizing the principal results to date has been sent to interested persons.

Work continued on the NPR reliability study. A digital computer program with the time dependent reliability over-all safety circuit system was written and executed, and the results presented to interested persons. An interim report, in the form of a letter setting forth a mathematical model underlying the analysis has been sent to personnel connected with the study.

Inventory Studies

A procedure to consider quantity discounts in procurement of general supplies was discussed with General Stores and Excess Property Operation management and buyers on February 26 and March 2. There was general agreement by all concerned on its value.

A sampling procedure similar to that outlined in Product Cost Accounting Bulletin, PC-15 was developed for sampling Spare Parts and Standby Inventory. The procedure was tested on a five percent of the same inventory for 1958 and found to give an inventory deficit of 58,000 $\pm$ 141,000 compared to a deficit of 60,000 found by 100 percent inventory. The procedure designed for the 1960 inventory calls for sampling 15 percent of line items representing 80 percent of the dollar value. Assuming the quality of inventory records to be as good as 1958, the error introduced by sampling in 1960 should be considerably less than one percent of inventory. Time for inventorying should be reduced to one-third of that used previously.

Redox Dissolver Study

The logical analysis of Malody's model emphasized that models of this type cannot be solved by assuming straight linear or even logarithmic relationships between variables. It is necessary to determine the exact or at least the approximate relationship between each variable based upon sound theoretical considerations. Consequently, effort has been expended toward searching the literature to obtain the necessary background relating to chemical kinetic theory, which has been incorporated into a rough model by CPD personnel. Current efforts are aimed at converting this model into a set of simultaneous

differential equations which describe the dynamics of the dissolver process as a function of time. The solution of this set of equations provides a model which can be reconciled with available initial and final conditions data.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

The analysis of data from the experiment designed to evaluate the effects on porosity and can wall thickness of canning bath temperature, vibration frequency, and time of vibration was completed. This was conducted as a replicate of a cuboctahedron design with four center points in each replicate. The results from the two blocks were very consistent, and the residual error agreed quite well with the true error estimate arrived at by the replications of the center point, which indicated that the quadratic surfaces were adequate to describe the yields. It was also possible to estimate the effects of different jacks and virgin vs. recovered cores in this experiment.

Analysis was also completed of data from an experiment to evaluate four cap vibrators having different cam designs. In this experiment, a block consisted of one canning bath set-up where a different vibrator was used on each jack. All 12 possible combinations were run, and some very interesting block effects were uncovered.

An experiment was designed to evaluate the effectiveness of diversey 600 in the aluminum component cleaning process. Different concentrations and different ratios of sulfuric acid to diversey within each concentration are being evaluated.

Dimensional data from bumper fuel elements were used to describe with tolerance statements the variability in dimensions of the present bumper fuel element.

AlSi density measurements were used as a measure of porosity in an additional experiment in which vibration frequencies and canning bath temperatures were varied. It appeared to be an insensitive measurement.

A descriptive analysis was made of warp and diameter change measurements from the continuing production test comparing chloride with carbonate salts in the heat treatment of bare cores.

Irradiation Processing Department

At the request of personnel of the Industrial Engineering Operation several formulas which give the reactor maintenance times for outages were checked and reviewed. The formulae were developed as an objective basis for comparing the several different systems of performing maintenance work.

A study has been made to determine how the frequency of factor determinations affects the factor accuracy. The data indicate that the variation within periods of equilibrium is small but that tube factors taken from non-representative time periods may often be expected to be in considerable error. This leads to the suggestion which is being tried at present, that reactor equilibrium and transition conditions be monitored by statistical control techniques on a sample of tubes, which are chosen for their sensitivity to

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change. The knowledge gained from these tubes will thus afford a basis for selecting the times for tube factor determinations.

A study has been completed which discusses various aspects of the accuracy of reactor power level values in the context of the control of SS materials. The evidence strongly indicates that the conversion ratios themselves are the most likely source of a large, persistent and overriding error. The report is being reviewed by IPD personnel before it is released as a document.

Mathematical solutions were obtained for the heat conduction equation in a small cylindrical resistance-heated electronic component. Due to the complexity of the exact solution, appropriate approximations were suggested.

Technical consultation on the subject of linear programming and associated techniques is being given a member of Manufacturing Operation.

Chemical Processing Department

The compliance with minimum plutonium content specification of fabricated parts was demonstrated for the first quarter of 1960. Due to excellent analytical and process control as well as a relatively high average purity, the highest minimum plutonium content to date was obtained.

Graphs illustrating the comparison of the presently used index of nuclear material control (BPID) and the recommended "minimum variance inventory" concept were prepared at the request of CPD Production Operation. The feasibility of officially adopting the minimum variance inventory method for nuclear material control in CPD for FY 1961 is to be discussed by personnel of the Production Operation (CPD) and Nuclear Materials Operation (Contract and Accounting).

Relations Operation

Several days were spent during the month on the Community Survey conducted at the request of the Relations Operation. Efforts concerned selection of a proper sample of Tri-City residents and guidance in the implementation of sampling procedures.

Contract and Accounting

Initial scoping and establishment of a measurement system to acquire analytical data describing the scheduling system for the IBM 709 computer operation has been accomplished. A detailed breakdown of loss time data involving the operators, equipment, programming systems, utilities, input and output control, and "production classes" is in process.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Aluminum Alloys Corrosion Rate

A statistical analysis was initiated using Al-Ni-Fe alloy corrosion data from a recent study conducted by the Corrosion and Coating Operation to

investigate the effect 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. The results of the analysis will aid Corrosion and Coating Operation personnel in designing similar experiments to determine the effect of the same variables on zirconium alloys.

Creep Rate Estimation

Secondary creep rate estimates and confidence intervals were constructed for personnel of Physical Metallurgy Operation using data from a current in-reactor creep capsule experiment. The results of the calculations plus an outline of the method used were forwarded to interested persons.

Reactor Kinetics

Several discussions were held with Dr. H. Poritsky of the General Engineering Laboratory on mathematical techniques applicable to the study of the properties of the solutions to the three-parameter reactor kinetics differential equation.

4000 Program

Plutonium Recycle

Several discussions were held with personnel of Programming Operation to explain the use of statistical methods for determining a maximum of a function defined over a multi-dimensional space. A modification of a steepest decent procedure based on fitting the best linear surface using a fractional factorial type statistical design was suggested for use with HLO's Meleager physics code. Current efforts are directed toward constructing a flow chart preliminary to programming the procedure.

The statistical analysis of the Phase I pressure test of the PRTR containment vessel has been completed and incorporated into an unclassified document, HW-64446, "A Mathematical and Statistical Approach to the Design and Analysis of a Reactor Containment Vessel Pressure Test." In addition to discussing the analysis of the Phase I test, the document considers the design of a future test including the positioning within the vessel of temperature and pressure monitoring devices, the analysis of data from these devices and the estimation and precision of leak rate estimates. This document will be made available to HLO personnel in the near future.

Swelling Studies

Further work was done on the theoretical model to account for the distortion, or extrusion, introduced in the sample preparation of replicates prior to electron microscopy. Study of micrographs of three distinct diameter plastic balls in a "scotch" median continues in an attempt to determine the effect of pore size on distortion.

6000 Program

Biology and Medicine

At the request of Experimental Animal Farm Operation, work was begun on

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PROGRAMMING OPERATION
MARCH 1960

A. REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. An analysis of neutron angular distributions calculated by the RBU Monte Carlo code was carried out. The results agree well with expectations. A modified and simpler technique for computing diffusion coefficients in RBU was developed. The input code was revised to conform to the error detection system used in the rest of RBU.

A preliminary formulation of the Box-Wilson optimization technique suitable for programming for the IBM-709 has been completed. The program is presently being flow-charted.

Fuel Cycle Studies. The general correlation of the reactivity worth of plutonium fuel enrichment proceeded during the month with a total of about 150 new reactor physics cases calculated using the Meleager code on the IBM-709 computer. These cases were calculated for the case of graded irradiation (continuous charge-discharge) and complement those cases calculated last month for batch exposure conditions.

A preliminary examination of the data suggests that maximum plutonium value in terms of exposure may be obtained from batch exposures in a reactor having several zones of varying moderator to fuel ratios. Initially, the plutonium enriched uranium-238 would be placed in the zone having the lowest moderator to fuel ratio, which leads to a relatively low reactivity and specific heat output, and a high conversion ratio. As the plutonium enrichment is depleted, the fuel elements would be moved to zones with increasing moderator to fuel ratios. The advantages of this procedure appear to be greater in plutonium than in uranium-235 enriched fuel systems.

The Meleager code is currently being used to check some preliminary hand calculations of breeding ratios in multi-reactor systems.

PRTR Startup

Work in support of PRTR startup included review and analysis of critical tests and process specifications. Also a Pilot Tube Test was designed in which a single PRTR tube is specially fitted and instrumented to achieve controlled higher operating temperature than other reactor process tubes. Detailed planning of the Power Test Phase was carried out under auspices of the Power Test Sub-Council.

PRTR Plans and Schedules. A set of tables was constructed for plutonium accountability during the first nine months of PRTR operation.

A review of the schedule for plutonium utilization in PRTR was made on the basis of most recent expectations and actual receipts of plutonium fuel. Although changes exist in the earliest part of the program, actual and anticipated receipts will permit continuation of the original schedule including the production of high exposure plutonium.

SPECIFIC FUEL CYCLE ANALYSIS

The physics calculations for the Advanced Pressurized Water Reactor Study as reported in TID-8502 Pt 1 by Combustion Engineering, Inc. have been repeated using the Meleager code. The results agree as to exposure and reactivity but disagree on the "boron mismatch" (the reactivity peaking due to uneven depletion of poison and fuel). An unshielded boron cross-section, corresponding to the description of the fuel elements in this reactor, was employed in our study, while the APWR study uses a reduced (self-shielded) boron cross-section. Boron poison is not apt to be used extensively in our studies for this reactor, but this discrepancy will be resolved shortly in any case.

The Specific Fuel Cycle Economics Code is now being programmed. Its logic and flow charting is complete. The code is completely generalized and, when coupled with any given reactor, fuel processing and economic parameters, will compute, with considerable refinement and detail, the costs of fuels of any isotopic composition (Th-232 through Pu-242).

Sub-codes are provided for each division (roughly chronological) of the fuel cycle. Principal of these are (1) Fabricating and Jacketing, (2) Pre-Reactor Inventory and (3) Nuclear Process Costs. The latter computes all ordinary fuel cycle costs from charging into the reactor to completion of separations.

Another sub-code computes extraordinary startup and close-down costs and amortizes them and applicable working capital costs to KWHe produced during the reactor's lifetime. These costs are mainly excess fabricating and jacketing and burnout (the latter only on close-down) incurred when, on a graded discharge basis, elements are discharged before completion of their normal in-reactor life. Burnout will not be a start-up factor, assuming graded enrichment of the initial load approximating that of an in-reactor equilibrium load.

Finally, a sub-code entitled "Payment Delay Holding Credit" computes the net decrease in working capital costs that may be gained by delaying completion of the fuel cycle and, thereby, final settlement with the AEC for net nuclear material consumption. This period may be infinite, given no AEC limitation on its length and a large enough spread between the AEC use charge rate and the cost of obtaining working capital.

The following chart gives a general picture of the code's composition. For this illustration, the matrix form has been reversed and the individual process steps in Fabricating and Jacketing and Nuclear Process Costs have been omitted.

Type of Cost	Fabricating & Jacketing (1)	Pre-Reactor Inventory	Nuclear Process Costs	Extraordinary Startup & Closedown (3)	Payment Delay Holding
Processing Cost			X		
Thruput	X				
(2) Recycle	X				
(2) Scrap & Loss	X				
Fuel loss	X		X		
(2) Value decline due to scrapping	X				
Pu-241 decay	X	X	X		X
AEC use charge	X	X	X		X
Working capital cost	X(4)(2)	X	X	X	X
Decay change in Pu batch value	X(5)		X(6)		
Startup and close-down amortization				X	
Reactor burnout			X		
Unsep. disch. alternate			X		
Separations recovery			X		

(1) Alternate sub-codes are provided. In one, all recycle re-enters the beginning of the process while, in the other, recycle may re-enter at any point previous to the point of rejection.
(2) These computations are eliminated wherever external purchase of either the fabricating and jacketing service or separations service is assumed.
(3) Computations in this column are eliminated in the case of batch discharge. In addition, Pre-Reactor Inventory computations are altered significantly although the same type of costs are involved.
(4) Includes in-reactor charges for working capital invested in fabrication and jacketing.
(5) Combined for Fabricating and Jacketing and Pre-Reactor Inventory.
(6) Combined for Nuclear Process Costs and Payment Delay Holding.

B. BIOLOGY AND MEDICINE - 6000 PROGRAM

Radiological Consultation

Consultation was rendered in the following areas: hazards in the use of plutonium in hot cells designed for fission products work, fission product release experiments with irradiated fuel, Environmental Monitoring Programs, revision of Radiation Protection Standard 3.1, the measurement of small particle size aerosols, long-range effects of fallout, a proposed standard on the operation of test and research reactors, the effects of the Columbia River on Hanford's environs, and on the deposition of radioiodine from the atmosphere and the influence of known variables on this deposition.

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Other activities included review of two proposed handbooks from the NCRP. An initial meeting of the American Board of Health Physics was attended; procedures for carrying out certification were discussed. Two meetings of the Steering Committee for the forthcoming hearings on Radiation Protection Standards were attended. The proposed testimony for the hearings from Hanford was outlined.

Discussions were held concerning the preparation of a book on "Radiological Engineering".

C. OTHER ACTIVITIES

Dr. Joseph Kaplan, eminent geophysicist, and professor of physics at UCLA spoke on Highlights of the IGY at a very successful Hanford Science Colloquium on March 22.

Negotiations were completed and instruction began on a new graduate level course, N. E. 501, Nuclear Reactor Theory Laboratory. This is the first complete laboratory course for college credit to be given using the facilities of Hanford Laboratories. Nine students are enrolled.

Assistance was rendered and arrangements made for seven tours (involving 44 people) through HLO and HAPO facilities.

L H McEwen

Manager, Programming

LH McEwen:dl

RADIATION PROTECTION OPERATION
MONTHLY REPORT -- MARCH 1960

A. ORGANIZATION AND PERSONNEL

On March 14, 1960, Evelyn VanFossen transferred to the Radiation Monitoring Operation to replace Joan M. Weston who transferred to Professional Placement and Relations Practices. Donald W. Constable, Technical Graduate, was placed on a three-month rotation with the Radiological Development Operation effective March 1. The force of the Radiation Protection Operation remained at a total of 133.

B. ACTIVITIES

There were no new cases of plutonium deposition confirmed during March, thus, the total number of deposition cases that have occurred at HAPO is 249 of which 180 are currently employed.

Radiation Monitoring was provided for vapor-plating olive material in the 231 Building. The maximum hand dose rate encountered, while wearing lead gloves, was 10.2 rems/hour including 200 mr/hour of gamma radiation with the remainder due to neutron radiation. The unshielded surface dose rate is expected to approach 400-500 r/hour, due primarily to soft gamma radiation having an average energy of 44 kev. A film study to determine the surface dose rate due to gamma radiation was unsuccessful. Further studies utilizing calibrated film of 44 kev energy are in process.

A surface dose rate of 9 rads/hour was encountered in the 231 Building while handling clad fuel rods containing palm material. Self-reading pencils have proven useful to control both body and hand exposure for this work.

Flow rates in the Columbia River dropped to 36,000 cf/s for several days in the middle of March. The normal flow rate for March is about twice this figure. The filling of the Priest Rapids Dam pool caused the low flow rates. Special samples were collected for isotopic analysis to increase HAPO knowledge of potential exposure from Columbia River water at low flow rates.

Discrepancies have been noted in the analysis results when comparing the amounts of radioisotopes reported discharged to the Columbia River at Hanford, and compared to the amounts measured with those expected at Pasco during 1959. To resolve the differences, three HAPO laboratories have performed analyses of the same sample for the same identical isotopes. A sample of the 100-KE reactor effluent water, taken at the same time during February, was submitted to the Purex Analytical Laboratory, Radiological Chemical Analytical Laboratory, and Radiological Chemistry Laboratory. The results of the analyzed radioisotopes were compared for the single sample. The highlights of the testing produced the fact that for two of the isotopes of principal interest, As^{76} and Np^{239}, Purex is apparently low by a factor of 2 for As^{76}; Radiological Chemical Analytical Laboratory is high by a factor of 2 for Np^{239}. Purex results also appear high on Na^{24} and low on Cr^{51}. Zn^{65} results were in good agreement. Investigations are currently in process by the concerned laboratories to reconcile these differences. To ascertain complete accuracy multiple samples must be analyzed for comparison.

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The Whole Body Counter operated satisfactorily during March with a minimum of down-time for equipment failure. Routine counting continued with a total of 141 HAPO employees and three nonemployees being processed.

A cooperative experiment was initiated by Radiological Physics with Dr. C. L. Finch of the University of Washington. The purpose of the experiment is to determine the uptake of orally administered Fe^{59}. Three subjects were given iron salt and three were given hemoglobin solution at the University of Washington. Two weeks later, they were brought to the WBC and counted. These three subjects were compared with two HAPO employees who volunteered and were given intravenous injections of Fe^{59}. The total result of the experiment cannot be reported until the University of Washington has completed their calibrations. Incidental to the experiment, an Fe^{59} calibration was obtained for the HAPO Whole Body Counter. The calibration was in good agreement with the value extrapolated from data for Na^{22}.

In calibration of the WBC for Zn^{65}, differences in calibrations have been obtained with different people. The discrepancies may be due to the distribution of Zn^{65} in the body for different individuals. A study was made on the distribution of Zn^{65} in one employee for a period of one month. The initial deposition of Zn^{65} was in the area of the liver, however, later counts showed a spread to the head and the legs.

Counting individuals in the WBC lying prone on a table by moving the crystal in four-inch increments has proven to agree within 5% with regular counts for K^{40}, Fe^{59}, Zn^{65}, and Cs^{137} based on the total count observed. Theoretically, this procedure is necessary for an ideal count, however, these data confirm that the HAPO technique is entirely satisfactory.

Film badge preparation was centralized and servicing of all badges from the 3705 Building started on March 28, 1960.

The comparison film badge exchange experiment between Savannah River, Rocky Flats, Los Alamos, and Hanford has proceeded. Some differences in results have been noted, however, a complete report will be published when all of the data has been submitted.

Some initial studies of the Bausch and Lomb microdensitometer reader have indicated a linear response for Co^{60} irradiated silver glass dosimeter rods in the range of 20 to 1,000 rads. A 50% fading was observed during the first 24 hours following irradiation. A fading rate of 2% to 4% per week is indicated after the first day. Due to the rapid rate of fading, it is doubtful whether doses of less than 10 rads can be determined with certainty. Doses above 1,000 rads have not yet been studied.

Installation of all major components at the Columbia River Monitoring Station has been completed. Continued electrical malfunctioning resulted in a visit of Minneapolis-Honeywell Regulator Company personnel to make repairs on equipment. With the exception of the alarm circuit, which has not been tested, all components appear to be functioning adequately. A test period of about four weeks will be used to observe the system under constant use and to make any necessary adjustments. The official termination of the construction phase of this project met the AEC deadline of March 31.

All equipment that was authorized and ordered on an appropriation request titled "Precision Medium Speed Digital Measuring Instruments and Plastic Man Phantom Including Skeleton and Body Organs" has arrived. This equipment will be used for a variety of neutron dosimetry studies leading to data useful in the development of a full energy range personnel neutron dosimeter.

C. EMPLOYEE RELATIONS

Six suggestions were received for evaluation. Five suggestion evaluations were made during the month. There are three outstanding suggestions at month end. Three suggestions by RPO personnel have been adopted, but have not been presented to the board for approval of payment.

There were eight medical treatment injuries during the month for a frequency of 3.41. No security violations occurred during March.

Students from local public schools visited the Whole Body Counter during March.

Radiation protection training included: A lecture on "Effects of Nuclear Weapons and Basic Defense" to employees of Special Separation Processing and Auxiliaries Operation (Redox, CPD); four 2-hour orientation talks to Plutonium Metallurgy, Radiographic Testing, and Chemical Effluents Technology personnel; four 2-hour lectures on radiation protection to Fire Protection employees in the 100 and 200 Areas; as well as several orientation and training lectures to numerous groups in the 300 Area.

D. SIGNIFICANT REPORTS

HW-64468 "A Portable Civil Defense Air Sampler" by L. F. Kocher.

HW-64523 "Analysis of Radiological Data for the Month of February, 1960" by R. L. Junkins.

HW-64591 "Monthly Report - March 1960, Radiation Monitoring Operation" by A. J. Stevens.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-February 1960 - Mid-March 1960)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.7	% MPC_{GI}*
Separations Areas	Gross Beta	1.1×10^{-7}	μc/cc
Pasco	Isotopic	5.8	% 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	1.2×10^{-8}***	μc/cc
100-F Area	Isotopic	2.6	% MPC_{GI}*
Hanford	Isotopic	2.2	% MPC_{GI}*
Pasco	Isotopic	16	% MPC_{GI}**
McNary Dam	Gross Beta	1.3×10^{-6}	μc/cc
Vancouver, Washington	Isotopic	0.4	% MPC_{GI}**
Columbia River Mud			
Pasco Vicinity	Gamma Emitters	3×10^{-5}	μc/g
Atmosphere			
I^{131} Separations Areas	I^{131}	9.7×10^{-14}	μc/cc
I^{131} Separations Stacks	I^{131}	0.2	Combined curies/day
Active Particles - Project	--	2.3	ptle/100 m^3
Active Particles - Environs	--	1.0	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} μc I^{131}/g)			
Separations Areas	I^{131}	1.6×10^{-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 Ore.	Gamma Emitters	2.4×10^{-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
March	2	1
1960 to Date	2	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
March	17,634	307	5	4
1960 to Date	57,096	695	12	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)	Average Dose Per Film Packet mr(s)
March	10,419	1,105	275	50	33	11.73	20.25
1960 to Date	32,565	2,941	558	127	95	10.83	20.12

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
March	1,251	1	0	0	7
1960 to Date	3,570	1	0	0	13
Fast Neutron					
March	322	14	15	0	6
1960 to Date	756	53	23	0	10

Bioassay		March	1960 to Date
Plutonium:	Samples Assayed	709	2,190
	Results above 2.2×10^{-8} µc/sample	62	129
Fission Products:	Samples Assayed	656	2,138
	Results above 3.1×10^{-5} µc FP/sample	1	1
Uranium:	Samples Assayed	311	910
Confirmed Plutonium Deposition Cases		0	5*

*This brings the total number of plutonium deposition cases which have occurred at Hanford to 249.

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	57	5.6	62	42	4.2	31
Hanford Laboratories	16	4.6	35	13	3.4	31
Chemical Processing	53	2.3	45	21	2.4	48
Chemical Processing*	5.2	4.1	3	3.7	3.0	3
Special Indicents	111	13	15	-	-	-
Random	18	1.1	38	-	-	-

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

Thyroid Checks	March	1960 to Date
Checks Taken	0	0
Checks above Detection Limit	0	0

Hand Checks		
Checks Taken - Alpha	31,801	93,072
- Beta-gamma	43,309	132,592

Skin Contamination		
Plutonium	23	69
Fission Products	46	115
Uranium	5	19

CALIBRATIONS

Portable Instruments	Number of Units Calibrated March	1960 to Date
CP Meter	839	2,670
Juno	272	861
GM	716	2,282
Other	185	540
Total	2,012	6,353
Personnel Meters		
Badge Film	1,252	3,976
Pencils	-	1,912
Other	493	1,273
Total	1,745	7,161
Miscellaneous Special Services	868	1,488
Total Number of Calibrations	4,625	15,002

A. J. Stevens
for the Manager,
Radiation Protection

AJ Stevens:kc

1252793

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - MARCH, 1960

GENERAL

Security performance for the Operation was satisfactory with no violations during the month.

Safety performance of the Operation was considered satisfactory. There were no major injuries; the minor injury frequency rate was 3.85 which is considered about average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the month was 22,612. This includes 17,665 hours performed in the Technical Shops, 3,831 hours assigned to Minor Construction, 159 hours assigned to other project shops, and 957 hours assigned to off-site vendors. Total shop backlog is 27,918 hours of which 40% is required in the current month with the remainder distributed over a 3-month period. Overtime hours worked during the month was 5.3% (962.5 hours) of the total available hours.

Distribution of time was as follows:

	Man-Hours	% of Total
Fuels Preparation Department	2,083	9.2
Irradiation Processing Department	1,061	4.7
Chemical Processing Department	2,224	9.8
Hanford Laboratories Operation	16,844	74.5
Construction Engineering & Utilities	195	.9
Miscellaneous	205	.9

The overtime rate declined slightly from the previous month -- .5.3% versus 5.7% for February. Total backlog increased approximately 19%. However, the greater portion of this increase was of a long-range nature not requiring emergency service. Continued assistance was provided to the Chemical Processing Department in the fabrication of graphite molds and test equipment used for high priority weapons work.

E. A. Kasey, Glass Technician, attended a Technical Conference on Glass Science and Technology held at the G. E. Research Laboratory in Schenectady. Kasey also visited the glass shops at K.A.P.L., General Engineering Laboratory, and the Transformer Department to observe recent developments in glass working techniques.

1252794

RADIOGRAPHIC TESTING OPERATION

Radiographic Testing Operation made a total of 3,114 tests, of which 1,031 were radiographic (including x-ray and gamma-ray) and 2,083 were supplementary tests. Out of a total of 2,000 man-hours, 773 (38.7%) were in connection with radiographic tests, and 1,227 (61.3%) were used on supplementary tests. The supplementary test work included; borescope, eddy current, penetrant (fluorescent O.D. and I.D.), surface treatment (alkaline cleaning and vapor blasting), and ultrasonic (flaw detection, core integrity, bond testing, and thickness measurement).

The number of pieces handled this month totaled 2,961 items. The feet of material represented by these items amounted to 42,737 feet. A high ratio of number of feet to number of pieces continues to be experienced as a result of the work with tubular components.

Work was done for 23 different organizational components representing most of the operating departments and service organizations. A total of 61 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 52 different occasions for advice and information on general testing theory and application for other than the jobs tabulated in Part II - Testing Statistics.

Full size NPR process tubes were tested under adverse conditions before all of the C-25 facilities were complete. The urgency for the test data stemmed from interest by the potential vendors in evaluation of their respective development tubes. Ultrasonic, fluorescent penetrant (both O.D. and I.D.), and radiographic (welds and suspect areas) tests were completed on 23 full process tubes. Work was performed on a 12 hour day, 6 day week schedule.

Reprocessing of three PRTR process tubes having questionable autoclave films was started. These tubes will be vapor blasted, pickled, and autoclaved. Three KER process tubes were also tested during the month. Test work included fluorescent penetrant O.D. and I.D., ultrasonic testing, and x-raying of suspect areas. In addition, ultrasonic thickness measurements were made over the entire length of the tubes.

Radiographic testing of TPU fuel rods for core location, core segregation, and can wall thickness has kept pace with production facilities. Two new tests have been added to the trans-plutonium fuel element service work. These tests are ultrasonic bond test and core integrity. The ultrasonic test work is being done on a two shift basis to obtain maximum utilization of existing test equipment.

Field activity continue at a moderate level with work progressing routinely. The major activity involve radiographic liaison work at the PRTR site and full development and implementation of a pressure vessel survey in the 100-F area.

1252795

A near serious accident occurred involving B. D. Howard in the field operation group. A 60 foot long NPR process tube, weighing approximately 450 lbs., rolled off the x-ray conveyor catching Mr. Howard's hand and pinching it between the tube and the conveyor edge. Three fingers on the left hand were fractured. This injury was classified as a minor injury treatment as no loss time was involved and it appears that there will be no permanent disability. Stops have been installed on the conveyor to prevent a reoccurence.

Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces	Description
CE&U	413	207	413	3 phase of PRTR containment vessel.
CPD	20	17	8	Radiograph welds on S.S. nozzle sections PRTR Project.
FPD	16	27	5	NPR Fuel Element.
HLO	2,194	31,497	2,375	S.S. clad UO_2 fuel element; 9/16" O.D. x 8' long UO_2 fuel rod; 9/16" O.D. x 5' long UO_2 fuel rod; 9/16" O.D. x 2-1/2' long UO_2 fuel rod; swaged large diameter UO_2 fuel rod; NPR fuel elements; S.S. clad NaK swelling sample; .680" I.D., zr-2 tubes; unmachined TPU fuel rod; Radiography Palm Dev and fabrication program; Radiograph existing welds on process tube mock-up in 189-D Bldg; .005" wall 304-L S.S. tube; .010" wall inconel x tubes; .015" wall; .680" I.D., zr-2 tubes; KER tubes; BD & F type ribless.
IPD	471	10,989	160	Carbon steel and zirconium furnace welds; radiograph welds on S.S. nozzle; NPR zirconium tubes; S.S. valves; CS and zirconium - furnace welds; Ultrasonic thickness measurements pressure vessel survey 100-F; TPU fuel rods; .680" I.D., zr-2 tube; .505" I.D., zr-2 tube; 9/16" O.D. PRTR Pu-Al fuel rods.
Total	3,114	42,737	2,961	

1252796

CONSTRUCTION OPERATION

There were 30 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $344,409. Fifty-two new orders, 2 supplements and adjustments for underruns amounted to $74,343. Expenditures during the month on HLO work were $156,748 (Includes C.O. Cost). Total J. A. Jones backlog at month's end was $262,004. Twenty-nine orders were closed out during the month.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	24	$ 273,938	6	$ 70,471
Issued during the month (Inc.Supp.& Adj.)	52	74,343	0	0
J.A. Jones Expenditures during month (Inc. C.O. Costs)		135,283		21,465
Balance at month's end	47	212,998	6	49,006
Orders closed during month	29	19,637*	0	0*

* Face Value of Orders Closed

Project CA-744 - Installation of equipment in the 306 Building Addition is progressing nicely and is ahead of schedule. Of the 17 pieces of equipment to be installed 12 are set and two more are in the building. The Lump Sum Contractor has been unable to energize the electrical buses in the building as the cable from the pole line to the transformer bank has not arrived. When the buses are energized 9 equipment pieces will be scheduled for inspection by vendor representatives and acceptance by operating personnel.

Project CA-747 - The removal of contaminated equipment by plant forces in 231-Z Building is on schedule and well within funds. Nine out of 12 pieces of equipment have been removed and transported to the 328 Building for reinstallation by J. A. Jones forces.

A Lump Sum sub-contract for plastering in the 308 Building was issued by Jones and plastering will begin 4/4/60. Much of the Jones work is being help up until the plaster contractor gets through with his work.

The Monarch Lathe Hood fabrication has been completed in the WB shops and installation is scheduled to start 4/11/60.

The autoclave job in 306 Building is complete except insulation which can not be done until Operations has completed hot testing and run-in.

1252797

FACILITIES ENGINEERING OPERATION

Projects

There were 18 authorized projects at month's end with total authorized funds of $6,383,365. The total estimated cost of these projects is $7,972,365. Four projects were completed and no new projects were authorized during the month. One project proposal was submitted to the Commission and three projects are in preparation.

The following summarizes the status of HLO project activity:

Number of authorized projects at month's end: 18

Number of new projects authorized during month: 0

Projects completed during the month: 4
- CAH-827, Automatic Columbia River Monitoring Station
- CGH-840, Sheet Metal Shop Addition - 328 Building
- CGH-879, The High Temperature, High Pressure Autoclave Facility - 306 Building
- CG-661, Additional Heat Generation Facility - 189-D Building (Note: This project was considered complete with exceptions 8-31-59 and accepted by the using operation with exceptions 11-19-59, however, the project has been carried as an 'active' project until the Physical Completion Notice was issued March 4, 1960.)

New project proposals submitted to AEC during month: 1
- CGH-888, Biology Laboratory Improvements

New projects awaiting AEC approval: 2
- CGH-832, Full Scale Physical Constants Testing Reactor
- CGH-874, Consolidation of Plutonium Metallurgy Facilities

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 final work on budget studies and preparatory engineering for project proposals. The proposal work included the Stress Rupture Test Facility and Field Servicing Center for Atmospheric Physics.

1252798

Title	Status
329 Building Cooling Problem	Funds are now available. Procurement has started.
Fire Detection System - 146-FR	Installation is essentially complete.
Electrical Modifications - Room 24-A - 326 Building	Field work essentially complete.
Electric Hoist - Graphite Shop - 3730-C Building	Funds have been made available for procurement.
Refrigerated Air Conditioning Room 130 - 146-FR Building	An appropriation request is being routed for funds for procurement and installation.
Reactor Room Exhaust Ventilation Control 326 Building Basement	Design is complete.
HLO Area Improvements Study	A summary report was issued this month.
Pressure Vessel Study	This is a continuing work program involving vessels and safety devices.
Design Eddy Current Table	Design complete.
Investigate Coaxial Cable Between 325 and 329 Building	Engineering work completed.
Install Sound Enclosure for 300 Ton Hydraulic Pump - 325 Building	Fabrication and installation work was completed.
Additional Improvements to Air Supply - Rooms 204 and 206 - 3706 Bldg.	Filters are being procured.
Laboratory Furnace Installation Room 39-B, 326 Building	Engineering complete. Field work to start in April.
Alterations to Negative Ion Accelerator - 3745-A Building	Design complete. A Work Review has been submitted.
Glove Boxes - 325 Building	Engineering design has started.
Equipment for Critical Mass Studies	Preliminary design is complete. Detail design has started.
Revision to Drain System - Truck Access - 325 Building	Preliminary design is complete. Detail design and installation to follow.
Study Portable and Process Water System - 325 and 329 Buildings.	Work in progress.

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 - 90% complete).
2. Break away Corrosion Loop (6 drawings - 40% complete).
3. Special Tools - Scope - High Level Utility Cell - 327 Building.
4. PRTR Fuel Element Rupture Facility -
   a. Scope of supporting facilities, i.e., equipment annex, water plant, retention tank and outside lines - 7 drawings completed.
   b. Test Loop - 5 drawings completed.
5. PRP Critical Facility - Service piping, weir, shielding block and safety rods (approximately 7 drawings required - 95% complete).
6. Loading Dock Enclosure - 321 Building (approximately 90% complete).
7. A, B, and G Hand and Shoe Counter - (approximately 10 drawings completed).
8. Ultrasonic Test Tank - (8 drawings required - 20% complete).
9. Physical and Mechanical Properties Test Cell - 327 Building - Equipment Scope (5 work sheets completed).
10. Extrusion Tools for 700 Ton Press (8 drawings required - 6 drawings completed).
11. Hood design for pyro-chemical work.

In addition to the above work, miscellaneous small design-drafting jobs are in progress including Project CG-681 "As-Built" work.

Approximately 245 drawings including sketches, work sheets, and formal drawings were completed during the month of March.

Maintenance and Building Engineering - Landlord Functions

Costs:	January	-	$ 161,558
	February	-	$ 152,204
	Total through February	-	$ 1,081,572

Analysis of Costs

The $1,081,572 expended to date represents 74.1% of the annual budget, and 101.45% of the expenditure predicted for the first eight months of FY-60. Of the $150,000 budgeted for improvement maintenance, $135,593 has been spent and $14,400 committed.

During this month, the significant variants from the forecast are: Total maintenance overrun, $31,800; total utilities underrun, $3,300; engineering overrun, $300; janitor and power operators overrun, $500. The total overrun this month is $29,300. This is reduced by previous underruns to a FYTD overrun of $14,900.

1252800

During March, maintenance routine orders were cancelled except a few covering lubrication and inspection. Individual work orders were issued for urgent necessary work. Month's end work order runs indicate that the result will be a saving of about $2,000. It now becomes clear that the budget as reduced is too low. It appears that the year end overrun will be about $40,000.

Improved Maintenance

Item	February	FY to February
Heating & Ventilation Correction	$ 4,778	$ 62,373
Relocation & Alteration	19,784	32,344
Paint	-	11,736
Electrical Improvements	593	2,040
Lighting	-	413
Crane Installation	-	24,910
Miscellaneous	-	1,777
Total	$ 25,155	$ 135,593

TECHNICAL INFORMATION OPERATION

Some preliminary promotion work has been done to have Robert Gunning, nationally known author of "How to Take the Fog Out of Writing" present a course in "Clear Technical Report Writing" ay HAPO. The Education, Communication and Community Relations Operation, Relations Operation, have begun negotiations and will meet Mr. Gunning in Seattle early in April.

The 1959 annual inventory of Research and Development reports was completed March 25 with the following results: 9,980 accountable copies; 28 copies outstanding from previous years; 2 copies outstanding this year; or a total of 30 copies outstanding. The official results will be reported to GE Security by month's end.

A description of the PRP Critical Facility was submitted to HOO with a request that the project be reviewed with the Division of Classification for the purpose of declassifying all information on the design, construction and operation of the facility.

The AEC and the Department of Defense have agreed on a new policy for the handling and review of photographs which do not disclose Restricted Data but come within the interests of the Department of Defense. The new policy appears to permit greater flexibility in within-plant handling of photographs in this category. As soon as the AEC Division of Classification approves the HAPO interpretation of the policy, it will be put intc effect.

Approval was received from the Division of Classification for topics on reactor production data which were proposed to the AEC November 1, 1959 in HW-61150. The topics covering reactor conversion factors were the only topics not approved as submitted. HOO advised that additional guidance or conversion factor information is forthcoming.

Considerable time was spent during the month in developing and defining new subject categories for Nuclear Science Abstracts, the AEC's nationally distributed abstract journal. This assignment was given at the last Technical Information Panel meeting to the Library and Document Control Committee, which is chairmanned by the Manager, Technical Information. Suggestions from Committee members are being consolidated, together with ideas from HLO technical people. The new categories, after approval by the Panel, will be used in the journal to arrange the abstracts for maximum usefulness and locatability by the technical reader.

A detailed study has been made of the time factors involved in the publication of formal Research and Development reports. The study covered the complete processing of the report from the day it is received in manuscript form by Technical Publications to the day that it is mailed offsite. Average for some 20 reports studied was 156 days. While this figure is high, it agrees reasonably well with the Commission-wide average of 22 weeks as reported by Arthur D. Little in their study of the same problem. About half this time is taken up with the mechanics of editing and publishing the report, and the remainder of the time with the required reviews and approvals prior to offsite distribution.

During the month teletype requests were received from the AEC requesting release of 61 HW reports to the CAProgram. These reports have recently been declassified in an AEC review now taking place. Each title released has been reviewed by supervision. Chief concern is that many informal, un-edited reports are being released to the public along with Hanford formal R & D reports.

The verifying of keypunch records was discontinued last month. This month was the first opportunity to determine the degree of keypunch accuracy. Six errors, or .08% errors, were detected from the monthly update. It is possible that other information was punched incorrectly, but not immediately evident since there were no delete transactions involved.

Work Volume Statistics

	February	March
Document Distribution and Files		
Documents routed and discharged (copies)	19,105	14,969
Documents issued (copies)	14,571	12,127
Documents sent offsite (copies)	3,722	6,047
Document reserves filled (copies)	842	810
Documents picked up and delivered	21,045	19,775

1252802

	February	March
Document Accountability		
Holders of classified documents whose files were inventoried	303	409
Documents inventoried in Files (copies)	9,746	19,500
Documents destroyed or retired (copies)	5,651	4,361
Documents revised (copies)	1,054	585
Documents pulled and documents filed (copies)	12,422	11,486
Documents reclassified	406	274
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents onsite	207,778	205,935
Reference and Publication		
Books cataloged (new titles)	135	276
Books added to the collection (volumes)	251	276
Ready reference questions answered by professional staff	180	120
Literature searches by professional staff	105	76
Reports abstracted (titles)	269	327
Formal reports prepared (titles)	11	7
Offsite requests for HAPO reports (copies)	330	624
Reports released to CAP (titles)	21	27
Library Acquisitions and Circulation		
Books ordered (volumes)	230	
Periodicals ordered	319	149
Books circulated (volumes)	1,895	2,038
Periodicals circulated (issues)	3,113	3,611
Inter-Library loans	72	69
Films borrowed or rented	11	39
Industrial film showings	40	89
Bound periodicals added to the collection	--	199 (Feb. & March)

Library Collection

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	29,000	8,373	1,567	2,008	40,948
No. of bound periodicals	13,408	1	1,431	96	14,936
	42,408	8,374	2,998	2,104	55,884

1252803

	February	March
Classification and Declassification		
Documents, including drawings and photographs reviewed for downgrading or declassification	98	45
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	46	41
Documents submitted to Declassification Branch, Oak Ridge	3	13

J L Boyd
Manager,
Laboratory Auxiliaries

JL Boyd:jw

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

MONTHLY PROJECT REPORT

HANFORD LABORATORIES OPERATION

HW - 64580 DEL

MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION: AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED or Actual COMP. DATE: DESIGN / CONST.
CG-731	Critical Mass Laboratory	$1,000,000	$1,000,000	100	77	5-22-58	- - -	2-24-59
			3-23-59	100	77	6-4-59	6-30-60	6-30-60
		USING COMPONENT: Physics and Instruments R&D				FEO ENGINEER: D. S. Jackson		

REMARKS: The fixed price contractor is 95% complete compared to a scheduled 95%. The instrument panels being supplied by Minneapolis-Honeywell are now 4 months overdue. The fixed price contractor has done everything he can to reduce project delays in spite of this situation. However, he has reached the limit to the amount of work he can perform without them. It now appears an extension of his completion date will be necessary because of Minneapolis-Honeywell's inability to meet their promised delivery date. These delays may also result in a request for additional funds by the contractor. The latest word on the panels indicates they will arrive at Hanford early in April.

CA-744	Metallurgical Development Facility - 306 Building	$2,650,000	$2,650,000	100	*	6-30-58	- - -	9-30-59
			11-5-58	100	**	3-20-59	9-1-60	9-1-60
		USING COMPONENT: Reactor & Fuels R&D				FEO ENGINEER: J. T. Lloyd		

REMARKS: The delivery of the chemical processing tanks remains the most critical item of the project for completion. Despite efforts of Purchasing to expedite delivery of the neutralization tank the promised shipping date was slipped from March 18 to April 1. Installation of equipment by J. A. Jones is progressing satisfactorily. Some shipment damage to equipment has been reported, none of it is sufficient to delay the schedule. Frank Lohses delay is due to late delivery of partitions.

*Total Project 66%; Jensen-Rasmussen 90%; J. A. Jones 45%; Frank Lohse 35%.
**Total Project 66%; Jensen-Rasmussen 90%; J. A. Jones 50%; Frank Lohse 18%.

CGH-790	High Level Radioactive Receiving and Storage Addition - 327 Building	$349,000	$345,000	100	97	6-23-58	- - -	12-31-58
			4-23-59	100	95.6	10-9-58	6-1-60	6-1-60
		USING COMPONENT: Reactor & Fuels R&D				FEO ENGINEER: J. J. Peterson		

REMARKS: Fixed price contractor has yet to complete controls on decontamination chamber so that final A.T.P. can be run. Weather has been holding up completion of exterior painting. Beneficial use was made as of 3-14-60 to allow J. A. Jones forces access to the building so that they could proceed with their phase of the work. CPFF forces installing basin door, preparing basin for painting and insulating steam and condensate piping. Revised construction schedule was approved on 3-22-60 by the Commission.

1252805

UNCLASSIFIED

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BUDGET CLASSIFICATION
General Plant Projects - FY 1959

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64580

MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CAh-827	Automatic Columbia River Monitoring Station	$34,000	$39,000	100	100	4-3-59	- - -	6-18-59*
			6-30-59	100	100	11-6-59	3-31-60	3-31-60
		USING COMPONENT: Radiation Protection				FEO ENGINEER: D. S. Jackson		

REMARKS: This project was physically completed on March 31, 1960. It will no longer be included in this report.

*A-E only.

CAH-837	Animal Pens, Isolation and Examination Facilities	$80,000	$80,000	100	100	3-30-59	- - -	6-5-59
			3-17-59	100	100	7-10-59	4-1-60	5-1-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS: The A.E.C. has issued a work order for part of the extra work by Minor Construction. General Electric Company has proposed using steam injection for hot water for cage washer which is expected to save considerable expense for electrical alterations and additions.

Construction was accepted from Contractor on 3-10-60.

CGH-840	Sheet Metal Shop Addition - 328 Building	$38,000	$40,000	N.S.	100	6-22-59	- - -	9-1-59
			6-18-59	100	100	6-25-59	5-1-60	3-28-60
		USING COMPONENT: Laboratory Auxiliaries				FEO ENGINEER: J. J. Peterson		

REMARKS: "As-Built" drawings are being prepared and project being unitized. Construction is complete.

AM-7300-019 (5-58)

UNCLASSIFIED

1252806

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

BUDGET CLASSIFICATION: General Plant Projects - FY-1959

HW - 64580 DEL
MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
CAH-848	Geological & Hydrological Wells - FY-1959	$56,600	$56,600 / 6-18-59	N.S. / 100	100 / 99	5-21-59 / 7-16-59	- - - / 5-31-60	7-6-59 / 4-15-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: H. E. Ralph

REMARKS: Fifteen of the sixteen wells have been developed. 3,500 Feet of new hole has been completed. Scheduled completion date for construction work is April 15, 1960.

General Plant Projects - FY 1960

CGH-819	Increased Laboratory Waste Facilities 300 Area	$193,765	$193,765* / 2-19-60	36 / 36	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: Revised design schedule transmitted to the Commission on 3-15-60. Design is on schedule with the drawings being received for comment todate.

*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 / 95	N.S. / 13	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: Award of fixed price contract was delayed two weeks because of an error claimed by Frank Lohse, who was low bidder, in his bid. Notice of Award and Notice to Proceed was sent to Lohse on 3-24-60, as error of $2,433.60 was allowed. The low bid was $18,900 which now totals $21,333.60. Penetrations are being made in exterior basement walls for piping by CPFF forces.

1252807

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64580 DEL
MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION: AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE: DESIGN / CONST.
CAH-864	Shielded Animal Monitoring Station - 100-F	$46,000	$46,000	100	N.S.	10-22-59	- - -*	2-4-60
			8-6-59	100	0	4-1-60	4-1-60	7-1-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS:

Bids were opened 3-31-60 for both CAH-864 and CGH-878. The low bidder was George A. Grant Company with a combined bid of $74,350. The combined Fair Cost Estimate was $70,000.

CGH-874	Consolidation of Plutonium Metallurgy Facilities	$285,000	None	0	0	1*	- - -	5*
			None	0	0	2*	- - -	11*
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: J. T. Lloyd		

REMARKS:

This proposal is still held by A.E.C. with no action.

*Months after authorization.

CGH-877	Pyrochemical Test Facility - 321-A Building	$70,000	$70,000	75	N.S.	12-8-59	- - -	4-17-60
			11-17-59	75	12	2-17-60	9-30-60	9-30-60
		USING COMPONENT: Chemical R & D				FEO ENGINEER: R. C. Ingersoll		

REMARKS:

Fabrication of the Mg Still Hood is essentially complete. An order was placed with Blickman for the three remaining hoods 3-21-60. Both induction generators have been shipped and one expected on site the week of 4-4-60. A construction schedule is being prepared.

AM-7300-019 (5-58)

1252808

BUDGET CLASSIFICATION
General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64589
MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
				DESIGN	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CAH-878	Additional Facilities for Isotope Study on Animals - 141-C Building Addition	$61,000	$61,000	N.S.	N.S.	12-7-59	- - -	- - -
			11-18-59	100	0	- - -	4-15-60	7-1-60
		USING COMPONENT: Biology				FEO ENGINEER: J. T. Lloyd		

REMARKS:
Bids were opened 3-31-60 for both CAH-864 and CGH-878. George A. Grant Company was low bidder with a combined bid of $74,350. The combined Fair Cost Estimate was $70,000.

CAH-885	Geological & Hydrological Wells - FY 1960	$69,000	$69,000	100	0	2-15-60	- - -	4-1-60
			2-5-60	100	0	4-15-60	11-15-60	11-15-60
		USING COMPONENT: Chemical R & D				FEO ENGINEER: H. E. Ralph		

REMARKS:
Bids for construction work will be opened on April 12, 1960.

Improvements to Production and Supporting Facilities - 60-a-1

CAH-870	Facilities for Recovery of Radioactive Materials - 325-A Building	$486,000	$486,000	100	0	9-18-59	- - -	3-1-60
			3-22-60	100	0	N.S.	6-1-61	
		USING COMPONENT: Chemical R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:
Title II, detailed design, was completed on the revised scheduled completion date of March 1, 1960. Directive No. AEC-165, Modification No. 2., authorized the expenditure of $475,000 plus $11,000 for transferred capital property for this project. General Electric was assigned performance of related management and Architect-Engineer services, technical direction of the A-E., Title III services, and tie-in of services and adjustments during start-up operations.

A bid package is being prepared and a preliminary notice will be issued to bidders approximately April 5, 1960.

1252809

AM-7309-019 (5-58)

BUDGET CLASSIFICATION Installation for Support of Bio-Medical Research - 60-h-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64580

MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED.	PROJECT PROGRESS IN PER CENT CONST. ACTUAL	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN	ESTIMATED OR ACTUAL COMP. DATE CONST.
CGH-888	Biology Laboratory Improvements	$300,000	-	-	-	-	-	-	1*	-	-	-	5*	-

USING COMPONENT: Biology

FEO ENGINEER: J. T. Lloyd

REMARKS: A Proposal requesting design funds only was submitted to the A.E.C. on February 28, 1960, and was approved locally on March 17. It has been sent to A.E.C. Washington, D.C. for approval. Scoping has been started and preliminary layouts have been prepared and estimates are being made.

*Months after authorization.

Improvements to Production and Supporting Facilities - 61-a-1

CGH-832	Full Scale Physical Constants Testing Reactor	$915,000	None	None	0	0	0	-	-	-

USING COMPONENT: Physics & Instruments R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS: New justification was submitted to HOO - AEC on 3-24-60 for replacement in the previously submitted Project Proposal giving more substantiation for this project based upon the 2000 Program.

Equipment Not Included in Construction Projects - Program Class 2900

CG-785	In-Reactor Studies Equipment - 105-KW Building	$276,000	$276,000	12-8-58	100	99*	0	1-5-59	3-22-60	-	12-31-60	5-15-60*	12-31-60

USING COMPONENT: Reactor & Fuels R&D

FEO ENGINEER: H. Radow

REMARKS: Construction activity has begun and initial phases such as material take-off, review of drawings, etc., are under-way. Delivery of the major instrumentation orders did not materialize. As a result of special expediting action, vendor has agreed to add personnel and work Saturdays and Sundays. Shipping promise is now mid-April. A cost-to-complete estimate, factoring in possible modifications for Helium conservation, has been prepared. With this estimate, the economics and other factors are being evaluated to resolve the course of action to be taken.

*Approximately 5 drawings have been held up because they are contingent upon the R&D Capsule Development Program. The required information has now been furnished and design effort towards completion of the drawings is being pushed.

AM-7308-819 (5-58)

1252810

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64580 DEL
MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR Actual COMP. DATE DESIGN / CONST.
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: Directive No. HW-460, Modification No. 2, was issued on March 23, 1960, reducing the authorized funds from $170,000 to $9,000 as requested and referred to General Electric's project proposal request for cancellation.* The costs to date are to be charged to expense of research and development, 25% to the 4000 Program and 75% to the 2000 Program.

A Physical Completion Notice remains to be written on this project to close it out.

*Partial design cost only. Project being cancelled at the request of the using component.

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: After a five week delay and several meetings with the A.E.C., they approved a purchase order for the Meehanite Cell Structure with Washington Iron Works, Seattle, Wash., (the previous vendor, who was also the low bidder the second time) and the order was placed on March 18, 1960. Delivery is scheduled in 180 days.

Discussion meetings were held with A.E.C. representatives outlining HLO's plans and program support for the 327 Radiometallurgy Operation. This project will be behind schedule on March 31, 1960, and so far no word has been received concerning G.E.'s project proposal revision requesting additional time and money. Other procurement is continuing. Corning Glass Co. has had difficulty in fabricating a satisfactory window frame, one has been rejected and another one lost. Delivery was scheduled last January. Model & Inst. Works, Seattle, has not met their delivery date in Feb. on the Slave Manipulator.

CGH-834	Modifications & Additions to the High Pressure Heat Transfer Apparatus - 189-D Building	$700,000	$700,000 / 4-1-59	100 / 98**	82* / 70*	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: Partial beneficial use has been attained in the completion of the steady state phase, and start-up activity is underway. The High-speed valve order has been placed and HAPO representatives visited the manufacturer's site to resolve design, testing and inspection parameters. The high pressure water storage vessel fabricator was also visited to clarify some problem areas on this order.

*A review of the extent of the work still to be done, based on remaining phases of detail design recently issued, revealed a significant number of mandays in excess of that indicated in the Cost-to-Complete estimate and field forecasts. Consequently, percent completion is now reported as less than scheduled. The construction schedule is being revised to reflect this, as well as more realistic anticipated delivery dates of the remaining procurement items. It is felt that the

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64580 MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CGH-834	Modifications & Additions to the High Pressure Heat Transfer Apparatus - 189-D Building (Continued)							
		USING COMPONENT				FEO ENGINEER		

REMARKS:

scheduled completion date and overall cost for the basic installation can still be met. However, receipt and installation of the High Speed Valve Assembly will not materialize until December, and it is planned to accomplish this as an accural after project close-out.

**Approximately four drawings cannot be completed until vendor's High-Speed Valve Assembly drawings are submitted and pertinent design details established.

CGH-857	Physical & Mechanical Properties Testing Cell - 327 Building	$500,000	$75,000	3*	0	10-20-59	-	4-1-61
			10-1-59	3*	0	N.S.	-	1-1-62
		USING COMPONENT				FEO ENGINEER		
		Reactor & Fuels R & D				R. W. Dascenzo		

REMARKS:

A suitable impact testing machine was located in the 327 Building that can be transferred to this project. Design modifications of this piece of equipment were started to place it in the cell with remote control outside the cell.

A revised project proposal, changing equipment design to G.E. from vendor design, was sent to the General Manager early in March. Justification for proprietary purchase of the in-cell equipment was presented to G.E. Purchasing on March 25, 1960, so that vendors can be contacted for their detail design of specific pieces of equipment. A.E.C. Purchasing was to be contacted for approval of this method.

*Equipment design, cell design not started.

CGH-858	High Level Utility Cell - 327 Building	$500,000	$70,000	10*	0	10-20-59	-	1-1-61
			10-1-59	10*	0	N.S.	-	11-1-61
		USING COMPONENT				FEO ENGINEER		
		Reactor & Fuels R & D				F. W. Dascenzo		

REMARKS: Scoping work on specialized tool design is continuing and on cell layout. Special consideration is being given to the drive mechanisms for the lathe and mill.

Directive No. HW-499, Modification No. 1, was issued on February 29, 1960, changing the methods of performing work. Design work will be performed either by a qualified tool manufacturer or General Electric Company.

*Equipment design, cell design not started.

AM-7300-019 (5-58)

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 64580 DEL

MONTH March, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CGH-866	Shielded Analytical Laboratory - 325 Building	$750,000	$10,000	0	0	9-5-59	-	12-15-59*
			8-12-59	0	0	N.S.	-	6-1-61
		USING COMPONENT: Chemical Research & Development				PEO ENGINEER: R. W. Dascenzo		

REMARKS: Approval has not as yet been received from Washington, D.C. - A.E.C. for design funds for this project. A letter, supplying additional information supplementing the design criteria, was supplied to HOO - AEC on March 28, 1960.

CGH-879	High Temperature, High Pressure, Autoclave Facility - 306 Building	$46,000	$46,400	100	100	8-3-59	-	1-22-60
			12-3-59	100	100	12-18-59	3-31-60	3-31-60
		USING COMPONENT: Reactor & Fuels R&D				PEO ENGINEER: D. S. Jackson		

REMARKS: This project was physically completed on March 31, 1960. It will no longer be included in this report.

		USING COMPONENT				PEO ENGINEER		

REMARKS:

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AM-7005-019 (9-58)

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of March 31, 1960, the staff of Hanford Laboratories totalled 1300 employees, including 618 exempt and 682 nonexempt. There were 528 employees possessing technical degrees, including 312 B.S., 115 M.S. and 101 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for March was 2.01 as compared with 1.44 last month. There were 2 security violations during the month, bringing the total for the year to date to 6 as compared with 14 during the same period in 1959.

An employee of the Radiographic Testing Operation sustained a severe medical treatment injury to his hand on March 2nd.

Each Laboratories building was provided with placards containing instructions and the airway appliance for the new mouth-to-mouth artificial resuscitation method.

PROFESSIONAL PLACEMENT

Thirteen Ph.D. candidates visited Richland for interviews during March. Three offers were extended to Ph.D. candidates, and there are currently four offers open. Follow-up visits were conducted with Chemistry and Chemical Engineering candidates at the University of Washington.

All campus visitations are completed for 1959-60 recruiting of BS/MS graduates. Follow-up visits were conducted at Oregon State, Washington and Montana State during March. One hundred seventy-five offers have been extended, with 31 acceptances received by month's end, and 128 offers continuing open.

Four Technical Graduates were added to the program rolls, and 8 accepted permanent assignments during March. Two Technician Trainees were dropped for failure to maintain a "C" average and transferred to more suitable employment.

At month's end there were 47 Technical Graduates and 5 Technician Trainees on the program rolls.

TRAINING

An additional class in Applied Creativity was started to accommodate the number of semi-technical personnel who have expressed an interest in taking the course.

COMMUNICATIONS

A TV newsfilm and newspaper stories on the ribbon-cutting ceremony at the Radiochemistry Cell have been approved and are scheduled for release in April.

COMPENSATION

Final preparations were made to implement the New Nonexempt Salary Plan which will become effective on April 11th.

EMPLOYMENT

There were 10 nonexempt vacancies filled during the month. With the receipt of 18 new requisitions and 2 cancellations, there are currently 11 openings for which 6 candidates are in process, 2 transfers pending, and 3 yet to be procured.

Manager,
Professional Placement
and Relations Practices

TG Marshall:lmh

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Feb	Mar.
Requisitions		
At end of month	5	11
Cancelled	3	2
Received	17	18
Filled	14	10

Nonexempt Transfers Request	Feb.	Mar.
Transfers		
Active cases at end of mo.	74	68
Cancelled	1	4
New	6	4
Transfers effected	3	6

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	563	134	38	26	17	6	4	4
Exp. BS/MS	366	187	57	3	76	41	13	35
Prog. BS/MS	383	-	-	-	175	31	128	7

*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.

B. Technical Recruiting Activity - HLO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	563	134	38	26	14	5	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.

In addition to the above activity, 11 exempt employees have transferred into HLO from other HAPO departments and 9 technical graduates have accepted off-Program placement in HLO to date.

C - Technical Graduate and Technician Training Program
Month ending March 31, 1960

	TG Program	TT Program
Number of Personnel on Assignment	47	5
(HAPO Tech Grad Program..... 38		
(Western District E. P. 9		
Distribution of Assignments by Departments		
HLO	23	1
CE&UO	2	0
FPD	1	0
IPD	18	4
CPD	2	0
C&AO	1	0
Distribution of Assignments by Function		
R&D or Engineering	39	5
Other	8	0

1252818

FINANCIAL OPERATION MONTHLY REPORT
MARCH 1960

Personnel

The Specialist - Measurements transferred to Operations Research and Synthesis, effective March 1, to fill an existing vacancy.

Activities

GENERAL ACCOUNTING

A special report on travel activity within the Laboratories was prepared and submitted to the HAPC General Manager in response to his request. The report highlighted reasons for the increase in travel and contained an estimate of total travel for FY 1960.

A new procedure was placed in effect. This will result in reporting travel expenses in the month in which incurred. A lag of at least a week in the accounting procedures has been eliminated.

Meetings were held with a McBee representative, C&AO EWIP Specialists and Technical Information's IBM people to investigate mechanization of EWIP and discuss mutual problems. McBee tabulating equipment would not provide all the necessary information required at a reasonable cost. Further meetings are scheduled with Technical Information IBM people. Upon completion of this study a more complete report of our findings will be submitted.

The inventories budget for FY 1962 and revision of FY 1961 was consolidated and submitted to Contract and Accounting Operation prior to the due date. Inventories for which Hanford Laboratories are responsible will not vary significantly for the present except for Zirconium, Heavy Water, Spare Parts, due primarily to the Plutonium Recycle Program, and Beryllium in support of Plutonium Metallurgy studies.

Twenty-six items valued at $16,032, were received at the Laboratory Equipment Pool Building during March. Three items valued at $1,055 were permanently transferred in lieu of placement of requisitions. There is a total of 191 items currently located in the storage area valued at $91,850. Equipment moving into the storage area has been slower than anticipated, however, the number of calls and visitors requesting information on the availability of equipment has increased considerably.

A report of results of the annual witnessed physical inventory of reactor and other special materials was issued by Contract and Accounting Operation. Findings reported indicated improvement could be made which resulted in a proposal being submitted to the Section Managers for their review and approval on March 8. The proposal will (1) eliminate the present nine HLO custodians responsible for recording and reporting of all materials for HLO, (2) provide, in the HLO Central Storage Area, a depository for materials not in use or occasionally

1252819

used, which may be sotred and/or available for use by more than one holder, (3) provide central screening of all purchase requisitions against available supplies, (4) provide a central stockpiling of scrap materials for shipment offsite. Benefits to be obtained from a central custodian are more efficient utilization of existing materials which should result in dollar savings and reduced inventory levels.

Preparations were completed for the physical inventory of movable cataloged equipment in the custody of Chemical Research and Development Operation, to begin April 11, 1960. This is the final inventory of movable equipment for fiscal year 1960.

The physical inventory of movable cataloged equipment in the custody of Reactor and Fuels R&D Operation continues. This inventory is behind schedule due to the large number of unlocated and/or recorded equipment found during the inventory.

In response to a request of Contract and Accounting Operation, HLO's forecast of Zirconium Sponge and Hafnium requirements for FY 1960 through FY 1963 was prepared and submitted for their use. A total of 8 tons of zirconium sponge was forecasted for HLO compared to 135 tons for total HAPO.

COST ACCOUNTING

Preparation of the Operating Cost Budget for FY 1962 and Revision of Budget for FY 1961 is essentially complete. Approval of Section Managers have been obtained and the consolidated Hanford Laboratories' operating cost budget will be submitted to Contract Accounting during the first week of April. Preparation of the Proposals for Research and Development represented a significant effort by many people in Hanford Laboratories during the month; there were 66 proposals consisting of 335 pages of typed material.

The operating cost control budget for Hanford Laboratories was adjusted during March to reflect changes in authorized funds as follows:

(1)	Provision to reflect cost of Gas Cooled Loop project as operating costs rather than equipment	$ 835 000
(2)	Increase in Research and Development authorizations from IPD:	
	(a) Reactor I (Chemical R&D)	35 000
	(b) Metallurgy II (Reactor and Fuels R&D)	13 000
	(c) New Production Reactor (Reactor and Fuels R&D)	4 000
(3)	Transfer of operating cost funds to equipment funds in the following programs:	
	(a) Plutonium Ceramics Research	(24 500)
	(b) In-Reactor Measurements	(15 000)
	(c) Atmospheric Diffusion Studies (Air Force)	(9 000)
(4)	Increase in budget to provide for Technical Graduate assignments	110 000

1252820

(5) Increase of $68,000 in Buildings and Utilities budget to provide necessary funding for balance of fiscal year (this represents and internal HLO adjustment - no increase in net costs)

A special request was received by Hanford Laboratories during March to fabricate plutonium test samples for the Bettis Plant in the amount of $10,000.

Two new program codes were established during the month for:

(1) .22 Gas Cooled Power Reactor Loop - The AEC has reclassified the manner of funding the loop project from equipment to research and development.

(2) .24 Graphite Contraction Studies - 4000 Program Research and Development.

Initial data on fabrication time, material costs and reject rates for the UO_2 PRTR elements have been obtained and the calculation of the fund cost for the first loading is nearing completion. Data are currently being accumulated as the fabrication progresses for the Pu-Al elements for the first loading.

The coding system for accumulating maintenance cost detail for PRTR operations has been discussed with Data Processing, Procedures and Cost Accumulation personnel and their concurrence obtained. Through this system we will provide cost detail by type of maintenance (emergency repairs, planned maintenance, modifications, etc.) by specific piece of equipment, and also total maintenance each month on about 40 equipment systems within the reactor facility.

By letter of March 14, 1960, from Contract and Accounting Operation, our Miscellaneous Capital Work Order funds were increased to $135,000 for FY 1960. Constant review of all incomplete orders now authorized is in effect. As soon as March costs are known, a complete analysis of our fund position will be prepared. It is anticipated that sufficient funds should be available to authorize the animal farm disposal system estimated at $15,200.

GENERAL

Payroll Statistics

Number of HLO Employees	Total	Exempt	Exempt
Changes During Month			
Employees on Payroll at Beginning of Month	1 305	619	686
Additions and Transfers In	12	9	3
Removals and Transfers Out	17	10	7
Employees on Payroll at End of Month	1 300	618	682

Overtime Payments During Month	March	February
Exempt	$ 4 291	$ 3 231
Non-Exempt	13 290	7 842
Total	$17 581	$11 073

Gross Payroll Paid During Month	March	February
Exempt	$530 566	$511 059
Non-Exempt	399 438	317 814
Total	$930 004	$828 873

Participation in Employee Benefit Plans at Month End	March Number	March Percent	February Number	February Percent
Pension Plan	1 136	99.5	1 132	99.5
Insurance Plan				
Personal Coverage	1 292	99.8	1 298	99.8
Dependent Coverage	926		925	
U.S. Savings Bonds				
Stock Bonus Plan	78	39.1	78	39.0
Saving Plan	89	6.8	92	7.1
Savings and Security Plan	1 025	88.7	1 028	88.9

Insurance Claims	March Number	March Amount	February Number	February Amount
Employee Benefits				
Life Insurance	0	$ 0	0	$ 0
Weekly Sickness and Accident	29	1 539	14	1 208
Comprehensive Medical	62	4 238	179	11 258
Dependent Benefits				
Comprehensive Medical	145	9 950	88	5 641
	236	$15 727	281	$18 107

Good Neighbor Fund	March	February
Number Participating	917	918
Percent Participating	70.5	70.5

W. Sale:bk
4-12-60

1252822

INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

INVENTOR	TITLE OF INVENTION OR DISCOVERY
Wallace W. Schulz	The Use of Small Concentrations of Nickel (II) Nitrate to Modify the Rate of Dissolution of Aluminum Metal by Nitric Acid-Mercuric Nitrate Solutions.
R. H. Moore	A Pyrochemical Method for Separation of Uranium and Plutonium Applicable to Ceramic Fuels Reprocessing.
L. L. Ames, Jr.	Cesium Removal from Aqueous, High-salt Solutions into Crystalline $BaSO_4$.

H M Parker

1252823