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HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

APRIL, 1961

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HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
APRIL, 1961

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By Authority of PR-24 (CG-PR-2)
DS Dowell 8/6/92
By DA Krusher 8/10/92
PM Eck 8-19-92

Compiled by
Operations Managers

May 15, 1961

[redacted]

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

This report was prepared only for use within General Electric Company in the course of work under Atomic Energy Commission Contract AT(45-1)-1350. Any views or opinions expressed in the report are those of the author only.

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TABLE I HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE April 30, 1961

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	125	116	241	126	117	243	0	0	1	1
Reactor & Fuels Research & Development	193	181	374	193	181	374	2	1	2	1
Physics & Instrument Research & Development	87	62	149	86	57	143	1	5	0	0
Biology Operation	33	46	79	33	47	80	0	0	0	1
Operation Res. & Syn.	16	4	20	16	4	20	0	0	0	0
Radiation Protection	39	98	137	39	98	137	0	1	0	1
Laboratory Auxiliaries	50	182	232	49	184	233	*1	2	0	*4
Financial	20	14	34	20	14	34	0	0	0	0
Prof. Placement & R. P.	59	11	70	62	10	72	3	1	6	0
Programming	15	4	19	15	4	19	0	0	0	0
General	2	4	6	2	4	6	0	0	0	0
Totals	639	722	1361	641	720	1361	*7	10	9	*8
Totals excluding internal transfers	639	722	1361	641	720	1361	5	10	7	8

* 1 NonExempt to exempt.

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BUDGETS AND COSTS

April operating costs totaled $2,222,000; fiscal year-to-date costs are $21,189,000 or 80% of the $26,522,000 budget.

Hanford Laboratories research and development costs for April, compared with last month and the control budget, are as follows:

(Dollars in Thousands)	Cost: Current Month	Cost: Last Month	Cost: FY To Date	Budget	% Spent
HLO Programs					
02 Program	$ 70	$ 96	$ 510	$ 661	77%
04 Program	917	841	7 988	9 812	81
05 Program	71	64	660	806	82
06 Program	180	198	1 874	2 402	78
	1 238	1 199	11 032	13 681	81
IPD Sponsored	190	260	2 589	3 170	82
CPD Sponsored	160	144	1 643	1 954	84
	$1 588	$1 603	$15 264	$18 805	81%

Due to the discontinuance of the aircraft nuclear propulsion program, Air Force purchase order ($55,000) for experimental investigation at Edwards Air Force Base and GE ANPD purchase order ($3,600) for X-ray Diffraction Analyses were cancelled.

Authorization was received from HOO-AEC to proceed with fabrication of 48 aluminum alloy clusters for Bettis. A total of $30,000 will be authorized for this work.

Costs for Project Chariot for the summer of 1961 were estimated at $32,800 (incremental). Authorization is expected in the FY 1962 Financial Plan.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

Startup testing and correction of construction deficiencies of PRTR continued. All of the Design Tests were completed excepting those to be performed in conjunction with later Power Tests, and the remaining Critical Tests were completed. The reactor was then shut down for discharge and cleanup of UO_2 fuel elements which had collected foreign matter from the primary coolant flow during the course of design testing. Much maintenance work was done, such as overhaul of two primary pumps, modification of the helium system to simplify condensate collection and oil removal, modification of shim rods, calibration of flow monitors, and check-out of safety and containment circuits and equipment.

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Construction continued on auxiliary facilities of the PRTR complex. The Maintenance and Mockup Building is about 80% complete versus 91% scheduled. PRTR site paving and landscaping are on schedule at about 40% completion. The Critical Facility Building is about 93% complete versus 100% scheduled, but extension of the scheduled completion date to August 15, 1961 has been approved by the Commission. The Rupture Loop Annex is about 97% complete versus 100% scheduled, and the Gas Loop is about 58% complete versus 91% scheduled.

PuO_2-UO_2 fuel development continued with studies of (1) the homogenization of UO_2 and PuO_2 powders mixed in a P-K blender, (2) methods to control the distribution of plutonium oxide during loading of a tube with mechanically mixed powders, (3) methods of achieving close length control of swaged UO_2-PuO_2 elements, (4) swagable end caps of various designs, (5) the determination of PuO_2 concentration by gamma spectrometer scanning, (6) gas evolution from UO_2 and PuO_2 powders, (7) melting points in the PuO_2-UO_2 system, and (8) stability of PuO_2-UO_2 mixtures at high temperatures in various atmospheres.

Bonded Zircaloy-clad, Al-Pu capsules fabricated by injection casting are being irradiated in the MTR. A four-foot long, Zircaloy-clad, seven-rod cluster fabricated by the injection casting technique is scheduled for irradiation testing in the ETR in June 1961.

The melting point of beta plutonium disilicide has been determined to be 1750 C ± 20.

Additions of 0.5 w/o or 0.1 w/o TiO_2 to micronized UO_2 produce no density advantage when high energy impact formed at 1100 C and 500,000 psi. An exploratory high energy impact compaction of UC at 1200 C and 500,000 psi produced a machinable, 97.4% dense billet.

The electrical conductivity of irradiated sintered UO_2 (0.005 a/o burnup) at room temperature was found to be approximately 20% of that of non-irradiated UO_2.

A tubular, vibrationally compacted test element is operating satisfactorily in KER-1 loop. A three-foot long prototypic nested tubular fuel element (PRTR Mark II-C dimensions) containing vibrationally compacted UO_2 was charged into the ETR 6x9 loop during the cycle beginning April 17, 1961.

Post-irradiation examination of the four-rod cluster fuel element containing recycled, partially decontaminated UO_2 revealed extensive relocation, dendrite growth, and formation of a large central cavity. This was expected because of the low bulk density of the fuel specimen.

A successful high frequency resistance welding technique (Thermatool) was developed for attaching ribs to 0.060-inch thick, 3.07-inch OD, Zircaloy-2

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cladding for the Mark II-C PRTR nested tubular fuel element.

The study of non-coaxial placement of I&E fuel elements within a process tube continued with determination that the limiting heat flux in the annulus of K reactor I&E fuel elements under fringe zone flow conditions is about 1,810,000 B/hr-sq ft when the fuel elements are positioned concentrically. Initial results of an investigation of subcooled boiling under normal operating conditions in Hanford fuel channels showed that the inception of local boiling could be predicted fairly well with the Jens and Lottes correlation (ANL-4627) at low flow conditions but not at the higher flow rates found in the central zones of the reactors. The determination of maximum heat transfer capabilities of the NPR tube-in-tube fuel elements continued.

Volume increases of four prototype NPR inner tubes (NIN-1) irradiated to 1000 MWD/T under NPR conditions averaged only 0.4 percent. Ten other NPR inner fuel components, heat treated under varying conditions, were discharged from KER Loop 1 on April 1 at an exposure of 1050 MWD/T. Examination should yield valuable information on the optimum heat treatment to be employed for NPR fuel elements.

Two KER size tube-tube elements were successfully irradiated to ca. 1000 MWD/T in the 6x9 facility in the ETR at the extreme conditions of a specific power of 317 kw/ft and a maximum heat flux of 1,100,000 B/hr-sq ft.

Accelerated hydriding of Zircaloy-2 has been observed at 425 C after 50 to 100 days in a simulated NPR gas atmosphere. This result can be related to the fact that the solubility limit for hydrogen was exceeded about this time. A tentative hypothesis, which will be evaluated in future tests, is that precipitation of the hydride phase in the metal results in a volume expansion which modifies the protective property of the zirconium oxide film.

The decontaminating procedures under development for the NPR and PRTR do not significantly increase the hydride concentration in the Zircaloy. The hydrogen content after eight complete cycles, alternated with high temperature operation, was less than 20 ppm.

Graphite samples for monitoring oxidation in KE Reactor were removed after three months in the He-N_2 atmosphere. The oxidation rate of all samples was below the established limit of 2%/1000 operating days.

Initial in-reactor check-outs of the modified second generation in-reactor creep capsule were favorable, showing lower gamma heating and more stable performance of the thermocouples and electrical transducers than in earlier models.

The computer program for calculating neutron attenuation in shields is complete. Results for a thick shield with a thermal neutron reduction factor

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of 10^{10} indicate that the calculations can reproduce the experimental data for fluxes and dose rates within a factor of two.

In support of the CANDU design, a study of the heat transfer and fluid flow characteristics of a horizontally located 19-rod bundle fuel element was started. Using an electrically heated test section identical in size to the PRTR Mark I fuel element, no high temperatures indicative of stratification were observed at a heat generating rate of 208,000 B/hr-sq ft with inlet conditions of 478 F and 1100 psia and with flow reduced to make the outlet coolant 20% steam by weight. The experiments will be repeated at higher heat generation rates.

2. Chemical Research and Development

The fourth strontium-90 recovery by ion exchange yielded 12,400 curies from centrifuged Purex feed free of troublesome solids. Several new process improvements were incorporated in the run; most noteworthy was the use of ammonium nitrate for final product elution wherein almost all the product was recovered in only six liters of eluant.

The Hot Semiworks was ready to proceed on large-scale recovery of strontium-90 at month's end. An extensive amount of backup technology and laboratory scale tests indicate an optimum flowsheet with no serious problems.

Progress was made on a concept of fission product packaging by means of a filter canister in which in situ chemical conversions would produce a final stable product form. This idea, when successful, will greatly simplify handling and shipment of highly radioactive products.

Less than 0.75 percent of cesium loaded on a Decalso inorganic ion exchange media was volatilized when the system was heated to 1500 C.

A series of glasses containing 30 to over 70 weight percent strontium were successfully prepared. These glasses hold promise for use as high-integrity, easily formed strontium-90 heat sources.

An intensive research program on Salt Cycle technology was continued on a broad front. Careful electrochemical measurements, improved experimental techniques, and investigation of alternate salt "solvents" are pointing to a better understanding of the chemical species present and the kinetics of their transformations. Electrochemical deposition of UO_2, in particular, is well characterized and large, dense crystals can be produced in a predictable manner. The largest engineering scale deposition of UO_2 produced over 20 pounds in one deposit from a potassium chloride-lead chloride molten salt solution.

Satisfactory core sampling of sediments from the floor of McNary Dam

reservoir showed material in the strata of sediments can be dated by measuring the Zn-65 to Co-60 ratios. Sediment cores varied from 8 to 14 inches in depth.

A broad base of knowledge on site geology and hydrology was used in a recent study which concluded that NPR decontamination wastes will be disposed to ground in a crib north of Gable Mountain some five miles from the NPR site.

3. Physics and Instrument Research and Development

An experiment to improve nuclear safety limits for one step in the 235 Building process was conducted in the plant. This was the first in-plant experiment of its type conducted at HAPO. In such experiments, the assembly of material is kept well below critical size with the conditions that would be required to obtain actual criticality deduced by extrapolation of the data. The work is a joint effort of CPD Research and Engineering Operation and Critical Mass Physics Operation and will continue through a series of measurements simulating normal and abnormal operating conditions.

Study of a simple approach to automatic control of existing reactors was continued. Again, outlet tube temperatures actuated on-off rod motion. In the two tests conducted this month, normal operator control had to be resumed when simulation of the simplified control operation did not adequately restrain shifting of the heat load in the reactor.

Substantial aid in overcoming inadequacies in the control system of CPD automatic lathes resulted from application of a technique to measure their dynamic characteristics which has been developed after considerable experimental difficulty. Reproducible data for defining the system non-linearities has been obtained for the first time.

Accumulation of backup knowledge on the behavior of neutrons in NPR type reactors continued through performance of exponential experiments. Improvements in the technique of analyzing such experiments are promised by recent application of improved theoretical methods to the treatment of some sources of variation in the results.

At the Critical Mass Laboratory the program of leak detection and repair made progress and volume calibrations were run on various solution-containing vessels. Satisfactory progress was also made in the fabrication of the assembly equipment to be used with simulated plutonium precipitates. Development of computation methods for predicting criticality also continued to make progress but emphasized the need for better information on the effects of Pu-240 in criticality situations.

Development of improved fuel failure detection systems will be aided by an experimental installation planned for the PRTR Rupture Loop. Instrumenta-

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tion is being designed and procured for the determination of gamma energy spectra, delayed neutron activities, and gross activities from defected fuel under various conditions.

Understanding of the physics of plutonium as a reactor fuel will be aided by a newly demonstrated technique for measuring "neutron temperature" variations throughout a lattice cell using Lutetium "neutron thermometers".

Detection of PuO_2 concentrations in PuO_2-UO_2 fuel rods may be done by gamma ray energy differences according to initial studies which detected localized concentrations of 2% of PuO_2 in rods where the average concentration was 0.5%. To date, detection sensitivity has been limited by variations in the total oxide density.

In non-destructive testing research, study of the optimum waveform to use in eddy current testing was assisted by receipt of the first quarterly report on our research contract at Johns Hopkins University. In other work, eddy current test coil temperature compensation was developed, further improvements were made in thermal bond test methods, and preliminary experimental search for nondestructive ways to detect Zircaloy hydriding yielded negative results.

Fallout of airborne contaminants due to rainfall is receiving increasing attention as analysis of voluminous dispersal data nears completion. New experimental techniques useful with both natural and artificial rains have given encouraging results in preliminary trials.

Improved detection sensitivity, by a factor of 10, for air contamination by fission products was obtained in a monitor installed in 327 Building. Increased sensitivity over present plant equipment entailed some increase in cost and loss of portability, factors which are not of importance for all applications.

At the whole body counter, information on the redistribution and elimination of several isotopes was obtained. Information on P-32 was obtained through the cooperative study with the University of Oregon Medical School and on Sb-125, Co-60, Zr-Nb-95, and Ru-106 through observations on accidental contamination cases.

4. Biology

In terminating the rabbit sampling program, the I^{131} content of a large series of thyroids and vegetation samples from the same collecting site were compared. The thyroid/vegetation I^{131} ratio was approximately 600. The I^{131} contents in thyroids from full-term fetuses were 1.02 ± 0.5 times those of their parents.

DTPA treatment of rats 60 days after administration of plutonium appeared to increase both biliary and non-biliary excretion of plutonium. Approximately one-fourth of the fecally excreted plutonium entered the intestinal tract via the bile.

From 15 to 35 percent of Pu^{239} intradermally injected into swine remained after eight months.

Clearance of Ce^{144} particles from the lungs of rats appeared to be slightly increased by inhalation of ionized air.

Oxygen deficiency to barley seedlings depressed uptake and transpiration of calcium.

Immature buds of yeast cells are radioresistant. Preliminary data obtained by a staining technique indicated that such buds do not receive nuclear material from the parent cell until half grown.

5. Programming

Development and improvement of computer codes employed for fuel cycle analyses studies has continued during the month, with various codes being both broadened in their capabilities and improved in accuracy, as well as optimized for minimum usage of 7090 machine time.

The "Salt Cycle" partial decontamination process may prove most attractive economically in "throwaway" cases, where the uranium is sufficiently depleted to be of essentially no value. Apart from its value as a separations process, the salt cycle may also be an attractive method of preparing mixed plutonium oxide-uranium oxide fuel with desired physical properties.

Analyses of typical uranium ore feeds to two different domestic mills confirm earlier hopes that some of these ore streams are attractive sources of Th-230, of interest for in-reactor formation of heat-producing U-232, and its daughter Th-228.

TECHNICAL AND OTHER SERVICES

Throughput rates have been achieved which meet current completion schedules for the non-destructive testing and accompanying treatment of NPR process tubes. A new ultrasonic test for transverse discontinuities was placed in routine use, and encouraging improvements were made in penetrant testing.

Two cases of plutonium deposition were confirmed during the month. The total number of plutonium cases that have occurred at HAPO is 267, of which 194 are currently employed.

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The Annual Summary Report for 1960 on the Radiological Conditions in the Hanford Environs was completed. One hundred copies were transmitted to HOO-AEC for distribution to government agencies and interested public officials.

There are 19 currently active projects having combined authorized funds in the amount of $18,904,000. The total estimated cost of these projects is $25,394,000. Total expenditures on them through March were $15,080,000. In addition, project proposals have been submitted to the Commission requesting authorization of $572,000 total project funds on 4 new projects.

All formal R & D reports will be reviewed by the Patent Attorney to ascertain whether patentable material and/or legal objections exist to prevent a document being sent off-site.

Estimation of parameters in empirical models expressing fuel element distortion as a function of reactor variables was completed and a satisfactory fit obtained.

It has been shown that the problem of determining the frequency of simultaneous reactor outages can be solved using available multi-channel queuing theory results. This analysis has been applied to further work on the problem of the optimum size for supplemental crews.

The required calculations for demonstrating conformance to specifications of parts shipped during the first quarter of 1961 were based for the first time on the recently adopted part-by-part acceptance techniques.

In connection with pulse column control studies a preliminary analysis was completed of mid-column photometer calibration data and the results used to guide a machine calculation to determine the best mathematical method of correcting for the temperature differential between calibration and experimental runs.

SUPPORTING FUNCTIONS

Financial has assigned a member to a task force to study ways for reducing costs of 300 Area transportation. The study is being centered on a review of motor pool and assigned vehicle practices which can be modified to reduce costs. FPD and Transportation are also represented on the task force.

A televised news feature on Operation Plowshare and Project Chariot was prepared.

Twenty presentations on changes in benefit plans have been completed. This represents approximately half of the total job.

The revised Suggestion Plan procedure for awards of $50 or less was effected April 17.

Advanced Degree - Twelve Ph. D. candidates visited HAPO for professional employment interviews. Eighteen offers were extended; three acceptances and one rejection were received. Current open offers total 17.

BS/MS - Offer acceptances rose sharply during April as did rejections. Year-to-date progress in campus recruiting has resulted in 152 offers, 48 acceptances and 42 rejections. We currently have 62 offers open.

Technical Graduate Program - Six Technical Graduates were placed on permanent assignment during the month. Three new members were added to program rolls. Current program members total 48.

Recruiting visits were made to ANPD at Cincinnati and Idaho Falls. A total of 125 interviews were conducted. Offers have been extended to 9 ANP technical exempt personnel and one acceptance has been received (Welding Engineer for HLO). In addition, we learn that 3 offers were extended to ANP financial personnel all of whom have accepted.

The guide portion of the Pressure Systems Task Force report will be revised and issued as an HW document, thus making information on pressurized equipment more widely available.

Current year-to-date incidence of security violations (18) are running at twice the rate for 1960 (9). There were eight violations during April. Medical treatment injuries totaled 42 for the month resulting in a frequency rate of 1.98 for April and year-to-date.

Carl A. Bennett
for Manager
Hanford Laboratories

HM Parker:CAB:mlk

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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 in Simulated NPR Gas. A number of Zircaloy-2 samples have been exposed at three temperatures (325, 375, 425 C) since October 1960 to a simulated NPR gas atmosphere. Tank helium was passed through a solution of potassium acetate to give an inlet dewpoint of approximately 0 C. This gas mixture was passed over graphite at 990 C, producing an exit gas with a composition of about 98.7% He, 0.5% CO, 0.7% H_2 and 0.05% H_2O. Samples removed after 27 and 57 days of exposure showed little or no hydrogen pickup at any of the test temperatures which could be attributed to the hydrogen gas content. At 107 days of exposure, the 325 C and 375 C samples still showed no hydriding, but the 425 C sample had picked up 645 ppm hydrogen, which indicated hydrogen absorption beyond the normal corrosion product hydrogen pickup. Samples recently removed after 160 days of exposure confirm the previous data with the 325 and 375 C samples showing no gaseous hydrogen pickup. The 425 C sample contained 3354 ppm hydrogen and was severely hydrided.

The 0.05% water present in the gas stream appears to be inhibiting hydrogen pickup at 325 and 375 C by formation of a protective oxide. At 425 C some inhibition still exists, but the hydriding rate is unacceptably high for reactor applications. The "breakaway" hydriding which began between 53 days and 107 days at 425 C can be related to the fact that the solubility limit for hydrogen was exceeded at about this time. The resulting precipitation of a hydride phase in the metal results in a volume expansion which could modify the protective qualities of the ZrO_2 film. More work is planned to determine the merits of this proposed mechanism.

Effect of Oxygen Concentration on Hydrogen Pickup in Zircaloy. To determine the effect of oxygen concentration on the hydrogen pickup for Zircaloy-2 and Zircaloy-4 during autoclaving in 400 C, 1500 psi steam, tests are being conducted under the following conditions: (1) refreshed system containing 3 to 4 ppm O_2; (2) refreshed deoxygenated system containing less than 0.1 ppm O_2; and (3) static system containing less than 0.1 ppm O_2 plus the corrosion product hydrogen normally generated during the exposure.

The results to date show that the percentage of corrosion product hydrogen pickup for Zircaloy-2 is considerably lower in the refreshed system containing 3 to 4 ppm oxygen than in the other two systems containing virtually no oxygen. For Zircaloy-4, the effect is much smaller. The amounts of hydrogen pickup for the Zircaloys in the oxygenated system

are 10% for Zircaloy-2 and 14% for Zircaloy-4 versus 28% for Zircaloy-2 and 18% for Zircaloy-4 in the deoxygenated systems.

Erosion-Corrosion of Aluminum Alloys. Tests were run in the erosion-corrosion test assembly to determine the qualitative effect of heat transfer on the attack of 1245 and X-8001 aluminum alloys. Heated samples were exposed to 300 Area tap water at a velocity of 65 ft/sec for 24 hours at inlet water temperatures of 15 and 95 C. Considerably greater corrosion was observed at the higher water temperature, with X-8001 experiencing greater attack than the 1245. Heat transfer increased the corrosion rate up to seven-fold over samples exposed to the same inlet temperature water without heat transfer. Corrosion rates were comparable to those observed with 110 C inlet water temperature and no heat transfer through the sample. The attacked areas were generally smooth and uniform with occasional pits near the intake. Back-pressure (300 psi) applied to the system had a marked effect in reducing the attack.

Radiometallurgy Laboratory Studies

The first KER, single tube, Zr-2 clad element with Zr-Be brazed end caps was sectioned. The end closure and cladding were found to be in excellent condition and the uranium free of cracks (RM-577). Eight irradiated capsules from a test designed to measure the in-reactor strength of Zr-2 jacketing material have been burst at a temperature of 337 C. The time to rupture at pressure was measured and found to vary with fabrication and irradiation conditions (RM-554). The results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

Basic Metallurgy Studies

Radiation Effects in Structural Materials. Four X-basket assemblies have been received by Radiometallurgy for measurement of irradiation damage to zirconium and Zircaloy-2. The accumulated exposures (flux $\geq$ 1 mev exposure time) were 4.55×10^{17} nvt, 1.38×10^{18} nvt, 3.60×10^{18} nvt and 7.56×10^{18} nvt. The first three exposures were obtained in the VH-4 position in the MTR where the maximum unperturbed thermal flux was 1.86×10^{14}. The highest exposure (7.56×10^{18} nvt) was obtained in the A-28-NW position, where the maximum unperturbed thermal flux was 5×10^{13}. Two X-basket assemblies with goal exposures $> 10^{19}$ nvt are still in the reactor.

Electron and Optical Microscopy. High purity aluminum foils irradiated in the Snout Facility to 2×10^{19} nvt (fast) are under study. X-ray diffraction was employed to measure lattice parameters before and after irradiation. Values of the lattice parameter a_o were obtained by measuring the d-spacings for the four high angle lines, 331, 420, 422, and 333.

Annealed,	pre-irradiation	a_o = 4.04860 A
"	irradiated 10^{18} nvt fast	4.04900
	irradiated 10^{19} nvt fast	4.04900

Cold-worked, pre-irradiation		a_o = 4.04882
" "	irradiated 10^{19} nvt fast	4.04902
	All values are ± 0.00005 A	

Broadening of the x-ray lines was very slight. For the annealed samples, differences in breadth between the irradiated samples and the unirradiated samples were of the same order as those between individual unirradiated samples. Inasmuch as the annealed foils contained a very small number of crystallites suitably oriented to diffract, differences between individuals were pronounced. The lines for the cold worked samples were broader than those for the annealed samples and were not further broadened upon irradiation.

A series of multilayered films of the type C-UO_2-X, where X is Pt, Pd, and Ge, were prepared in such a fashion that the thickness of metal X varied in the ratio 1:2:4:8. After irradiation and electron microscope study of the fission fragment tracks in these films, the series containing Pd was recoated with additional Pd. The purpose of the additional Pd coating was to make all films of the Pd series equal in respective layer thicknesses. Re-examination conclusively showed that fission fragment damage perceived by transmission electron microscopy is a function of the distance between the fission fragment path and the free surface of the film, and is not subject to contrast effects associated with different thicknesses of metal X. Comparison of Pt and Pd films with equivalent thickness ratios also indicates that fission fragment damage is a function of the specific metal used. Different metals have different fission fragment scattering powers.

A detailed examination of all films subjected to fission fragment damage has revealed some common characteristics of track geometries and contrast. It is believed that the present interpretation of damage is correct and that the direction of travel of the fission fragments with respect to the surfaces of the films can now be described.

Foils of aluminum prepared by electrolytic thinning to approximately 1000 A thicknesses were coated in a heterogeneous fashion with UO_2 and then irradiated. Passage of a fission fragment through the aluminum is accompanied by removal of the UO_2 from the top surface of the foils along the projected path of the fission fragment. Passage of a fission fragment through the aluminum in regions which are devoid of UO_2 does reveal a track due to decrease in effective electron scattering power of the aluminum in the region through which the fission fragment has passed. Aluminum foils containing large grains, therefore, behave differently than fine grained, evaporated aluminum films supported on carbon substrates described in previous reports. This difference may be associated with the fact that a large grain of aluminum is diffracting electrons quite uniformly, whereas with a fine grained film, only a small percentage of the grains are in an equivalent diffracting position. Consequently, slight changes in the electron scattering power of the aluminum in the region of a fission fragment path will give rise to considerably different contrast effects. If, for example, the aluminum foil is oriented to an

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extinction position, the fission fragment track can no longer be detected. Motion of dislocations present in the aluminum foils coated with UO_2 can be observed. Some of these dislocations pass near fission track regions and in some cases appear to interact. This interaction is in the form of a pinning interaction and provides further evidence for believing that considerable damage in the aluminum lattice has occurred.

X-Ray Diffraction Studies. Orientation of extruded uranium tubes and rods with various fabrication and heat treatment histories is being determined by several x-ray methods. It has been shown that satisfactory pole figure and growth index values can be obtained on fine grained alpha extruded or cold worked uranium. But growth index determinations on beta heat treated uranium tubes are often unreliable due to the large grain size. This conclusion is based on results of experiments on KER and NPR tubes where GI values were determined from a given surface (approximately 3/4" x 1" in area) and then redetermined after removing about 10 mils from the original surface. Typical GI values (Morris ten plane method) from one piece of beta heat treated uranium are as follows:

	Long.	Trans.	Rad.
Surface 1	-.1	0	-.15
Surface 2 (10 mils removed from surface 1)	+.1	-.3	-.25
Surface 3 (5 mils removed from surface 2)	+.15	-.2	0

Using these same specimens, GI values were obtained using the Sturkin 31 plane method. There was a direct correlation between results, showing that there is no added advantage in using the longer method. To obtain more reliable results, more surface area must be used in the determinations. Experiments are in progress to determine how much surface must be examined in order to have a statistically representative sample.

Notch Sensitivity of Zircaloy-2. Recent failures of Zircaloy-2 clad test elements have indicated that the cladding material fails locally with little uniform straining in the remainder of the material. Sensitivity of Zircaloy-2 to surface irregularities such as a notch or deep striation introduced during forming might be the cause of this failure tendency. In order to determine the degree of notch sensitivity of Zircaloy-2, a series of tests at an elevated temperature of interest is being conducted with notch depth and strain rate as parameters. A plot of notch depth fraction (notch depth/thickness) versus uniform plastic strain at failure should permit extrapolation of the curve to a critical notch depth at zero plastic strain.

Flat specimens rolled to 0.020" and cut tranvserse to the rolling direction are notched parallel to the rolling direction and fully annealed

prior to testing. Results at two strain rates indicate little notch sensitivity below 0.006 inch notch depth. Near a notch depth fraction of 0.3, there is extensive deformation at the notch, as well as the gage section with failure occurring unpredictably within the gage section or at the notch. Specimen width may be a critical parameter in controlling this behavior. Testing will continue with additional strain rate variation and wider notch depth range. Tests will also be initiated to determine the effect of increased specimen width and notch orientation with respect to the rolling direction.

Zirconium Alloy Fabrication. Hot rolling of the 13 zirconium base alloys (March 1961 monthly report) has been completed. Rolling was done from a furnace set at 750 C. Reductions of 10% per pass were used with one pass per reheat. Some edge cracking was noted on one alloy containing 4.0% Sn, 2% Mo.

Metallic Fuel Development

Fuel Irradiations. Radiometallurgical examination of KSE-3 fuel elements discharged during January at 1200 MWD/T has continued, and no serious fuel element design deficiencies have been observed. The average length change of the four 18-inch long elements is -0.070 inch, and the average OD change is +0.004 inch. Post-irradiation single throw warp ranged from 0.004 inch to 0.015 inch, representing warp changes of -0.002 to +0.008 inch and an average change of less than +0.002 inch. Microscopic examination of the Zr - 5 w/o Be eutectic closures and of the uranium fuel in the braze heat-affected zone has revealed no fuel cracking or distortion and no indication of braze or clad bond failures.

Radiometallurgical examination of KSE-3 fuel elements discharged during February at 2000 MWD/T has started. The average length change of the four 18-inch elements is -0.034 inch and the average OD change is approximately +0.010 to +0.012 inch. Post-irradiation single throw warp ranged from 0.006 to 0.013 inch. Some distortion on the inner bore of the fuel tube in the heat-affected zone was evident upon superficial examination, but sectioning in one such area indicates that dimensional changes are negligible.

Four NIN-1 fuel tubes (NPR inner tubes) were discharged during April at 1000 MWD/T exposure because of a fuel element rupture indication. Examination in the basin did not reveal the cause of the indicated failure. The average volume increase of the fuel, determined by weighing in the basin, is 0.4 percent. This is approximately one-third of that observed with the KSE-3 elements at equivalent exposure. The decreased swelling of the NIN-1's as compared to the KSE-3's is attributed to somewhat lower fuel temperatures and greater OD clad restraint. The NIN-1 elements have 0.040 inch outer clad thickness as compared to 0.025 inch for the larger diameter KSE-3 elements.

Radiometallurgical examination of two KER tube/tube fuel elements irradiated to an exposure of 3200 MWD/T was essentially completed. One

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element had a uranium core and one a uranium - 2 w/o zirconium core. The inner tube of the uranium core element failed by clad splitting. Localized recrystallization of the uranium core in a cross-section of the outer tube was reported last month. Longitudinal sections showed that this recrysallization occurred during cutting. Apparently, coolant flow during cutting was inadequate and overheating of the fuel resulted. The end caps of these fuel elements were recessed to allow for expansion of the uranium during irradiation. A longitudinal section was made through the end cap of the uranium outer tube after irradiation. Uranium, which has flowed plastically, filled about 95 percent of the end cap recess.

An obsolete NPR inner tube (KSN-1) failed in a KER Loop after 1700 MWD/T. The end caps on the element had been welded in place with no allowance for uranium expansion. Radiometallurgy examination revealed a shear failure in the clad of this element at the base of the end cap. Thermal contraction of the uranium during reactor shutdown was the cause of the shearing force which led to the failure. The diameter measurements made on this element showed a maximum increase of 0.024 inch for the outer diameter and 0.004 inch decrease for the inner diameter. A volume increase based on diameter measurements would be 3.8 percent.

The two NIN elements with brazed closures, GEH-4-57, 58, irradiated in the MTR were discharged March 25, 1961, due to a rupture. Failure occurred on startup of the fifth irradiation cycle. Failure appeared to occur through a longitudinal crack across the rupture blister. Detailed examination of the rupture and brazed end closures will be performed after the radioactivity decays to a safe level. Exposure at time of failure was 1050 MWD/T (0.12 a/o burnup or 6.0×10^{19} fissions/cm^3). The specific power was 75 kw/ft, with a uranium surface temperature of 180 C and a core temperature of 350 C.

Two brazed KER tube-tube fuel element assemblies have completed one cycle of irradiation in the 6x9 loop of the ETR. These elements ran at a specific power of 317 kw/ft with a maximum clad temperature of 380 C and a maximum core temperature of 627 C. The outer tube accumulated an exposure of 1200 MWD/T (0.14 a/o burnup or 6.8×10^{19} fissions/cm^3) and the inner elements accumulated 825 MWD/T (0.09 a/o burnup or 4.0×10^{19} fissions/cm^3). This experiment was an extremely severe test for the 12 Fe + 4 Be + 84 Zircaloy braze because of the high temperatures and extremely high fluxes involved. These elements will be examined and measured in the new ETR Basin Measuring Facility prior to shipment to HAPO for detailed metallurgical examination.

Ten 15-inch long elements of NPR inner tube stock, processed with variable beta heat treatment, have been discharged after irradiation in KER Loop 1. The charge average exposure was 1050 MWD/T. The average and maximum element power was 48 and 54 kw/ft, respectively, and the weighted average tube outlet temperature was 286 C. The elements operated without any unusual incidents and were subjected to a total of 24 shutdowns during irradiation. Examination of all the elements will be made in Radiometallurgy.

Two elements of the same group were irradiated in the ETR 3x3 Loop during Cycle 36 (GEH-10-44 and 45). These elements operated 17 - 25 effective days at an average power of 102 kw, including the basket. The average element specific power was then 40 kw/ft. Total exposure was 149 MWD/T. These elements will be measured for dimensional changes and warp before continuing irradiation.

A section of the Zircaloy-2 basket from the fifth ETR rupture test, cut from directly over the defect in the ruptured fuel element, has been analyzed for hydrogen. The analysis showed 95 ppm hydrogen in the basket in the region analyzed as compared to the 22 ppm hydrogen in the Zircaloy stock used for the basket. The hydrogen increase is attributed to in-reactor operation with the ruptured fuel in contact with the Zircaloy-2 basket.

Fuel Component Development. Over a year ago, fifteen thin-walled Zircaloy-2 tubes were burst tested in-reactor under stress rupture conditions. The total fast neutron exposure during the test was approximately 10^{19} nvt greater than one mev. According to plan, after seven of the capsules burst in-reactor, the test was discharged. The eight remaining unburst capsules were recently burst at 337 C in the Radiometallurgy facility. These capsules were burst at initial hoop stress levels of 46 to 49 thousand psi and time to failure varied from 0.1 hour to 30 hours. A parametric plot (involving rupture time, test temperature, and stress) of the burst data shows the post-irradiation strength and ductility of the burst capsules to be comparable with the pre-irradiation strength and ductility. One specimen fractured at the predicted time, temperature, and stress, but it failed as a pinhole without appreciable strain. This specimen will be examined to determine if localized necking or a defect in the Zircaloy-2 cause the pinhole failure.

Additional measurements of room temperature residual stress in the outer clad of NPR fuel elements confirmed previous measurements. The average compressive residual stress was about 40,000 psi. Residual stress alone can cause warp if one or more of the fuel components is asymmetric with respect to the other. One rather extreme case was examined analytically. The outer jacket on an inner tube was assumed to be 40 mils thick on one side and 50 mils thick diametrically opposite. The inner cladding and uranium core were assumed to be symmetrical about the axis of the fuel. Calculated warp from residual stress was equivalent to 15 mils double throw in 24 inches.

Two high temperature (1050 C) swage sizing tests have been made on 406 SS material. The first was the reduction of an AISI 406 SS 0.750 inch diameter hot rolled rod to 0.593 inch in diameter. The second was the reduction of a 2.250 inch diameter cast billet of AISI 406 SS to 1.50 inch in diameter.

Both materials worked well at 1050 C and showed no signs of flaking or cracking. The surface was very smooth and exhibited only a thin oxide film. Further reduction of the cast billet by hot rolling at 800-900 C

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will be conducted soon. This billet will eventually be hot worked from the original 2.25 inches in diameter to 0.593 inch in diameter.

Further attempts have been made to roll bond AISI 406 SS to uranium. A spotty bond was made by rolling sandwich at 650 C to approximately 20% of its original thickness. It appears as though the rolling should have been carried out to 10%. The areas that were bonded exhibited an extremely brittle bond. Rolling at a higher temperature would put the test into the beta phase. The introduction of an intermediate layer of niobium will be tried in an effort to reduce the brittleness of the bond.

Heat Treatment Studies. All x-ray data taken to date from samples of uranium given a variety of beta heat treatments have shown that the heat treatments have given an effective randomization of the grain orientations. The consistency of the data has made identification of any one of the heat treatments as the "best" heat treatment very difficult. Further analysis of the data and discussions with x-ray personnel in the Physical Metallurgy Operation has led to the conclusion that an insufficient number of grains were scanned by the x-ray beam to give a true statistical sample. An investigation is now under way to determine the surface area required to give a true statistical sample.

Component Fabrication. Several Zircaloy-2 extrusions have been made using a thin (0.0005 inch thick) copper immersion plate originally developed for the hot heading process as a substitute for canning the billets in copper. The copper can provides protection for the Zircaloy-2 during the billet preheat and aids in lubrication during extrusion. The copper immersion plate has the advantages over the thicker copper can of providing a smoother surface on the extrusion and is inexpensive and easy to apply to the billets. A plate of this type could prove valuable to the coextrusion process requiring only that the uranium be sealed within the Zircaloy-2 cladding sleeves before immersion plating the billet. The copper plate appears to be adequate to prevent the formation of white Zircaloy oxide when the billets are preheated to 750 C. This white oxide is very abrasive to the extrusion tooling and increases the tendency for the extrusion to gall heavily.

Six one-inch diameter billets were extruded into rods at a 10 to 1 reduction using the copper immersion plate without any indication of galling during the extrusion. Two types of graphite lubricant were coated over the billets; one consisting of a mixture of Fel Pro (a commercial compound of suspended copper fines) and graphite, and the other consisting of a mixture of water glass and graphite. Results indicate that the graphite and Fel Pro tends to produce the smoother surface on the extrusion.

Prototypical 1008 steel-clad, Zircaloy-2 supports on the dummy element in Elmo-7 ex-reactor loop have accumulated a total exposure of 2959 hours. Water conditions during normal operation are 300 C, 2000 psi, at a pH of 10. No detrimental effects to the steel shoes have been observed. The loop was emptied and decontaminated during this exposure. No crud buildup was observed in the support clearances after startup as had been experienced with crimped supports of an earlier design.

Samples of prototypical N outer tube supports were exposed to decontamination cycles to determine the extent of decontaminant attack. Two dummy elements with 1008 steel and ingot iron clad supports were exposed to high temperature water for 646 hours at 300 C. During this exposure they were subjected to two decontamination cycles. Each cycle was as follows:

1. Two hours at 105 C with AP-18, 3.
2. Two hours at 60 C with Oxal-1 (12 oz/gal).
3. One hour at 60 C with Phos-1 (5 v/o).

Minor surface pitting was observed on the steel surfaces. Weight loss measurements on coupons of 1008 steel and ingot iron indicate about 6 to 10% weight loss on the 1008 steel and about 2% weight loss on the ingot iron after one cycle. After two decontamination cycles the 1008 steel weight loss is 7 to 10%, and the ingot iron shows 9% weight loss. This weight loss figure should be conservative since the coupons had two large areas exposed to moving fluid, whereas the support shoe "in place" exposes half of its surface area to a dynamic fluid.

An ingot of 3% enriched uranium has been arc melted, heat treated, upset from 3.5" diameter to 4.0" diameter, and is currently being machined for a tube extrusion billet. The extruded tube will be used as an outer enriched component for coextruding with a zirconium clad and depleted core piece to form a 0.600" diameter dual enriched rod. An electrode of depleted material is being assembled for the core material.

Closure and Joining. Work has continued on the effect of beryllium and uranium on the corrosion properties of Zircaloy. As reported last month, the presence of beryllium causes a dulling of both the etched and autoclaved surfaces, but not in proportion to the beryllium content. When as little as 250 ppm of uranium was added to the alloys, the etched surfaces darkened in proportion to the beryllium content. Also, during autoclaving, white oxide appeared on the surfaces of the uranium contaminated 4.8% Be-Zircaloy alloy. When the uranium content was increased to 2500 ppm, the white oxide appeared at progressively lower beryllium concentrations. The autoclave film did not change appearance appreciably from that at 20 hours after 200 hours. Also, the weight gains did not show an appreciable rise during the same time interval. A new instrument, called the "Densichron", has been used to measure reflected light from the coupon surface. This instrument is very sensitive to changes in composition which result in changes of the surface appearance not visibly evident. Light adsorption on etched samples with 250 ppm uranium increases from 8% for 0% Be to 120% for 4.8% Be. A group of uranium-zirconium samples was autoclaved to determine the composition where the yellow oxide first appeared. No visible change in the autoclaved surface was observed up to 2% of uranium. At 3% of uranium a lighter surface was observed and at 4% of uranium a yellowish-tan surface was first observed after 20 hours in 400 C steam. The corrosion rate increased rapidly up to 70% of uranium and at 80% of uranium the coupons completely disintegrated. These results provide an indication of how much uranium can be held in Zircaloy and not be detected by visual examination.

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NPR fuel elements as presently conceived require a holding clip which prevents the inner tube from sliding out of the outer tube. The clips are attached to the inner clad of the outer tube by resistance welding. A number were attached for testing. Shear strengths were found to average 800 lbs. Micro sections were prepared, and it was determined that the welds were of good quality and did not show excessive penetration. Six prototypical elements were welded for FPD. These are scheduled for testing to determine the effectiveness of the clipping device under simulated discharge conditions.

Fuel Deformation Studies. A report, HW-69175, describing a model for metallic tubular fuel elements has been written. The model allowed for cyclic straining of the cladding but neglected the resistance of the fuel material to shear stresses. Test data from Hanford irradiations were analyzed and compared with the model. These particular data did not correlate with the model and would not have correlated with any model not containing anisotropic or ratcheting terms which would allow slight geometrical or irradiation variations to alter dimensional changes. The testing apparatus needed to evaluate the effects of incremental straining during strain cycling is being fabricated. All components have been procured, and the extensiometer is built and calibrated.

A test is under way which will simulate swelling strains by forcing a hardened tapered rod into the bore of a section of an inner-tube fuel element. The fuel element section is thermally cycled to increase the plasticity of the uranium and to cause the hardened taper, of lower thermal expansion coefficient than the uranium, to thermally ratchet into the bore and cause a gradual increase in outside diameter of the fuel. One piece has cycled at a rate of one cycle per hour for 72 hours through a temperature range of 100 C. Results indicate a larger temperature range is necessary to get the desired strain rate.

Chemical analyses of Zircaloy-2 clad uranium rods irradiated in NaK capsules indicate 25 to 50 percent higher burnup than is obtained by calculation from uranium temperatures and adjacent process tube powers. The burnup obtained on two samples by the chemical analysis is 0.21 and 0.32 a/o as compared to 0.13 and 0.25 a/o obtained by calculation. Additional samples will be chemically analyzed to verify these figures. Additional metallography was completed on one of the striated rods from these capsules to obtain further data on the cladding thickness variations associated with localized clad failures. To further study the effects of cladding thickness variations on the susceptibility to failure, a series of NaK capsule irradiations of Zircaloy-2 clad fuel rods is planned for the Hanford reactors. Eight unalloyed rods have been coextruded and fuel rod samples with no striations and with machined striations are being fabricated for irradiation. Fifteen U - 2 w/o Zr rods to be used in this study were autoradiographed before and after longitudinal striations were machined in the cladding. These radiographs will be used in determining the cladding thickness at the location of any failures that might occur in the striated or unstriated rods.

Temperature cycled constant load tests on uranium have continued. Separation of the straining occurring during the heating and cooling portions of the temperature cycles was attempted, but the present equipment was judged to be inadequate. The testing capsule has been redesigned, and the bellows necessary for the capsule's construction are on order.

2. REACTOR PROGRAM

Coolant Systems Development

Improved Aluminum Alloys for Hanford Reactors. Of several aluminum alloys tested the uniform corrosion rate in 120 C process water increased in the order: C-64, C-810 and the cermet 171303 (ALCOA), and X-8001. The uniform corrosion rates of all of the alloys decreased slowly throughout the test.

After six months, the total corrosion in mils for the different alloys was: C-64, 4.5; 171303, 5.2; C-810, 5.4; X-8001, 6.5. The resistance of the cermet alloy to surface erosion was quite noticeable. The X-8001 aluminum samples showed considerable surface roughening toward the end of the test. The C-64 and C-810 alloys also showed some non-uniform surface attack, while the 171303 alloy remained almost completely smooth, even under 20X magnification.

Further testing of these alloys is under way to better compare their relative resistance to erosion corrosion. Various shapes of obstructions in the flow stream will be employed to create turbulence. Other aluminum alloys which are now being tested include wrought alloy X-8003 and the cermets 199116 (ALCOA) and 288C.

Atmospheric Corrosion Studies. Sections of capped carbon steel pipe containing vapor-phase inhibitors for corrosion protection were opened after a year's exposure to the climate at the K Reactors. Even though some water had been injected into the pipes, the surface was well protected as long as some inhibitor was present. Carbon steel strips (A212 Grade B) have been coated with the Turco and Oakite protective oils and a vapor phase inhibitor and exposed at 2000 F to determine whether cleaning and welding of the carbon steel piping will result in excessive carburization. Tensile and hardness tests will be run on the specimens.

KER Crud Analysis. Radioactive crud specimens collected on hot crud probes (carbon filters) and specimens obtained by manually filtering room temperature coolant samples through 4-micron filter paper are being analyzed to determine the gamma spectra of the crud activity. The purpose of these tests is to identify which radioisotopes are selectively adsorbed and determine their concentrations. It is hoped that the hot crud probes can eventually be replaced by the samples collected on filter paper from room temperature coolant.

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Sodium Nitrite Inhibitor Test. An inhibitor is required which can be added to reactor discharge basins to prevent the severe rusting of carbon steel which is normally found. A test to determine if $NaNO_2$ will effectively inhibit corrosion of carbon steel and aluminum in nonflowing service water is in progress. The results after one month indicate that 200 to 300 ppm $NaNO_2$ will effectively inhibit the uniform corrosion on both metals. Carbon steel corrosion at one month was reduced from 0.3 mil to $<$ 0.01 mil. The uniform corrosion of aluminum was essentially unchanged by the inhibitor; however, a severe galvanic attack between stainless steel and aluminum was eliminated by the inhibitor.

Laboratory Evaluation of Decontaminants. Laboratory screening tests of decontaminants indicated that a mixture of citric and glycolic acids (2.5 mole percent of each) preceded by the AP-18-3, is a candidate for carbon steel-stainless steel systems and should be further tested under flowing conditions. Another formulation, Alkalume-22, has shown promise in the laboratory tests as a decontaminant for both present and future reactors using either single-pass or recirculation procedures. It is possible that Alkalume-22 could be used as a single-step decontaminant for future reactor systems. Tests with this single-step procedure will be made in dynamic systems.

Present Reactor Decontamination. Laboratory testing shows that an inhibited sulfuric-oxalic acid mixture efficiently decontaminates aluminum and stainless steel reactor components at solution temperatures of either 70 or 45 C. The time required for efficient decontamination is longer at 45 C than at 70 C. Perforated aluminum dummy fuel pieces were cleaned in 30 minutes with decontamination factors (DF) of 30 to 115. Dummies cleaned for 60 to 90 minutes show DF's of 75 to 185. Aluminum process tubes in 70 C solution for 30 minutes showed a DF of 6 to 20; however, at 45 C, the solution was ineffective. The DF's of aluminum tubes are improved by longer exposure times. After 60 to 90 minutes, the DF's were 44 to 70 at 70 C and 4 to 85 at 45 C.

Stainless steel tubing connectors (pigtails) show DF's of 47 to 619 in 30 minutes at 70 C, and DF's of only 1 to 4 in 30 minutes at 45 C. After 60 to 90 minutes, these stainless steel connectors were decontaminated by factors of 11 to 131 at 70 C and by factors of 8 to 300 at 45 C.

The maximum corrosion of aluminum and carbon steel in these inhibited sulfuric-oxalic acid tests was $<$ 0.1 mil. Corrosion of stainless steel, Inconel-X, and Zircaloy-2 was very low (0.002 to 0.02 mil).

At 45 C the proprietary mixture, Wyandotte 5061 in a concentration of 6 oz/gal is a less efficient decontaminant for aluminum and stainless steel than the sulfuric-oxalic mixture. Aluminum process tube sections were decontaminated by a factor of only 1.3 after 30 minutes and by a factor of 3 after 90 minutes. The decontamination factors for stainless steel connectors were in the range of 1.3 to 2.1 for 30-minute treatments and 2.0 to 15.4 for 60 to 90-minute treatments. The proprietary mixture, Experimental Weedac 3909-2, is too corrosive to be considered for use at 75 C.

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Production Test - Decontamination of Hanford Reactors. The first in-reactor decontamination using inhibited sulfuric-oxalic acids, Sulfam-3 (Turco 4306-D) and Sulfam-1 (Turco 4306-B), was performed in three fuel channels at C Reactor by members of Research and Engineering Operation, IPD. The solution temperatures were 35 C. Reductions in activity by a factor of about four for the sulfuric-oxalic and the Sulfam-3 mixtures, with somewhat less reduction with the Sulfam-1 were achieved. Corrosion monitoring samples were inserted and will remain in the reactor for one operating period subsequent to this decontamination.

Structural Materials Development

NPR Process Tubes. The ultrasonic test for small transverse tears in NPR process tubes has been successfully adapted to the mechanized equipment at White Bluffs. Good discrimination between one and three-mil notches and between three and five-mil notches was obtained when the tube was scanned at 44 rpm and 11½ in/min translation. All NPR tubes will be tested by this method.

Standards were prepared and are currently being evaluated on a production basis at the Harvey Aluminum plant. It is anticipated that this test will be used to scan the remaining tubes at the vendor's plant.

Examination of KER-1 Zircaloy-2 Tube. A number of tests have been conducted and reported periodically on the Zircaloy-2 process tube removed in April 1960 from the KER-1 in-reactor loop. The following summarizes the results to date.

The Zircaloy-2 pressure tube was fabricated during 1956-57 by Bridgeport Brass Company and Tube Reducing Corp. The tube was hot extruded and cold reduced 65% in area by a single pass on a tube reducer. The tube was bright pickled and white-light borescoped prior to installation in the reactor. The numbered end of the tube was cropped during preparation for installation in the reactor, and the identity of the tube was lost. This precludes any further investigation into the process history of this tube; however, histories of tubes made by the same fabricators at approximately the same time are available.

The tube was installed in the in-pile KER-1 loop and operated for 26 months. During this time the loop operated a total of 380 days at temperatures ranging from 200 C to 270 C. In-reactor borescoping of the tube revealed what appeared to be defects in the tube wall and the tube was removed. After removal, the general appearance of the tube was good. The lower portion of the inner surface was covered with a reddish film. Gouges and pits reported from in-reactor borescoping were essentially limited to damage of this film rather than the base metal. Samples were cut from five locations along the tube. Metallographic examination revealed a generally heavily cold worked structure with a ring of large grains at the outer surface. Partial recrystallization was evident throughout the length of the tube. Examination of the microstructure of companion tubes produced by the same fabricators revealed a similar cold worked structure with large grains at the outer surface.

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Flattening tests performed on rings cut from several locations along the tube revealed circumferential ductility. The rings were flattened approximately one inch at both room temperature and 300 C without failure. This is in direct contrast to the rings from the Zircaloy-2 tube removed from KER-2 which broke after a 0.2" deflection at room temperature. The room temperature burst strength of the tube averaged 16,750 psi for samples taken at the one-quarter and three-quarter points. The fractures were semi-ductile. A sample from the center of the tube (high neutron flux area) burst at 5000 psi. The fracture was brittle in appearance, and detailed examination revealed that the most probable cause of this low burst pressure was the presence of cracks on the inner surface of the tube wall. These cracks were introduced during the cutting operations. Two additional burst tests were run on samples of the tube from near this location. The average burst pressure was 16,250 psi, and the fractures were semi-ductile.

In examining the cracks, an area covered by a heavy oxide film was located on the inner surface. The cracks propagated through this oxide film. Under this oxide, the parent metal contained 1000 ppm or greater of hydrogen at the inner surface, diminishing to less than 50 ppm at the outer surface. Examination of the remainder of the tube revealed no hydrogen pickup. The operating history of the tube reveals no cause that would account for the excessive corrosion and hydrogen pickup in this localized area. A fuel element rupture did occur near this vicinity, but it was a minor split-type rupture. Photographs of the ruptured element showed no high temperature indications. A metallurgical sample from near the heavy oxide film had a beta transformed structure, and it was first thought that the tube was overheated during fabrication or operation. Further investigation revealed that the overheating was caused during sample preparation (cutting operation) and was not connected with reactor service or tube fabrication.

Detailed examination of the grain structure under the oxide was not possible because of the heavy hydride concentration. No evidence of local contamination or any significant variation in chemical composition has been found which would explain the high corrosion rate.

Wet chemical analysis of the parent metal under the oxide revealed the following concentrations of alloying elements: nickel, 0.07%; iron, 0.30%; and chromium, 0.17%. Spectrochemical analysis showed 1% tin. Copper was determined by wet chemical methods and spectrochemically and gave concentrations of 10 ppm and 100 ppm, respectively. The spectrochemical analysis of the oxide showed the presence of zinc at about 500 ppm concentration. It has not been determined whether the zinc was present in the oxide or whether the sample became contaminated during handling or during oxide removal.

Corrosion tests are now being conducted on a sample cut from the high corrosion region. The sample was cleaned of all oxide, etched, and exposed to 300 C, pH 10 water. Comparative samples from sections cut from the unirradiated end of the KER-1 tube and 30-mil Zircaloy strip are also included in the test.

After 25 days of exposure, the irradiated sample is corroding at an accelerated rate with evidence of a transition in the corrosion curve at approximately 15 days. The time to transition for normal Zircaloy-2 exposed to 300 C, pH 10 water is at least two years. The irradiated sample appears to be corroding at a rate of two mils per year as compared to 0.10 mil for the unirradiated KER section and 0.05 mil for the 30-mil strip comparison pieces.

A qualitative gamma scan of the irradiated test piece has not revealed the presence of radioactive fission products which would have been produced by uranium contamination.

Nonmetallic Materials Development

Graphite Burnout Monitoring at KE Reactor. The graphite monitoring samples, which were in Channel 3066 at KE Reactor from December 1960 to March 1961, showed burnout rates below the established limit of 2%/1000 operating days. These are the first samples which have been exposed to the He-N_2 atmosphere authorized by Production Test IP-358-AC.

Van Stone Seal Inserts. The rear Van Stone flanges contain a silicone rubber insert seal. Significant costs savings could be realized if the seals were fabricated from nitrile rubber. However, recent experience with nitrile inserts shows that they stick in the process tubes. A recent investigation suggests that the compressive stress on the nitrile inserts may be as high as 7000 psi, as compared with 500 psi for the silicone inserts. This difference is due to the lower compressibility of the nitrile rubber. The high compressive load, coupled with a small amount of swelling from water adsorption, probably caused the nitrile rubber to be stressed beyond its elastic limit. Since the deformation was not completely recovered, the nitrile inserts stuck in the process tubes.

The compressive load could be reduced by redesigning the insert. Studies are continuing on the selection of a nitrile rubber insert which would allow the material to seal under a relatively light load of 500 to 1000 psi.

Graphite Compatibility with Helium Containing 0.1 mm of H_2O Vapor. Gas mixtures of helium with 3% CO, 3% H_2, and 0.1 mm H_2O have been passed over small cylinders of NPR core graphite at 850 C. In each case the sample was found to gain weight. This indicates that part of the CO-H_2 mixture is adsorbing on the surface to the extent that the water-graphite reaction is inhibited. Previous tests with 3% CO and no H_2 did not show such strong inhibition. The possibility of using H_2 alone is being examined. However, even if an effective inhibitor is found, there is still the problem of maintaining a suitable inhibitor-water mixture throughout the moderator stack. It is possible that any CO or H_2 added to the gas would adsorb on the first graphite available leaving the water in the stream to react with the graphite. In other tests CO adsorption has been shown to occur rapidly even at 25 C.

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NPR Graphite Irradiations. Post-irradiation measurements of the NPR reflector graphite which was irradiated in the GEH-13-5 capsule are being made. The samples were irradiated at 700 C to a maximum exposure of approximately 1.4×10^{21} nvt (E > 0.18 Mev). The six samples located in the two high flux positions of the capsule showed erosion of the polished edges used for length measurements. An investigation of the cause is under way. Length measurements on these six samples will be based on measurements between holes drilled in the samples which were provided as a back-up in the event the edges were damaged.

The GEH-13-7 capsule is being installed in the ETR during the current shutdown. The capsule contains 24 quarter-round samples of NPR reflector graphite and CSF graphite. The temperatures will be monitored during the irradiation.

Thermal Hydraulic Studies

Boiling Burnout Conditions for Eccentric Annuli. The program to investigate the effects on heat transfer conditions of the non-coaxial positioning of fuel elements within a K Reactor process tube was continued. During the past month emphasis was placed on obtaining boiling burnout data with a concentric case for comparison with data previously obtained at 50, 75, and 90% eccentricities. (Percent eccentricity is the fraction of the normal annulus thickness that the fuel element is displaced from a coaxial position toward the wall of the process tube.)

The test section used was a 24-inch long electrically heated rod, 1.457 inches in diameter, placed within a 1.681-inch ID tube. All of the heat generated within the rod was transferred to water flowing through the annulus. During two different attempts to obtain boiling burnout data for various water temperatures at a flow of 23 gpm and a pressure of 53 psig, the test section failed by melting. The conditions at burnout were as follows:

Run No.	Flow Rate (lb/hr-sq ft)	Water Temperature (°F below boiling pt)	Heat Flux (B/hr-sq ft)
77	2,970,000	6	1,890,000
78	3,000,000	23	1,810,000

In both of these runs boiling burnout took place at a location farther upstream than expected and did not result in high readings of the thermocouples placed in the heater rod very near the downstream end. Since reliance is placed on these thermocouples for the detection of burnout, the test section melted before the heat generation could be reduced. Discoloration patterns on the heated surface indicated that one of the pins supporting the heater rod in the flow tube may have changed the flow conditions sufficiently to influence the boiling burnout point. For that reason these boiling burnout heat fluxes may be lower than would be obtained for an idealistic case of annular flow but are probably quite applicable to those Hanford fuel elements which have "bumpers" or other devices for support within the process tubes.

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Visual Boiling Studies. Experimental equipment was set up in the heat transfer laboratory to define the degree of subcooled boiling which is possible and probable under normal operating conditions in Hanford fuel channels. The test section consisted of a Hastelloy tube (1.300-inch OD) placed inside of a Pyrex glass pipe (1.500-inch ID). All of the heat generated electrically in the Hastelloy tube was transferred to water flowing in the 0.100-inch annulus. This approximates the conditions in the annulus formed by I&E fuel elements in a K Reactor process tube.

Initial operation of the equipment covered the following range of conditions: (1) with fluid mass velocity similar to that in the fringe tubes at K Reactor, heat fluxes were increased up to 624,000 B/hr-sq ft with 100 F water (150 F below the boiling temperature) and to 460,000 B/hr-sq ft with 220 F water (30 F below the boiling temperature); (2) with fluid mass velocity similar to that in the central zone tubes at K Reactor, heat fluxes were increased up to 805,000 B/hr-sq ft with 100 F water (170 F below the boiling temperature) and to 720,000 B/hr-sq ft with 200 F water (40 F below the boiling temperature). (A heat flux of 800,000 B/hr-sq ft corresponds to a specific power of about 125 kw/ft in a K Reactor tube.) These conditions fairly well represent the capability limits of the present equipment without undue hazard to the personnel who must stand quite close to the test section to see the boiling conditions.

The objectives of this study are to define the conditions under which subcooled boiling is initiated and to determine the resulting void volume in the water coolant. From the results to date, observations indicate that the inception of local boiling can be predicted fairly well with the Jens and Lottes correlation (ANL-4627) at the low flow rate conditions. However, at the high flow rate condition, subcooled boiling was not detected with the unaided eye under any of the conditions investigated. High speed motion pictures were taken to further verify these observations.

Heat Transfer Experiments Pertaining to NPR. The studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel elements were continued. Experimental data were obtained in the heat transfer laboratory to determine if a boiling length effect exists for previously obtained data applicable to the center hole of the fuel element.

The test section installed for this investigation consisted of a 60-inch long tube, 0.440 inch ID, with flow through the inside. The tube was heated by electrical resistance heating and boiling burnout conditions were detected by noting the temperature excursions as measured by thermocouples attached to the outside wall of the test section.

Five boiling burnout points were recorded at 1500 psig for different mass flow rates between 2,000,000 and 7,000,000 lb/hr-sq ft. The heat fluxes for these points varied between 580,000 and 1,210,000 B/hr-sq ft. A preliminary comparison of these data with data obtained previously with a test section one-half as long indicates that for the same outlet enthalpy, the burnout heat flux is slightly lower for the longer test section.

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Calculated Time Before Melting of Uncooled NPR Fuel Elements. A computer program was written to aid in calculating the temperatures of fuel elements discharged from the NPR but cooled only by the natural circulation of air. This program is an extension of the work reported in HW-67747, Rev. 1, which reports times before melting of discharged Hanford fuel elements which fail to enter the water storage basin.

The results of these calculations are useful in evaluating hazards and establishing procedures in handling such fuel elements.

Shielding Studies

Attenuation Studies. The program for calculating neutron attenuation for use on design of shields is complete. The theory uses multigroup equations which are solved for each spatial region in the shield, and in this program the graphite reflector is treated as part of the shield so that the inner boundary conditions for the whole shield assembly will be applied at the core-reflector interface. The program first determines the source distribution of neutrons in the shield from the uncollided fast neutron flux originating in the core. This source provides the source term for the highest intermediate energy group.

Using boundary conditions at the interface between the core and the reflector in the top shield of the 105 DR Reactor, neutron fluxes were calculated through the fringe poison, graphite reflector, iron thermal shield, and in this case, through as-cured ordinary concrete. The total thickness of the shield was about 220 cm. The calculation gave the correct shape of the thermal neutron fluxes in the ordinary concrete and, compared with the experimentally determined thermal fluxes within a factor of two through 220 cm and a thermal neutron reduction of ten cycles of ten. The program also computes the neutron dose rate at any point in the shield. An estimate was made, using gold and sulfur foil, of the dose rate at 220 cm thickness. The dose rate obtained using foils agreed within a factor of two with that obtained with the computer program.

The gamma program, which will be used with the neutron program, is in the debugging stage.

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

PRTR Project Management

PRTR Construction. Construction of the Maintenance and Mockup Facility (including the PRTR Rupture Loop Annex and Critical Facility Buildings) is about 85% complete versus 93% scheduled. The M & M Building portion is about 80% complete versus 91% scheduled. The vermiculite roof slab on the M & M Building was poured. The structural steel work was completed and installation of the exterior siding is about 10% complete. Piping, electrical, and mechanical equipment installation is proceeding at the -14 foot basement level. The inflatable seals for the PRTR exhaust stack filters were installed and passed a soap bubble leak test. The second frame was loaded with activated charcoal filters, installed, and successfully tested.

Site paving and landscaping is estimated to be 40% complete. The initial phase, consisting of roads and paving, is scheduled for completion by May 7. All roadways, except those adjacent to the Critical and M & M Facilities, have been primed, and paving is scheduled to start the first week of May. Landscaping is scheduled to be completed by June 21. Earthwork has started and piping for sprinklers at PFPP is installed. Maintenance of the grounds under this contract will continue until July 21, 1961.

The load-out trailer and cask unit were tested at the Radiometallurgy Building. Improvements in the supporting equipment is required to permit unloading the cask and examination of elements.

The vendor of the Fuel Element Examination Facility manipulator has received delivery of the new 400 series spline shafts and has started reassembly for final testing. Shipment is scheduled for the week of May 8, if final testing is successful.

Procurement and installation of stainless steel tankage to permit drainage and storage of PRTR system D_2O has been investigated. Three available tanks of adequate total capacity ($\sim$760 gal. each) were located. Cost estimates for decontaminating, modifying, and installing these tanks for PRTR use are being prepared. It appears that the most practical location for these tanks is in the service building basement, adjacent to the containment vessel. This area is currently being used to store D_2O in barrels.

Plutonium Recycle Critical Facility (CAH-842). A project proposal revision extending the scheduled completion date to August 15, 1961, has been approved by the Atomic Energy Commission.

The construction contractor is about 93% completed versus 100% scheduled. It is estimated that he will be finished about May 15. Remaining work includes installing the building siding and the ventilation equipment.

The Fuel Transfer Lock has been installed, and preliminary tests have been completed. These tests disclosed deficiencies in the operating mechanisms, which have been called to the lock vendor's attention for correction. The lock installation involved considerable piping work not previously anticipated. This resulted because the vendor had not completed the specified piping prior to shipment and had not provided drawings which adequately defined the remaining work. The necessary piping intertie drawings therefore had to be prepared here in order to complete the work. The lock vendor also had failed to complete the painting of the lock. This work was completed during installation of the lock and will be at the vendor's expense.

The equipment installation package has been sent to the CPFF contractor to the AEC for an estimate. If a satisfactory estimate is received, the CPFF contractor will be requested to install the equipment after the present construction contractor is completed.

The moderator storage tank and the reactor and thimble coolant pumps have been received. The low bidder on the Instrument Package, General Electric, San Jose, is having difficulty in obtaining some of the specified components in time to meet the scheduled delivery in June 1961. Orders have been placed for the flux chambers for the reactor. The bid price was $5,270 versus an estimated $5,000.

Fuel Element Rupture Test Facility (Project CAH-867). Minor revisions to existing drawings were performed during the month. These included modifications to "B" Cell piping to allow more complete and rapid drainage of RLHX-1, and changing critical control valve air line materials from plastic to copper. Assistance has been given to IPD personnel who are scoping facilities for experimental work related to detection of fuel rupture and fission product release from rupturing fuel elements. These facilities would consist of various types of detection chambers and associated electronic equipment and are to be located in the underground annex building.

Construction of the underground annex is 97% complete versus 100% scheduled. Construction of the water filtration plant and holdup tank was scheduled to begin March 1, 1961. Design drawings and specifications have been ready for bid release since January, but no action has been taken toward releasing this material by the AEC for contractor bidding. No action has been taken to initiate the "B" Cell and underground annex equipment installation work pending resolution of this water plant-holdup tank delay.

All bids were rejected on the electrical switchgear and motor control center which were received early this month. Specifications were revised to reflect revisions in the control circuitry required by changes in

drive motor sizes and in the primary pump control circuits. Rebidding these items will not delay project progress beyond that delay already caused by the water plant. The vendor who is fabricating the cooler (RLHX-2) is radiographing the high pressure nozzle-to-bonnet and bonnet-to-tube sheet welds. As reported last month, the vendor believed that radiography of these welds was not feasible; discussions with qualified HAPO personnel indicated that such radiography should be routine.

Design and Component Testing

PR-10 - Primary Loop Mockup. The spare primary pump operated 757 hours during the month for a total of 5947 hours. The seal leakage varied from a high of five gph down to near zero at one time. Some seal damage occurred at the low leakage period as shown by two short duration (5-10 min) increases of seal temperature, one from 120 F to 165 F and the last from 120 F to 135 F. The seal temperature returned to normal following both excursions and the leakage has increased to about 0.01 gph. Better balancing of the pump will be attempted following the present outage to install the new insulated motor end bell. Present maximum vibration is 0.9 mil.

The prototype pump with the self-adjusting seal assembly operated 777 hours during the month for a total of 7514 hours. The present seal leakage is 0.7 gph. The seal test stand operated an additional 65 hours and 22 starts during the month for a total of 875 hours and 117 starts with the two prototype mechanical seal assemblies.

The Aldrich injection pump has not operated for test purposes this month. The Disogrin packing rings are on hand, the packing inserts have been fabricated, and testing of this packing will proceed when craft labor and engineering time can be coordinated for installation.

Flexure Loop. The three-clamp Grayloc transition union (SS to Zr-2) has completed 796 hours and 132 cycles operation at 2000-2100 psig and 200-600 F with no apparent leakage. Usage of the flexure loop and burst test loop has at times been delayed because of insufficient information as to the facilities construction. To eliminate this problem in the future, flow diagrams of the piping, instrumentation, and electrical systems for both facilities have been made.

PRTR Calandria Access Plugs. A short testing program has been established to determine which anodize coat will best prevent galling between the access plug and calandria top plate.

PRTR Special Tools. Use of the Splash Guard (a stand pipe which screws into the top of the nozzle to prevent spillage of heavy water during discharge of a fuel element) has proved to be unsatisfactory. Design of a new splash guard has been completed, and fabrication is 20% complete.

Shroud Tube Replacement. The detail design of the mockup section is complete and fabrication has been started. Final design of the support section is contingent upon whether this mockup is placed in the west test

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pit of the 314 Building or the Maintenance and Mockup wing of the 309 Building. The latter site is more suitable for the mockup.

Two prototype bellows collars were shrunk fit onto a piece of shroud tubing. The collars were heated to 200 C and then slipped over the tube. The collars had 0.010 interference fits. One of the collars "grabbed" before it was all the way on the tube. This was anticipated because of the thin wall of the aluminum shroud tube dissipating the heat so rapidly. However, by either raising the temperature and/or cooling the tube with dry ice, it is felt that this can be eliminated.

Critical Facility Mockup. The weir fabrication is now 90% complete. The major component of the weir remaining to be completed is the synchro - readout system. The motor for the weir has been sent back to the Exactel Instrument Company to be assembled with the synchro as a package unit.

The weir seal was tested and this seal design is well within the design limits. A leak of 0.1 gpm could be tolerated, while with the mockup the leak rate was less than 0.1 of a gallon per hour.

All parts for the neutron source positioner have been received. It is expected to be completed during the first week in May.

The support rails for the source positioner are being fabricated by Minor Construction. The rails are being made of stainless steel Unistrut rather than channel iron for ease of fabrication.

The swivel joints have been received for the thimble. Upon examination of the joints, it was observed that they were too stiff to be used with flexible tubing. After discussing this with the factory representative, the joints were disassembled and the seals dressed down, resulting in better action.

A review of control rod and safety rod design is under way to insure reliability of materials and satisfactory operation of these components at all times. Re-heat treating of the 17-4 PH drive screws and ball nuts will be investigated as well as additional structural reinforcement of the aluminum shell or housing tube to decrease the potential for rod deactivation due to physical damage from crane loading and unloading activities. Most of the parts for the control and safety rods have been ordered. The motors for the control rods have been sent to the Exactel Instrument Company for assembly with the synchro units.

Specifications for major components of a highly sensitive temperature measuring system were issued for bid. This system will be evaluated for possible use in the critical facility for measuring and recording moderator temperatures during reactor experiments. The system will utilize platinum resistance temperature detectors in a balanced wheatstone bridge circuit and an amplifier and recorder for readout. Zero suppression will be provided so that accurate differential temperatures may be measured.

Specifications submitted for components of Critical Facility instrumentation were reviewed. Problem areas have developed in obtaining some specified special modifications of the equipment being purchased. These special features include the addition of level trip circuits for intermediate flux level channels, a special audible output for the scaler, a 3-15 second range of adjustment of period trip for intermediate channels, and special calibration of intermediate channel recorder and meters. These problems were discussed with representatives of the manufacturer furnishing the system. The intermediate flux channel problem will be resolved by obtaining instruments which are essentially duplicates of those used on the PRTR and adding solid state level trip circuits. The scaler audible output was found to be available in a unit exactly equivalent to the one originally specified but having a different model number. Some delay in delivery may result from the above alterations.

Bids were received for the Critical Facility control rod magnet power supply. None conformed to the specified range of adjustment of output voltage. This is the second time bids have been rejected for this reason. Consideration will be given to designing and building this power supply on site.

Rupture Loop Mockup. Technical Shops has completed machine work on the nozzle-to-process tube testing apparatus. This will be used for thermal cycling and gasket leak tests.

The inlet butterfly shutoff valve is being tested at the vendor's plant and should be delivered by May 8. Part of the delay has been due to poor quality of stainless steel castings. The vendor has had to re-order castings twice.

The outlet connector fitting, a Grayloc joint, will be delivered in early May. Tests at the vendor's plant show that thermal stresses will be decreased for the material combination of 300 series stainless steel studs and hubs, and 410 stainless steel clamps. For a slight increase in price, Gray Tool Company is furnishing 316 SST studs that have rolled threads.

The corrosion test coupons from the tube assembly parts did not pass the surface color requirements after autoclaving at Chase Brass. However, the samples were retested locally and 18 of the 20 coupons were acceptable. The tube drawing process is now completed on both inlet and main (3.6 inch OD, 0.342 inch wall) tube sections. A two-step process was used on the main tube after a one-step drawing process proved unworkable. The Zr-2 tube assembly sections are now being welded together, and at least four of the original three to five tubes ordered will be built.

Design Analysis

PRTR Power Tests. Detailed procedures for Power Tests are now being completed in addition to the final Operating Standards and Procedures necessary before power operation begins. All test descriptions have been completed and approved for the 24 power tests currently planned. The

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power test document has been published as HW-61900 C, and transmitted to the AEC as requested.

PRTR Safeguards Analysis. Supplement 3 to the PRTR Final Safeguards Analysis was published and transmitted to the AEC for approval. This supplement reports the results of a study of effluent activity limits for the PRTR.

Refined effluent activity limits have been determined for the PRTR. For both the aqueous and gaseous effluents, two limits on the concentration of radionuclides in the effluent stream are established. The upper limit is a concentration which could potentially result in undesirable contamination of the environs unless the release from the PRTR containment vessel is stopped in a few minutes, and at this limit automatic reactor scram and containment will be executed. The lower limit is a concentration which could result in water or air contamination approaching the MPC in the environs of the PRTR, and at this limit the reactor will be shut down, following normal procedures.

The effluent activity concentrations for these trips are:

Aqueous Effluent Activity

Containment Trip	5 $\mu c/cc$
Alarm Trip	5×10^{-3} $\mu c/cc$

Exhaust Air Activity

Containment Trip	5×10^{-2} $\mu c/cc$
Alarm Trip	5×10^{-5} $\mu c/cc$

Recent studies have resulted in recommendations for increased back-up air supply for the PRTR. An analysis of the instrument air system shows that several components require a continuous air supply and that an adequate back-up air supply is required. Air is required for Light Water Injection System components to provide information that will assist in determining the location of primary system leaks and to regulate valves for the most effective use of the system. Air is required for primary, secondary, and helium system valves and instruments to provide pressure and level information and pressure control during natural convection cooling and steam cooling. A back-up air supply should also be provided for the breathing air stations.

Critical Facility. The comment issue of the Critical Facility Final Safeguards Analysis document was completed.

Preliminary testing of a prototype thermostat for the Critical Facility Poison Injection System indicates that the response time of the thermostat is slower than was expected. Thermal response data obtained to date is not adequate to determine the exact time required for the thermostat to trip.

PRP Reactor Physics Calculations. A replacement version of the operational FLUX-WEIGHT Code is being assembled and debugged. Increased specialization of calculational methods using perturbation theory require this new version to be more aptly titled "SWAP" (Statistical Weight and Perturbation) Code.

Continuing effort is being made to establish the reactivity effects of loss of H_2O-degraded coolant with conditions of varying moderator quality. Considerable information has been developed with regard to relative effects at a given position. However, an inability to date to assess properly the effect of neutron streaming and perturbed resonance absorption has delayed an acceptance of the whole-reactor coolant loss solutions.

PRTR Operations

Reactor Testing and Activation. The bulk of the testing work has been completed on Design Tests, with the exception of the following which are to be performed in conjunction with Power Tests:

DT 23	D_2O Recovery System
DT 58	Rupture Monitor System
DT 35	Unit Motion
DT 3-D	Primary System, Hot and Pressurized D_2O
DT 25	Fuel Element Loadout
DT 56	Process Cell Waste Collection System.

The PRTR was loaded with 55 UO_2 and 30 Pu-Al fuel elements and the following remaining Critical Tests were completed on April 26:

CT 17	Kinetics Measurement, Three-Zone Loading
CT 21	Cell Flux
CT 14C	Final Shim Rod Calibrations.

A shim-free critical moderator of 62.5" was obtained This is about one inch higher than previously obtained for this loading; however, the absolute calibration of the moderator level may be in error by nearly this much at the present.

After completion of the above Critical Tests the reactor was shut down for discharge of all fuel elements to permit the cleanup of the UO_2 fuel elements which had collected foreign matter from the primary coolant flow. Individual screens were then provided for the nozzles of each tube and the primary coolant was circulated to clean out any additional material which had collected.

Two primary pumps were overhauled during the month. On Pump No. 2, which had excessive vibration and a loose seal thermocouple, modifications included seal and thermocouple replacement, addition of thrust springs, and installation of an insulated end bell on the motor. Pump vibration at high pressure was reduced to less than one mil by these changes, and balancing was unnecessary, although vibration is higher when the pump is run with the primary system unpressurized. Indication of high seal

leakage flow on Primary Pump No. 3 caused automatic closing of the bleed valve, resulting in overpressurizing the secondary shaft seal. During the seal replacement, thrust springs were added, and an insulated motor end bell was installed. Automatic actuation of the bleed valves has been disconnected to prevent recurrence of this action.

The helium system was modified to simplify condensate collection and oil removal as a result of operating experience. Automatic remote condensate handling piping and valving was removed and a new condensate collection system installed. Condensate is now collected manually in "C" Cell. This change also made possible removal of some oil absorber units which have created operating problems because of leaching of the absorber ore by heavy water which is sometimes carried into the system. Considerable effort has been required in cleaning valves throughout the helium system in order to achieve satisfactory performance.

The reactor dry gas system has been placed in operation. Air contamination has been the chief obstacle to achieving satisfactory system performance. Considerable moisture has been removed from the system, but moisture content is still higher than desired for sustained operation.

Modification of eighteen shim rods was completed and the rods installed. Modification of the six spare assemblies continues.

All flow monitors were pneumatically and electrically calibrated during the month. Two minor modifications were made to the system during calibration efforts. The pointer spring and the pivot were changed to reduce the play in the mechanical connections. It appears flow trips can be set to ± 2 percent and that data readout accuracy of ± 2 percent can be obtained. A high frequency preventative maintenance program is being established to insure maintenance of the 2 percent accuracies noted.

Safety and containment circuits and equipment were thoroughly checked out. Both systems are now in normal operating condition. Several pressure switches in the safety system were changed to either improve the reset range or improve the reproducibility of trip settings.

The light water injection system instrumentation was connected and tested. Blanks were installed in the water lines and the valves blocked to protect against inadvertent mixing of light and heavy water during testing. The system will remain partially bypassed until operation above 1 MW begins.

Debugging of the rupture monitor has begun. An equipment manufacturer's representative will be on plant in May to assist in the initial operation of this system.

All secondary system instruments and controls have been calibrated and tested. Final testing of the system will be performed when steam generation in the heat exchanger begins.

Plans and Procedures. At month's end thirteen Operating Standards and ten Operating Procedures remained to be approved by the PRTR Startup Council.

Plutonium Fuels Development

PRTR Fuel Fabrication. A number of different approaches to the problem of blending UO_2-PuO_2 have been tried. Low temperature calcined PuO_2 has been heated at 1000 C and blended with UO_2. Analytical results from a number of samples taken from the blender showed a deviation of more than 10 percent from the mean. To check the operating characteristics of the P-K blender, several 20 kg blends were made using only UO_2. The sieve analysis from these runs was used as a measure of blending efficiency. When the percentage of the -200 mesh fraction was analyzed, it was found to vary plus or minus 15 percent of its mean value. Although this variation was not clearly systematic, the percentage of fines showed a tendency to be higher in the samples taken from the middle of the blender as compared to the top and the bottom. This suggested that the particles were not tumbling in the blender as they should but were sliding. Experience in pouring a mixture of particles has shown this same tendency. The blender was loaded more heavily in an attempt to increase its tumbling action. Unfortunately, the excessive weight of the load burned out the motor which is now being replaced by a larger one.

Two methods were developed to control the distribution of plutonium oxide along the length of a tube loaded with mechanically mixed UO_2-PuO_2. One method consisted of preparing and mixing "one-tube batches" of oxides with a high percentage of fines (-325 mesh particles) in the batch. The other method consisted of incrementally loading the tube so that each small increment contains the required amount of plutonium. Since both of the methods were developed with UO_2 fines, determination of variations with mixed UO_2-PuO_2 fines was investigated.

Three elements were loaded with the addition of PuO_2 to the UO_2 fines; two by the high percentage of fines method and the other by the incremental loading method. One high fine element and the incrementally loaded element were destructively sampled, as loaded, for longitudinal Pu analysis. The other high fine element was swage compacted and will be sampled for longitudinal and radial distribution of plutonium. No analytical results have been received on these samples.

The UO_2-PuO_2 elements must be closed by welding prior to swaging for contamination control, therefore controlling the finished length of the element is a critical problem. Since experience to date has shown variations up to 1-3/8 inch, methods to control length more accurately are required. Three methods are being evaluated to achieve accurate length control. One method involves closely controlling the volume and weight of both the tube and core material before swaging. The other two methods involve final finishing operations after swaging; one is precision draw-sizing which reduces the diameter and correspondingly increases the length of the tube (0.001-inch change in diameter causes approximately 0.4-inch change in length). The other method involves swagable end sections, which could be reduced in diameter for accurate finishing. The latter methods involve swaging to a minimum length followed by a sizing operation to

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achieve desired length. The objective of these methods is to achieve length control within 1/16-inch.

Further development of swagable end caps was continued. Design changes were made in order to eliminate the internal notch that was present after welding and swaging. Welding conditions were found to be critical. Complete penetration is essential, but minimum heat input on the final closure is also required in order to keep the entrapped gas from overheating and blowing out through the weld. Welding conditions to meet these requirements have been established. Corrosion tests on sections of swaged tubing and end caps are in progress. Five two-foot UO_2-bearing elements and one full length UO_2-PuO_2-bearing element with swagable end caps have been swage compacted successfully.

Density measurements have been made, using a gamma absorbtometer, along the length of seven swaged UO_2-PuO_2 rods. The measurements were made at one inch intervals, for six inches, at both ends of each rod and at six-inch intervals along the remainder of the rod. Chart tracings, when compared to three density standards, indicate densities of 87 percent to 90 percent along the length of the rod with the exception of the preswaged end regions which are approximately 80 percent to 85 percent. Additional standards having a greater range of densities would be required for more accurate determinations. The rods have been sectioned to provide irradiation, density, chemical, and autoradiographic samples.

Several loading techniques are being tried for vibrationally packed rods. The most promising method to date is one in which the charge is loaded into the tube, shaken, tamped, and shaken again without exposing the inside of the loading hood to any dusting. This design has the advantages of keeping the contamination of the tube end to a minimum while maintaining the inside of the hood reasonably clean. With high exposure oxide the latter consideration may be of overriding importance.

Development of Zircaloy-clad plutonium-bearing extended surface fuel elements continued using oxide fuel material. Ceramic grade UO_2 was used as a stand-in for PuO_2. Two zirconium-UO_2-zirconium sandwiches were roll-clad. Bonding of the zirconium-zirconium picture frame around the UO_2 core was obtained along with bonding of the zirconium through the core. Radiographs showed the fuel to be distributed in a uniform reticular structure similar to the structure previously observed on the metallic plutonium-zirconium sandwiches.

Capsules of UO_2-PuO_2 containing defect sections of various PuO_2 concentrations have been tested on a gamma spectrometer by the Nucleonics Instruments Operation. Each capsule was loaded with a blend of UO_2-PuO_2 (0.446 w/o) with the exception of a section approximately 0.2-inch in length in each capsule, which contained a higher PuO_2 concentration. These sections contained 1 w/o, 2 w/o, 3 w/o, and 10 w/o PuO_2. Gamma spectrometer scans detected all but the 1 w/o defect. For certain capsules, however, counting rates varied if the sample was rotated 180°. Gamma autoradiographs of the capsules obtained by the Nucleonics group showed that the

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defect distribution in certain capsules did not appear uniform across the diameter. In the autoradiographic technique that was used, the capsules were placed on the flat film. Additional autoradiographs have been requested, in which the film will be wrapped around each capsule.

The detection of PuO_2 content on the order of magnitude currently desired (nominal 0.5 w/o ± 5%) is not obtainable at the present time. This is due in part to the inherent "noise level" of the equipment being used in combination with statistical counting variations in the gamma spectrometer examination. Refining the present techniques, or the possibility of a new scanning technique to detect the dilute PuO_2 concentrations is being investigated.

UO_2 and PuO_2 powders are being studied to evaluate the gas evolution which might be expected from swaged or vibratory compacted fuel elements. Ceramic grade and fused UO_2 have been analyzed in the as-received, vacuum outgassed (48 hours, 900 C) and "stored" conditions. The outgassed samples were brought up to a helium atmosphere and stored in helium and/or air for various times. The total gas from the fused samples decreased from 0.035 cc/g to 0.008 cc/g on outgassing. After storage the gas content increased to a maximum of 0.02 cc/g. The ceramic grade went from 2.0 cc/g to 0.048 cc/g on outgassing. The outgassing treatment most probably reduced the surface activity of this powder since it increased to only 0.11 cc/g after one week in helium followed by two weeks in air. The experiments are currently being repeated on PuO_2 powders.

Attempts to extrude zirconium tubes directly from loose particles of scrap have been only moderately successful. Niblets of Zircaloy-2 (about 1/4-inch cubes) were poured into a copper can and the can was welded by the electron beam process. The canned Zircaloy billet was preheated two hours at 800 C and extruded over a 5/8-diameter mandrel in a container preheated to 600 C. The exterior of the resulting extrusion was very good, but the mandrel failed in tension in two places. The resultant tube was good for only about 18 inches of a planned 60-inch length. A section of the good part of the tube has been sent to the testing group for an autoclave corrosion test. Lubrication is the present problem, and a further attempt to extrude a tube resulted in a breakdown of equipment. While the equipment is being repaired, more investigation of lubricants will be carried out.

Fuel Evaluation. The two capsules (GEH-14-27, 28) with Al - 2.1 w/o Pu - 2 w/o Ni alloy cores fabricated by injection casting are presently being irradiated in the MTR (Cycle 155). The Zircaloy-clad samples will be in the reactor for two cycles. The specific power is 25 kw/ft, and the surface heat flux is 590,000 Btu/hr-sq ft. In addition, a four-foot long Zircaloy-clad seven-rod cluster has been fabricated by the injection casting technique for irradiation testing in the ETR. The element contains an Al - 2.53 w/o Pu - 2.0 w/o Ni corrosion resistant alloy which will generate a maximum of 15 kw/ft in the 3x3 loop. The test proposal is being written, and irradiation of the element is scheduled to commence in June 1961.

Examination is under way on a Zircaloy-clad Al-Pu three-rod cluster fabricated by inserting Al-Pu cores into 0.030-inch thick Zircaloy tubing. A four- to five-mil diametral gap existed between the core and cladding. The element received 34 days of exposure in the MTR at a heat flux of about 677,000 Btu/hr-ft^2. Length measurements taken on the ten-inch long cores indicate that two have shrunk 0.006 and 0.010 inch. A length measurement on the other core has not been obtained due to decanning difficulties.

The effect of pressure on thermal cycling results for Zircaloy-clad aluminum cores is being investigated with ex-reactor tests. Rods with 0.030 and 0.035-inch thick Zircaloy cladding are being cycled at different pressures. Results of preliminary cycling data are given below. The numbers indicate the number of rods affected due to the cycling treatment for each set of conditions. The results show the effect of testing pressure and cladding thickness on the cycling results. Tests are also being made under PRTR conditions (1050 psi).

	30-Mil Cladding		35-Mil Cladding	
	1250 psi	1150 psi	1250 psi	1150 psi
Number of rods affected at 25 cycles from a group of 8	3	1	0	0
50 cycles	3	1	1	1
100 cycles	6	3	2	2

Two of the six PuO_2 impregnated graphite capsules which were irradiated in the MTR are presently being examined by x-ray diffraction. X-ray data indicate that damage to the graphite and PuO_2 has occurred. This is evidenced by an expanded C_o spacing in the graphite. Systematic line broadening and expanded lattice parameters on the two PuO_2 samples increased 0.33 and 0.58 percent, which is considerable. The effect of irradiation temperature on annealing neutron induced damage in the graphite is not apparent. X-ray studies of the other samples are being made.

The capsules for the first part of the Phoenix experiment have been shipped to the MTR for irradiation. Calibration measurements in the ARMF have commenced. A document titled "The Reactivity of High Exposure Plutonium," has been written.

After considerable delay, the Zircaloy-clad Al-Pu rupture experiment has been approved by the MTR/ETR Reactor Safeguards Committee. It is presently scheduled to rupture the element during the last part of May 1961.

The test proposal has been completed for the in-reactor sintering studies on UO_2-PuO_2 and the direct comparison of the radiation behavior of UO_2-PuO_2

and enriched UO_2, operating under identical conditions. The test proposal document, HW-69281, is currently being prepared for issuance.

The PuO_2-UO_2 test element components for the reactivity measurements in the SNOUT Facility mockup in the 305 Reactor are presently being fabricated. The design had to be modified. The inner aluminum cylindrical section has been split longitudinally to facilitate more accurate placement of the full length copper and nickel flux-monitoring wires. It is planned to use an Al-Co alloy, full-length, flux-monitoring wire in a 1/16-inch OD stainless steel tube at the center of the fuel material. The order for the highly enriched UO_2 required for this test has been placed with the vendor. The material is scheduled for shipment during the second week in May 1961.

UO_2 Fuels Development

Fuel Irradiations. Post-irradiation examination of irradiation test element, GEH-4-59, a four-rod cluster element containing one fuel rod of partially decontaminated, recycled UO_2, was completed. The "recycled" rod revealed extensive relocation, columnar grain growth and formation of a large central cavity in the UO_2. Dendrites of UO_2 were observed in the outermost portions of this material. Lesser grain growth and central cavity formation occurred in the two rods containing electrodeposited, non-recycled UO_2. The sintered UO_2 pellets in the fourth rod exhibited no grain growth or UO_2 relocation. The three particle containing rods generated a maximum surface heat flux of about 500,000 Btu/hr-ft^2, while the rod containing sintered pellets generated only approximately 300,000 Btu/hr-ft^2. The results of this irradiation test are similar to other irradiations involving low density UO_2 and the test demonstrates the feasibility of fabricating and re-irradiating partially decontaminated UO_2 such as can be produced by electrodeposition with the Salt Cycle Process.

The second Hanford UO_2 defect test element (HD-2) successfully completed eight weeks of irradiation. During this period the element experienced five power cycles. Only very small amounts of fission products are being released to the coolant. Irradiation is continuing.

A three-foot long prototypic nested tubular (PRTR Mark II-C) fuel element containing vibrationally compacted high energy impact formed UO_2 was charged into the ETR 6x9 loop during the cycle beginning April 17, 1961. Irradiation will begin about April 30. Heat generation rates will be greater than those which will be experienced in the PRTR.

A hot swaged four-rod cluster test element (GEH-4-60) is being irradiated in the MTR to a maximum surface heat flux of 430,000 Btu/hr-ft^2. This test will continue until May 15. The element will be discharged at that time and will be returned to HAPO for post-irradiation examinations.

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Fabrication Development. Metallographic examination of an autoclaved sample of hot swaged Zircaloy-4 revealed that hydrogen dissolved in the metal during swaging does not precipitate as embrittling hydride platelets during subsequent autoclaving. The sample was autoclaved for 24 hours in 315 C, 1500 psi steam.

Fansteel 80 and Fansteel 82 are columbium alloys which have excellent high temperature strength. Tubes and end caps of these materials were prepared for experimental hot swaging tests at temperatures to 1600 C. These tubes will contain -60 mesh fused UO_2. Inconel X and Hastelloy F tubes will also be included in the studies.

Recently procured Zircaloy-4 tubing exhibited excellent cold-working properties, as determined by free-sink cold swaging. Random samples were reduced from 0.750 inch to 0.325 inch OD without cracking or splitting This is significant because vendors insisted only about one year ago that Zircaloy tubing could not be free-sink swaged without failing. This increased swagability may be the result of the finer grain size observed in these tubes.

Studies are being pursued jointly with Operations Research and Synthesis Operation to establish optimum particle size distributions for vibrationally compacted fuel elements. Results are being used to: (1) define mixtures that can be compacted to the same high density in cladding having radically different geometries (e.g., the components of the nested tubular fuel element), and (2) specify complementary size distributions for any one type of fuel element to permit greater utilization of as-crushed fuel material. Calculations have revealed mixtures having quite different particle size distributions which can be packed to densities approaching the maximum for a three-size system of 98.3 T.D.

An effective activation treatment developed for a 2% enriched UO_3 powder is: hydrogen reduction of the UO_3 at 500 C, air oxidation of the UO_2 product to U_3O_8 at 500 C, hydrogen reduction of the U_3O_8 at 500 C, and ball milling the resulting UO_2 for four hours. The average particle size after milling was $\sim 0.7\ \mu$. The powder was sintered to 97.5% T.D. during 12 hours at 1750 C.

High Frequency Resistance Welding. Tooling was changed from spiral rib welding to straight rib welding. Eight equally spaced ribs were successfully welded on a 3.063" OD x 0.060" wall tubing.

Preliminary tests were run on stainless steel to gain experience and to establish welding parameters for large diameter, thick wall tubing (3-1/16" OD by 0.060" wall). Straight ribs were also welded to Zircaloy-2 cladding with little apparent difficulty. Destructive tests have not yet been completed.

Modifications which are expected to improve weld quality and process dependability are: (1) addition of ferramic impeders to concentrate the current path in the tube, and (2) installation of a new draw bench for improved tube alignment.

Cladding Material Studies

Burst Testing of Weldrawn 406 SS Tubes. Weldrawn 406 SS tube sections, 0.563" OD x 0.010" wall x 8" long, with (a) TIG-arc welded 406 SS end caps and (b) magnetic force resistance welded 406 SS end caps were internally pressurized, primarily to test the quality of the welds. All of the five specimens with arc welded end caps that were pressure tested failed in the tube section at an average of 3150 lbs, which equals about the tensile strength of the weldrawn 406 SS tubes in the "as received" condition. There were no indications of leaks or failures in any of the end cap welds. In the pressure tests of tube sections with magnetic force resistance welded end caps, out of eight specimens four failed in the end cap welds at lower pressures, and four fractured in the tube walls at practically the same average pressure as those of the first test series.

These results prove that satisfactory end cap welds can be obtained by either TIG-arc or resistance welding of 406 SS end caps to weldrawn 406 SS tubing.

Vibration Testing of 406 SS Weldrawn Tubes. High frequency (vibration) cycling of six weldrawn 406 SS tube sections with TIG welded Ferral or 406 SS end plugs resulted in one premature, transverse tube fracture about six inches above the fixed end, and in fractures starting in the welds of the end plugs and proceeding through the tube walls in the other five tubes tested at from 600,000 to over one million cycles. Although no attempt was made to determine the stresses developed in this test, they are believed to be much more severe than those resulting from vibratory compaction of ceramic fuel. No comparative data of other materials tested by this method are available so far. Vibratory cycling tests of 304 and 406 SS thin-walled tubes of identical dimensions with TIG welded end caps of the same materials, solution heat treated after welding, are in progress.

2. PLUTONIUM CERAMICS RESEARCH

Plutonium Dioxide - Uranium Dioxide

Several leaks had been found in the hydrogen piping on the experimental sintering furnace and much of the past month was spent on leak checking and replacing the initial tubing, which has been in existence for about three years. Several runs were made, however, to provide additional PuO_2 specimens, containing varying O/Pu ratios, for thermal expansion data. PuO_2 pellets sintered in dry hydrogen, dry helium, vacuum, and oxygen should provide additional data on the 600 C expansion discontinuity and on the speculation that a eutectoid reaction occurs at this temperature.

Additional melting point data are being obtained on PuO_2 rich compositions in the UO_2-PuO_2 system. The post melted structures will then be analyzed to provide data on PuO_2 reduction versus UO_2 concentration.

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Dry pressed pellets of ceramic grade PuO_2-UO_2 powder mixtures were arc-fused in a static argon atmosphere. Spectrochemical analyses were requested for samples from buttons which were fused with a tungsten electrode. Tungsten contamination, as estimated from weighing the electrode before and after melting a pellet, could be as high as 30 ppm. A molybdenum electrode was tried but was abandoned because its consumption rate over that of tungsten was far more than could be justified based on the difference in cross-section of the two elements.

When the powder compacts start to melt, the furnace chamber immediately becomes covered with a deposit which obscures the electrode and hearth. This deposit was collected and weighed on a Vycor tube for several runs, and was found to be as high as four percent of the starting pellet weight. The over-all weight losses for these arc-melting experiments, based on pellet weight and fused button weight, ranged from seven to twenty percent.

Plutonium Carbides

The bulk of the past month was spent in working out capillary loading techniques for x-ray examination of plutonium-bearing powders via the Debye Scherrer method. A satisfactory technique has been found, and several Pu-C alloys are presently being investigated in an effort to derive some data on the defect zeta phase.

Based on lattice constants found previously, the theoretical density of a 45 a/o C PuC alloy is 13.59 gm/cc, including an isotopic correction for the Pu used in the experiments. As-arc-melted densities of PuC have been determined by immersion in tetra bromo-ethane. The mean density, corrected for temperature, is 13.59 gm/cc, or 98.23 percent of theoretical.

Plutonium Silicides

A stoichiometric mixture of PuH_3 and Si was arc-melted in argon in an attempt to produce PuSi. The products formed consisted of a fine black powder and a silver colored metallic substance. Identity should be provided subsequent to x-ray analysis. The metallic substance is pyrophoric.

The material previously reported as having been formed by arc-melting alpha plutonium and silicon has an immersion density of 9.76 g cm^{-3} at 25 C. Its melting point has not been determined, but that of the beta plutonium disilicide prepared by reacting plutonium dioxide with silicon carbide has been, and its value is 1750 C $\pm$ 20°.

Experiments are also under way to prepare Pu_3Si_2. Although not previously prepared, it is thought to exist.

Thermal Conductivity Studies

More minor alterations were made on the apparatus, primarily aimed at making placement and seating of the insert less difficult. These

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included shortening the thermocouple lengths to the minimum possible and using a new, less bulky type of insulation on the connectors. A vacuum leak developed in one of the Kovar-glass seals while installing the rewound balance heater.

Using all three heaters, the thermode temperature was raised to a maximum of 980 C, with a range in the specimen area of 660 C to 800 C, the highest range yet achieved and approaching the desired area of investigation. The top balance heater burned out at this point, causing shutdown and disassembly of the apparatus. Inspection of the heater showed that a short had developed in the same manner as that which previously occurred in the bottom balance heater. The insert was found to have a coating of grease on its upper half, and after reassembly, a run at slightly elevated temperatures proved that the vacuum grease seal was leaking.

A re-evaluation of the existing thermal conductivity apparatus, considering observations made and difficulties encountered during the test runs made to this point, showed the setup to be unworkable in its present condition and arrangement. Preliminary sketches of a new insert were made and sent to drafting.

3. UO_2 FUELS RESEARCH

Electrical Conductivity of Irradiated UO_2

The first series of electrical conductivity measurements on irradiated UO_2 (0.005 a/o burnup) was completed. The specimen was an extruded, isostatically pressed and sintered piece similar to those on which thermal conductivity measurements were previously made. First appraisal of the data shows:

1. Electrical conductivity (EC) of the irradiated sample was initially 1/5 that of the non-irradiated specimen of similar density at room temperature.

2. After heating both irradiated and non-irradiated samples to 800-900 C and cooling, the EC of the irradiated specimen was about 1/3 that of the non-irradiated specimen.

3. A sharp rise in rate of increase of EC with temperature of irradiated UO_2 occurred at 50-100 C (a similar rate increase occurred in non-irradiated UO_2 at about 500 C).

4. EC of non-irradiated UO_2 at room temperature decreases as density is increased over the range 86-96% theoretical density; but EC of the irradiated specimen (90% density) was less than 1/2 that of the non-irradiated 96% density UO_2.

5. All samples measured (irradiated and non-irradiated) have about the same EC at temperatures above 600 C.

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The next irradiated specimen scheduled for electrical conductivity measurements has acquired a 0.0645 a/o burnup. Thermal and electrical conductivity measurements will be run concurrently.

High Temperature Electron Microscopy

Examination of cleavage surfaces of fused UO_2 single crystals continued. Observations of the surface by reflection electron microscopy while the sample was heated between 1000 and 1150 C for one hour revealed minor changes, primarily vaporization of some of the surface "debris" originally present. Optical microscope examination showed evidence of fusion and other heat effects along edges of the specimen, suggesting that the temperature in the area on which the electron beam impinged in the microscope was considerably greater than that indicated by the thermocouple at the lower sample surface.

Work was begun on calibrating the electron diffraction attachments on the electron microscope and developing techniques required for their use. Concurrent recording of diffraction patterns and microscope images will provide more information for interpretation of phenomena occurring at elevated temperatures.

Lucalox supports and a tungsten heater are expected to be delivered during May to permit assembly of a miniature resistance heated high temperature stage (1800-1900) for the J.E.M. electron microscope. The probe shaft assembly for the internal electron detector was redesigned to provide continuous insulation, improved shielding and ease of installation. The internal electron detector will be calibrated for use as a photometer. Preliminary results indicate that the internal electron detector will provide greater selectivity and sensitivity than commercially available photometers.

Simultaneous comparison of irradiated and non-irradiated UO_2 at temperatures near the melting point provided further evidence of an increase in thermal stability as a result of irradiation. Irradiated and non-irradiated specimens of approximately the same size and shape were heated simultaneously on a resistance heated tungsten strip. The irradiated material (0.20 a/o burnup) was selected from a specimen which had previously been observed to melt at 2880 C, 90° above the melting point of non-irradiated UO_2. When the temperature was raised to 2790 C, the non-irradiated oxide melted at the point of contact with the filament and vaporized rapidly. The irradiated material did not melt at that temperature and vaporized quite slowly. About 70% of the non-irradiated material vaporized during 20 seconds at 2790 C, while the irradiated UO_2 did not melt and was less than 30% vaporized. All of the non-irradiated and about 90% of the irradiated UO_2 vaporized during five minutes at 2880 C. A small amount of solid material remained at the point of contact between the irradiated oxide and the tungsten until the filament melted at about 3400 C. A series of photomicrographs was taken to record the sequence of events described above.

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A document, "High Temperature Microscopy of Irradiated UO_2," by J. A. Christensen and J. L. Bates, HW-69234, was prepared for presentation at the American Ceramic Society meeting in Toronto, April 23-27. The paper describes the high temperature behavior (to 3000 C) of irradiated and non-irradiated UO_2 as observed through an optical microscope.

Fuel Cladding Reactions

Studies of high temperature reactions between various cladding materials and UO_2 and UC were continued. Fuel weight changes during 10-minute contact with various metals at 1000 C and 1500 C are recorded below. These data have only qualitative significance since they include no exact measurement of the contact area between the specimen and the metal.

	Weight Change (%)			
	1000 C		1500 C	
Cladding	UO_2	UC	UO_2	UC
Tungsten	-0.093	0.015	0.096	-0.037
Tantalum	0.005	0.110	0.011	0.388
Molybdenum	-0.054	0.070	-0.065	0.060
Zircaloy-2	-0.063	0.205	-0.100	0.215
304-L SS	-0.131	5.44	-0.121	--
Inconel	-0.012	0.050	--	--
Hastelloy F	0.110	0.97	--	--
Fansteel 80	0.995	0.019	2.55	0.293
Fansteel 82	0.110	0.002	0.112	0.068

Metallographic examination of each cladding material after heating in contact with UC revealed mixed carbides and fused base metal in all of the higher temperature tests. Stainless steel was the only material to react appreciably at 1000 C. A polished cross section showed a hemispherical reaction zone extending 0.013 inch into the 0.015 inch thick stainless steel.

High Energy Impact Forming of Nuclear Materials

Densities and O/U ratios were determined of UO_2 samples from a series of experiments statistically designed to simultaneously define the roles of temperature, pressure and O/U ratio on the high energy impaction of UO_2. The data are being analyzed by Operations Research and Synthesis Operation. Preliminary indications are that: (1) there is very little temperature effect in the range 1000-1200 C for pressures in the 500,000 psi range, but as pressures are decreased and O/U ratios are increased, there is a trend toward higher densities with increasing temperature, (2) a greater uranium oxide density results when the O/U ratio of the starting material is increased (in the O/U ratio range studied, 2.01-2.26), (3) the pressure required to compact uranium oxide to $\geq$ 99% T.D. may be as low as 400,000 psi. The last might be accomplished under certain conditions of temperature

and O/U ratio in a conventional impact die using a carbide punch rather than the more complicated modified Bridgman anvil apparatus.

Electrodeposited UO_2 crystals of approximately -28 +48 mesh were compacted by high energy impact at 1100 C and 500,000 psi to produce a bulk material having a particle density of 10.88 g/cc (99.2% T.D.). Photomicrographs and electron micrographs of the compacted UO_2 revealed extensive plastic deformation of the crystals.

Micronized UO_2 - 0.5 w/o TiO_2 and micronized UO_2 - 0.1 w/o TiO_2 were high energy impacted at 1100 C and 500,000 psi to densities of 97.3 and 97.8% T.D., respectively. Photomicrographs of the compacted UO_2 revealed no reaction (such as the formation of a liquid eutectic phase which lowers sintering temperature of these mixtures) between the TiO_2 and the UO_2. A density of 10.85-10.90 g/cc (99% T.D.) is usually attained with micronized UO_2 alone under similar conditions of temperature and pressure.

Thoria, alumina, and a 50 w/o ThO_2-Al_2O_3 mixtures were compacted by high energy impact at 1200 C and 500,000 psi. Densities attained were 9.59 g/cc (95.9% T.D.), 3.37 g/cc (84.9% T.D.), and 6.33 g/cc (90.0% T.D.), respectively. The thoria was obtained by calcining thorium nitrate, and the alumina was a Linde A metallographic polishing powder which had an average particle diameter of 0.3 micron. The compacted thoria had a glassy appearance and was recovered in fragments 1/8 to 1/4 inch diameter. The thoria and thoria-alumina will be used for basic studies of nuclear materials.

Uranium monocarbide previously fused and crushed to -6 mesh size was compacted by high energy impact at 1200 C and 500,000 psi to a machinable solid having a density of 13.28 g/cc (97.4% T.D.). The material will be used for basic studies of refractory nuclear fuel materials.

4. BASIC SWELLING PROGRAM

Irradiation Program

Constant temperature capsules Nos. 7 and 8, each containing three hollow split uranium cylinders are now being irradiated at control temperatures of 525 C and 575 C, respectively. An additional capsule also containing three split uranium cylinders is approximately 40% complete. At present, it is planned that the new capsule will be charged into a reactor in tandem with another capsule so that two capsules can be tested in the same test tube.

Annealing treatments have begun on three laboratory capsules containing specimens identical to those in the in-reactor capsules Nos. 4, 5, and 6. The thermal histories of each laboratory specimen will duplicate the in-reactor specimen. Upon completion of the tests, evaluation will be made of the physical, geometrical, and microstructural differences that exist between the irradiated and non-irradiated specimens.

Two capsules are now undergoing irradiation in the MTR. Each contains a single specimen: a section from an extrusion which has a core of depleted uranium and a shell of enriched uranium. One surface of each specimen was completely precharacterized. The purpose of these irradiations is to provide specimens for studies of the mobility of fission products in uranium, particularly inert gases.

Post-Irradiation Examination

Previously irradiated capsules, Nos. 4, 5, and 6, were opened in Radiometallurgy and the recovered specimens have been examined visually and photographed. One sample was destroyed by the cut-off wheel during opening and another sample was badly split, presumably due to the high irradiation temperature. The remaining spheres retained their shape and have exhibited no gross macroscopic damage. The specimens were irradiated at volume average temperatures ranging from about 550 to 800 C and to calculated burnups ranging from 0.03 to 0.3. The split, hollow cylinders in capsule No. 6 appeared to have suffered some surface "bumping" and perhaps some warpage. This was expected, of course, as the irradiation temperature was about 300 C where "growth" effects should still be quite pronounced. The specimens from these capsules will have their density, hardness, and metallography determined and selected ones will be subjected to vacuum annealing treatment.

An unrestrained, precharacterized specimen of uranium irradiated at the MTR at low temperatures, < 150 C, to a nominal burnup of 0.25 a/o, has been examined in Radiometallurgy. Prior to irradiation, the specimen was a right cylinder, 0.50" in diameter and 0.198" thick. After irradiation the surface of the beta heat treated specimen was extremely rough, presumably due to extensive growth (bumping) associated with its low irradiation temperature and the large number (40) of full power irradiation cycles. In addition, the specimen had become barrel shaped. Diameter measurements varied from 0.577 to 0.606" and thickness measurements gave values from 0.207" to 0.233". Due to surface roughening, these values are maximum and probably indicate very little concerning the volume change experienced by this sample. Replicas of this specimen in the as-irradiated state and after repolishing and etching have been prepared. Microphotography and density determinations are in progress.

Pore Size and Distribution

Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. Such information is needed in order to understand how gas atoms migrate, coalesce, and grow into large pores.

Specimens used for study of the swelling phenomenon were obtained from clad rod specimens irradiated to burnups of 0.29 and 0.41 a/o, respectively. Since swelling in the as-irradiated state was slight, it was felt that ex-reactor studies of declad specimens under a variety of post-irradiation annealing histories should provide valuable swelling information. It would

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furthermore, provide a convenient way to obtain a variety of pore distributions from a common abundant supply of specimens in order to develop the appropriate statistical methods for analyzing the pore size distributions. This phase of the experimental portion of this study, annealing, metallography, density measurements, and measurements on micrographs, has been completed. Statistical evaluation of the data and indicated changes in the degree of swelling sustained by the test specimens are in progress.

Fission Product Mobility

A knowledge of the mobility of rare gas fission products in uranium is important to the understanding of the basic mechanisms underlying the swelling phenomenon. Uranium specimens are being examined that have had inert gas introduced into the surface by "glow" discharge and U-U diffusion couples are being studied that have had an appreciable amount of fissioning occurring in one-half of the couple but none, or at least very little, in the other half. Samples for the latter are currently being irradiated.

Krypton evolution studies are continuing on uranium disks that have been subjected to "glow" discharge and to cathodic vacuum etching under various conditions. A disk was glowed at ambient temperature for six hours at a Kr pressure of two mm of Hg and a current and voltage of 40 ma and 0.8 Kv, respectively. There were positive indications that gas was being consumed during the flow. The disk was removed from the system, cut in half, and one piece heated to above its melting point while monitoring the evolved gas with the mass spectrometer. A small peak in the evolution rate amounting to roughly 7.0×10^{11} atoms per second was observed at about 500 C and a second peak was observed upon melting. When the "glow" system was heated and the evolved Kr monitored, two large peaks in the evolution rate were observed, one at 300 C and another at about 700 C with peak heights being about 11×10^{13} and 4.4×10^{13} atoms per second, respectively. These data are in close agreement with that previously reported and corroborate the concept that most of the Kr consumed during the "glow" is trapped on the walls of the system. Large quantities of uranium are deposited on the walls during the flow, and it is probable that the condensing metal acts to trap the gas. The surface area involved here, of course, is enormously larger than that of the specimen making a realistic comparison of the gas in the system and sample difficult.

Two other uranium disks were prepared in a cathodic vacuum etching chamber which uses Kr gas as the etchant. One sample was etched in the normal fashion at low pressure (approximately 5 μ) while the other was etched at a much higher pressure (approximately 50 μ) so that redeposition occurred. Each sample was then heated to above the melting point and the Kr evolution monitored. A small amount of Kr was evolved from both samples and both exhibited peaks in the evolution rate in the 300-500 C temperature range and upon melting, but the data have not yet been processed sufficiently to allow definitive comparisons to be made. There did not appear to be gross differences.

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Restrained Irradiations

Swelling experiments of Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposures are being conducted employing NaK-filled temperature monitored capsules. Three swelling capsules, GEH 14-94, 14-95, and 14-99, are presently being irradiated in the MTR to various goal exposures. Exposures and average center uranium temperatures for the fuel rods in these capsules are respectively 0.24, 0.32, and 0.43 a/o and 575, 500, and 540 C. Seven capsules from this series of experiments have been discharged from the MTR and are now awaiting Radiometallurgy examination.

5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

Pre-Irradiation Material Characteristics

Activation energies for creep of Zircaloy-2 in the temperature range 50 C to 275 C are being determined. Both flat and round annealed creep specimens are being used. The fabrication history of the flat specimens differs appreciably from the round specimens which are identical to the material to be used for in-reactor testing. The activation energies determined fall between 15,000 and 30,000 cal/mole in the temperature range 50-190 C and climb to 75,000 cal/mole at 277 C. These values differ appreciably from previously reported values determined at different creep rates. The activation energies determined in April are more accurate than those previously reported. The 15,000 to 30,000 cal/mole thermal activation process appears to be both stress and strain dependent. The nature of this dependency is currently under investigation. The high activation energy measured at 277 C is related to strain aging in annealed Zircaloy-2.

In-Reactor Creep Measurements

A modified creep capsule was charged this month; the capsule contains an annealed Zircaloy-2 specimen. The prototype capsule was discharged, and the new capsule installed in the vacated tube. The modification work performed on the capsule has resulted in lower gamma heating and more stable performance of the thermocouples and electrical transducers. As described in previous reports, the modification involved the removal of heavy metal gamma heating slugs, replacement of the thermocouples, and lubrication of the gear box and micrometer screw on the mechanical extensometer. The operation of the capsule has shown that the removal of the gamma heating slugs resulted in a decrease of 96 watts of heat generation. With this decrease in heat generation, the operating temperature of the capsule can be controlled at 300 C (572 F) which is within the design temperature limits of 250 to 400 C. The capsule's new thermocouples and modified electrical transducer mountings indicate a behavior of the sensors identical to the performance tests conducted out of the reactor before the capsule was charged. The stress has not been placed on the specimen as yet; it is intended to accumulate an exposure before beginning the creep test so the test will begin on an irradiated specimen while it is being irradiated.

Capsule and Instrument Development

Another review of the drawings, materials, and techniques of construction for six third-generation capsules was completed this month. During this review at the vendor's plant, final approval of the design and prints was given. No major changes were required. Component fabrication will begin in the coming month.

6. GAS-GRAPHITE STUDIES

Graphite Reaction with Microwave-Activated Nitrogen Gas

Specific weight loss rates from 4 to 20 x 10^{-5} g/g-hr have been observed for the reaction of graphite with microwave-activated nitrogen in a pressure range from 140 to 740 μ Hg. There appears to be a possibility that more than one maximum exists in the rate versus pressure curve; this is being investigated further. As in the earlier work, the product of reaction appears to be largely paracyanogen, $(CN)_x$.

Steam-Graphite Reaction

In case of heat exchanger leaks in gas-cooled reactors, there may be extensive reaction between the steam and hot graphite moderator. An apparatus for the investigation of this reaction has been designed and is in the initial stages of construction. Steam near atmospheric pressure will be passed over a graphite sample heated in the range 600 to 1200 C. Reaction rates will be measured by determining the rates of production of CO and CO_2. The effects of steam flow rate and composition of the influent gas will be determined.

Gas Analysis for the PRTR Gas Loop

The gas chromatograph was tested and calibrated following modification and repairs by the manufacturer. The peak heights did not change when the inlet sample pressure was varied as had been observed earlier. Peak heights were directly proportional to the concentrations of O_2, N_2, CO, and H_2 in helium gas in the range from 0.01 to 4%. The gas chromatograph and mass spectrometer were moved to the PRTR for installation and additional calibration.

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

Construction is estimated to be 58% complete versus 91% scheduled. All the equipment packages have been installed in "B" Cell and welding of connecting piping is in progress. Installation of the in-reactor section is being postponed because of uncertainties of blower operation. Further testing of the in-reactor sections will be performed in "B" Cell.

The single blower, for interim operation of the out-of-reactor portion of the gas loop at reduced conditions, has passed proof tests and been shipped by the vendor, Bristol-Siddeley. The blower arrived in New York on

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April 18, and is in transit to Richland. The vendor has been notified that he will be advised of a firm installation date, when present construction work permits, to preclude undue travel expense and better utilization of his service representative. The blower electrical circuitry requires modification to accommodate the recently established high starting currents.

An order has been placed with Struthers-Wells to reduce the amount of NaK in the main loop heater to an amount (150 pounds) compatible with the maximum allowable containment pressure. This reduction is being accomplished by displacing NaK with stainless steel castings contoured to fit around the heater tubes. Completion of this work is scheduled for May 12. The heater and one main loop valve, which leaked during testing and was replaced by the vendor, will have to be installed before blower operation is started.

An order has been placed for the sample handling casks which are scheduled for delivery by the middle of June. The drawings of the shielding plates for the loop have been received from Struthers-Wells, but drawings of the supporting framework will not be completed until the first of May. A requisition for the shielding plates has been processed.

Component Testing. The shortened electrical heater described in last month's report was installed in the in-reactor test section. Two preliminary runs were made where heater and inner tube temperatures reached 1400 F and 1080 F, respectively. On the third run, which was to bring the test section to gas loop design conditions of 1500 F, phase-to-phase arcing of the heater occurred. Arcing then took place between the heater and inner tube, melting a circumferential hole three inches long and one inch wide in the inner tube. The arc then progressed to the outer or pressure tube and melted a one-fourth inch hole in that tube. The heater, inner tube, and pressure tube temperatures at the time of the incident were 1600 F, 1290 F, and 925 F, respectively. Since direct electrical heating has not been satisfactory, the in-reactor test section will be set up in "B" Cell and connected to the reactor gas loop system. Future tests will be run with the test section heated by gas from the loop to gain experience in operating the loop system while final testing of the in-reactor section is completed.

Dismantling of the 314 Building gas loop mockup has been completed. The Roots-Connersville blower has been delivered to the reactor and repair of the test section has been started. A design survey to determine the best location in "B" Cell for the in-reactor test section and the additional piping components required for this installation is 50% complete.

Although no firm conclusions can be drawn from the sparse test data, extrapolations indicate that temperatures across the test section would be as follows (with no moderator in the calandria and CO_2 inlet gas temperature at 1500 F): inner tube, 1400 F; pressure tube, 1000 F. The temperature of that portion of the pressure tube which extends below the bottom primary shield would be 800-900 F during normal operation.

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7. GRAPHITE IRRADIATION DAMAGE STUDIES

Irradiation of Pyrolytic Graphite

Measurements have disclosed that the distance between carbon layer planes (c spacing) does not change appreciably in as-deposited pyrolytic material upon irradiation to 2100 MWD/AT (1.7×10^{21} nvt, E > 1 Mev) while heated to 500 to 600 C. In these materials the c spacing was 6.85 A before and after irradiation. These results in conjunction with the length changes reveal that the 1% increase in bulk density inferred from length measurements on as-deposited materials is not caused by crystallite expansion.

The c spacing of graphitized pyrolytic carbon is 6.71 A. This is very nearly equal to that for single crystals. After the exposure cited above, the c spacing of graphitized material expanded about 0.3%. This result is consistent with experience with single crystal material.

High Temperature Graphite Irradiations

The GEH-13-6 capsule containing four special graphites (see March monthly report) has operated successfully for one cycle in the ETR. The four controlled temperature positions are operating at the design temperature of 650 C. It is estimated that the three non-instrumented positions are operating at 600 C.

A capsule is being designed for irradiation of graphite samples at very high temperature in the ETR. It is expected that temperatures of about 2000 C can be attained by insulating the sample with porous graphite. The sample temperature may be monitored by following the temperature-sensitive c spacing of baked carbon wafers enclosed with the samples.

Fast Flux Monitor Materials

Iron and titanium appear to be promising fast flux monitor materials. Irradiations have been completed in the Hanford Quickie Facility, and the isotopes Mn^{54} (from the $Fe^{54}(n,p)Mn^{54}$ reaction) and Sc^{46} (from the $Ti^{46}(n,p)Sc^{46}$ reaction) were counted. Since no information is available on the cross section for these n,p processes as a function of incident neutron energy, an empirical relation between the nickel activation and the activation of these materials will be necessary. Additional longer term irradiations are in progress to determine if burnout of the activated isotope is a problem.

Electron Microscopy of Graphite

The electron microscopy of replicas taken from polished and cathodically etched surfaces of graphite has been extended to pitch-bonded graphite prepared with a carbon black filler. Thermax carbon black particles in a sample processed to a maximum temperature of 2570 C do not show well developed polyhedral faces noted by other investigators in blacks graphitized at 3000 C. The cathodic etch apparently attacks the carbon black

particles more rapidly than the coal tar pitch binder, leaving depressions in the binder roughly circular in outline. Occasional angular outlines suggest rudimentary development of polyhedral structure.

8. ADVANCE EVALUATION STUDIES

Conceptual Design - Fuel Element Fabrication Plant

The final draft of the Introduction and Part I have been completed. Part II has been issued for comment.

Supercritical Pressure Water Reactor Study

The economic evaluation of a 300 MWe Supercritical Pressure Power Reactor continued with detailed consideration of the equipment in the power cycle, reactor core design, fuel element hydraulics, fuel cycle costs, and plant layout.

Power Cycle. Cost estimates have been received for the main boiler feed pumps. The pumping unit proper will cost about $100,000. The drive unit for the pump, if a turbine, will cost about $400,000, and if an electric motor, about half that amount. The differential operating cost for the two drives (assuming six mills per kwhr electric power) is about $250,000 per year in favor of the turbine. Hence, a turbine drive has been selected. From an emergency back-up power point of view the turbine drive appears more desirable also, since it can operate on steam generated following a reactor scram at temperature.

The vendors recommend a five- or six-stage pump operating at speeds of up to 7650 rpm. Pump efficiency will be approximately 80%. A half capacity, full head electric drive boiler feed pump unit for startup and/or backup purposes will also be a multistage high speed unit. The cost of this pump is approximately $150,000. Both pumps have high NPSH requirements. Booster pumps will probably be required to assure adequate suction head.

Estimated costs and size information for the feedwater heaters have been obtained. Each of the four stages of high pressure feedwater heating will require from 7200 to 9000 square feet of surface area. Tube material will be Monel. Performance is based on zero degrees terminal difference and 15 F approach. Total estimated cost of the four heaters is $400,000.

Jumper piping to and from the 85 fuel element clusters (each of which contains seven fuel elements) will be 3" OD x 2" ID, 316 stainless steel tubing. To simplify access to the jumper piping and reduce insulation costs, a loose fill type insulation will be used instead of conventional pipe insulation. When access is required, the insulation will be vacuumed from the area to be serviced.

Reactor Core Design. Radial flux distributions through the supercritical reactor core are being performed using the three-group Flux Weight Code. Uncertainties in the cross-section input has led to an attempt to duplicate

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some experimental results from a uranium dioxide, light water moderated lattice. After these experimental results can be duplicated, radial flux distributions over the core can be carried out.

Several flux distributions over the core will be performed with the core being uniformly enriched with 2.5%, 3.0%, and 3.5% U-235. The benefits of zone type enrichment, moderator poison addition (boric acid), and variable lattice configurations with respect to flux distribution across the core will be investigated.

A feasibility study of moderator poisoning with boric acid for long term reactivity control continued. Solubility of boric acid at proposed moderator operating temperatures appears to be no problem. Continuous moderator cleanup for corrosion products without removal of borate ions is feasible by utilizing a mixed bed demineralizer containing commercially available strong base anion resin.

The concept of an unpressurized moderator appears to be lending itself well to fuel handling requirements. Reactor piping and control mechanisms will enter from the top face of the reactor and fuel charging and discharging will be performed through the bottom of the reactor. Since the "reactor vessel" simply sits in a large pool of water, a trapdoor type arrangement on the bottom of the vessel (to prevent gross mixing of the moderator and shielding fluids) is moved aside, and fuel clusters are dropped into an underwater cart and transported from under the reactor. New fuel is charged in the reverse manner.

The inverted cluster fuel element configuration is being analyzed to determine allowable flux deviations within the reactor based on primary and secondary stresses developed within the Hastelloy-X tubes. Flow versus pressure drop curves are being calculated for various heat flux patterns and for each coolant pass through the reactor. These individual fuel element curves are then combined with an assumed reactor neutron flux shape to obtain the outlet temperature distribution from a seven fuel element cluster.

Fuel Cycle Costs. Fuel cycle economics are being examined on the bases of power density, fuel to moderator ratio, and type of fuel management (batch discharge versus graded discharge). While it has been generally assumed that high specific powers (approximately 20 MW/T average) are desirable, there is some indication that with high cross-section materials in the core (such as Hastelloy X) the ratio of the volume of fuel to the volume of cladding is a significant factor. Hence, reference fuel designs with power densities ranging from 20 MW/T to 5 MW/T and fuel to clad ratios ranging from about six to one to twenty to one are being evaluated with respect to total fuel cycle costs.

Fuel to moderator ratios (which reflect in the amount of plutonium formed and burned in situ) are being examined also. The fuel element cost (estimated at about $10,000 each) suggests long exposures with considerable in situ plutonium fission. This in turn suggests low moderator to fuel ratios

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and a hardened thermal neutron spectrum. However, if the lattice spacing becomes too close, then construction and fabrication tolerances may become impractical.

Preliminary fuel cycle costs are in the range of 2.5 to 3.0 mills per kwhr for graded discharge and about 0.25 mills higher for batch discharge. Additional reduction may be obtained when the fuel design is optimized.

Plant Layout. Additional equipment layouts have been made within the reactor building. Indications are that the building diameter may be reduced from 220 feet to about 180 to 200 feet due to a reduction in the area required to be serviced by the main crane. It was originally intended to use the crane to pull the generator rotor; however, as now conceived, the rotor will be pulled with a separate crane or a cart-track mechanism thereby reducing the length of travel required for the main crane.

Fuel Element Design. Preliminary design of the fuel element for the SPPR has been completed to a point that vendor quotations can be obtained for the various components. As presently conceived, the fuel element will be of the "inverted cluster" type fabricated primarily by vibratory compaction methods. It is anticipated that the pressure-bearing member of the fuel assembly can be purchased in much the same fashion as small heat exchangers, i.e., on a completely fabricated and tested basis. The multiple U-tube pressure member will be inserted in a Zircaloy, hexagonally-shaped, thin wall container and UO_2 placed by vibratory compaction. Zirconia insulation will minimize heat loss to the unpressurized water moderator exterior to the Zircaloy container. The fuel elements will be assembled in clusters of seven and charged and discharged from the reactor in that fashion. Present calculations indicated that 85 such clusters will produce sufficient heat to generate 300 MWe net.

9. ALUMINUM CORROSION AND ALLOY DEVELOPMENT STUDIES

Oxygen Inhibition Test

A test to determine if high oxygen concentrations will inhibit the uniform corrosion of carbon steel, 304 stainless steel, X-8001 aluminum, and Zircaloy-2 has been started in neutral pH, 300 C deionized water. After four weeks of exposure the corrosion rates are 0.39, 0.06, and 40 mils/year for the carbon steel, stainless steel, and aluminum, respectively. The Zr-2 is exhibiting normal weight gains. These rates are all comparable to rates obtained without the addition of oxygen. However, there are two factors which may affect these results. The rates were obtained from the first four weeks of exposure. Normally, corrosion rates in high temperature water decrease significantly after the first month of exposure, and it is these lower rates which are normally reported. In addition, oxygen was added by inserting known volumes of O_2 gas into the makeup water and resulted in concentrations of only one ppm. The oxygen is now added to the makeup water in the form of hydrogen peroxide. Oxygen concentrations of 20 to 30 ppm are now being maintained using this method. The carbon steel and stainless steel samples all have a tight, shiny gray oxide film

covered with a thin, loose, red oxide film. The aluminum samples have started to form a tight gray oxide which is felt to be more protective and may reduce the rates.

H-1 Loop

It is planned to use the H-1 Loop for corrosion testing of aluminum-clad fuel elements. A project is being initiated to: install replacement pumps; provide automatic dumping with a switch to single-pass cooling if normal coolant is lost; improve the control of heat exchangers; and make other improvements in loop operation or safety required for the new test program.

10. COOPERATIVE USAEC-AECL PROGRAM

Heat Transfer Studies

As part of the Cooperative USAEC-AECL Program, a study was started to determine the feasibility of steam generation with a 19-rod bundle fuel element in a horizontal position. The concern in this problem is that stratification of the steam-water mixture would take place for such a horizontal fuel element and leave the uppermost rods in the bundle to be cooled in a steam atmosphere. Excessive fuel temperatures could be expected for such a case.

An electrically heated test section identical in size to the PRTR Mark I 19-rod bundle fuel element was placed in a 3.25 ID horizontal process tube in the experimental heat transfer apparatus. Heat was generated in the test section at a constant rate while the flow was reduced in steps until boiling conditions were established. With the inlet temperature and pressure held constant at 478 F and 1085 psig, flow was reduced from 150 gpm to 50 gpm for a tube power of 1250 kw and to 30 gpm for a tube power of 750 kw. At the end of both of these runs the outlet quality was approximately 20% by weight. In neither of these were high temperatures detected in the rods at the top of the bundle. Apparently the wire wraps which are put on 12 of the 19 rods to maintain proper spacing and promote flow mixing do mix the two-phase coolant sufficiently to prevent stratification.

The highest heat flux encountered in these tests was 208,000 B/hr-sq ft for the outer 12 rods of the bundle during the 1250 kw run. Attempts were made to investigate conditions at a higher heat flux, but during a 1500 kw run the seal at the end of the test section failed to hold. The test section was removed for modification.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage in various metals, including aluminum, copper, iron, molybdenum, nickel, titanium, zirconium, and type 347 stainless steel, is being studied by a number of techniques. Electrical resistance, x-ray diffraction, and mechanical properties measurements are the primary methods being used.

The variation of properties with irradiation and the kinetics of property recovery upon annealing are being analyzed to arrive at a damage model.

Recovery studies have been concentrated on irradiated iron and kinetics have been determined for all recovery stages except that which is centered at 245 C. To recapitulate, recovery occurs in three stages for iron with an exposure of about 4×10^{18} nvt: at 100-200 C, 225-260 C, and 275-375 C. At an exposure of 1.5×10^{20} nvt, recovery occurs in a single stage over the range 250-400 C; substages may be present but are not pronounced. At an exposure of 1×10^{17} nvt, recovery again occurs in a single stage, from 200-300 C.

The 100-200 C recovery stage at 4×10^{18} nvt proceeds by a single process having essentially first-order kinetics. The activation energy is 39,700 cal/mole (1.7 ev). The 275-375 C stage at 4×10^{18} nvt also takes place by a single process with first-order kinetics. The activation energy in this case is 27,850 cal/mole (1.2 ev). Recovery of damage in a specimen with an exposure of 1.5×10^{20} nvt occurs by two processes. The low temperature reaction proceeds with activation energies which vary according to the measurement technique. Resistivity measurements indicate an activation energy of 41,900 cal/mole (1.8 ev) and a reaction order of 1.25. The activation energy as determined by microhardness recovery is 29,800 cal/mole (1.3 ev); the reaction order for microhardness recovery has not yet been determined. The high temperature reaction occurs with an activation energy of 84,800 cal/mole (3.7 ev) for both resistivity and microhardness recovery. Based on the above results and tensile behavior reported previously, recovery of neutron damage in iron is tentatively described as follows:

Exposure	Temperature Range	Process
1×10^{17} nvt	200-300 C	Precipitation of interstitial impurity element(s) (C,N,O)
4×10^{18} nvt	100-200 C	Breakup of defect clusters
4×10^{18} nvt	225-260 C	Precipitation of interstitial impurities
4×10^{18} nvt	275-375 C	Release of trapped interstitials
1.5×10^{20} nvt	250-400 C	a) Release of trapped interstitials b) Self-diffusion

Factors which relate to the damage and damage recovery mechanisms in body centered cubic metals such as molybdenum, tungsten, niobium, tantalum, and iron, are being evaluated. Analysis of available information shows that some of the radiation damage recovers during annealing in temperature ranges which are very close to those in which internal friction peaks due to dislocation-impurity atom interactions are observed in non-irradiated metal. The

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possibility that some of the annealing of radiation damaged body-centered cubic materials is due to these reactions is being studied.

Changes in x-ray extinction resulting from irradiation-induced defects are being investigated as a method for studying irradiation damage in single crystals. Faces have been cut parallel to crystal planes on single crystals of aluminum and molybdenum. The intensity of x-ray beams diffracted from these faces are being used to determine the amount of and type of extinction effects. In addition, by comparing the observed intensities with those calculated for 0°K, the temperature correction is determined, and an estimate of the Debye temperature can be made.

The cold worked layer resulting from the cutting of the faces has proven troublesome for aluminum crystals. Alternate chemical etching and electropolishing is being employed to remove this layer. Both aluminum and molybdenum show considerable extinction, indicating a high degree of crystalline perfection in the unirradiated state. Selected samples will be irradiated to observe changes in extinction and in the x-ray temperature factor. Also, x-ray measurements will be conducted at temperatures other than room temperature to determine the temperature correction more precisely.

E. CUSTOMER WORK

Radiometallurgy Service

Examination of three bumper fuel elements with high corrosion weight loss was completed this month. Corrosion occurred over three-fourths of the surface with the unaffected area being between the process tube ribs. About six mils of cladding were removed from the spire surface. Uranium growth resulted in an increase of both internal and external diameters of the fuel. Ellipticity up to 30 mils was also observed (RM-418).

Examination of a longitudinally-split failure from 3781-H revealed that water penetrated the element at the female (upstream) end. An oxide blister formed distorting the cladding into the external coolant annulus. Evidence indicates that the downstream surface temperature exceeded 350 C. Splitting was probably caused by rapid cooling of the very brittle uranium (RM-420).

A wire-wrapped Zr-2 bar was examined for fretting corrosion after exposure in KER-3. The wire was loose and in those spots where the wire contacted the bar, deep spiral grooves had formed. The greatest depth of penetration measured was 14 mils (RM-342).

Electron Microscopy Service

A positive replication technique has been successfully applied to a resin-impregnated, resin-mounted graphite specimen. Polystyrene sheet, 0.125" thick, was used as a primary replica. The polystyrene was presoftened in an oven at 142 C. The polished graphite surface was placed on the polystyrene and a one-pound weight was placed on top of the specimen. When the oven temperature again reached 142 C, the specimen and adhering polystyrene were removed and

allowed to cool. The graphite was separated from the polystyrene leaving a primary or negative replica. A polyvinyl alcohol positive replica was made from the negative. The primary replica serves as a permanent reference of the specimen in a given condition. The specimen itself can then be given any number of additional treatments and a comparison made to an identical area in the base condition.

Metallography Service

The type 304, schedule 80 stainless steel piping of KER-2 which had been repaired on January 8, 1961, failed again on March 22. The failure consisted of a longitudinal split three to four inches in length and, as in previous failures of the stainless steel loops, it occurred immediately downstream from the cold water inlet from the heat exchanger. Adjacent to the main crack were networks of fine cracks as revealed by Zyglo fluorescent dye penetrant. Metallographic examination of these cracks showed that they originated on the inner wall of the tubing and were identical to cracks examined from other loop failures. A high resemblance to the cracking found in stress corrosion failures was apparent in this latest examination.

A metallographic examination was made of the type 347 stainless steel tubing from the KER-3 reactor front-face crossheader. Samples were cut from areas in which indications of possible cracks were found by dye penetrant testing. Extensive cracking was found in two of the suspected areas. All the cracks originated on the outer wall of the tubing, and they were of the type associated with chloride stress corrosion cracking. It is suspected that the chloride ions may have been leached from the lagging with which the tubing was wrapped for insulation.

Samples Processed During the Month:

Total Samples	577
Replicas	35

Photographs:

Micrographs	807
Macrographs	62
Electron Micrographs	299
	1168

NPR Charging Machine

Fabrication and assembly of the NPR charging machine are estimated to be 47% complete. Status of individual components is as follows: transfer arm subassemblies are complete and their installation was started; installation of modified main frame components was completed; the main frame has been installed on the cross travel drive assembly, aligned, and fastened in place; idler roll assemblies are 80% complete; drive roll assemblies are 50% complete. The cross travel drive and vertical lift assemblies have been operated. Hydraulic piping is 25% complete.

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Shielding for Fuel Recycle Pilot Plant

Shielding calculations in support of the design of the Fuel Recycle Pilot Plant were continued at the request of Facilities Engineering Operation. For a PRTR fuel element, cooled for 15 days, about 50 inches of heavy aggregate concrete should be used. This is based on magnetite aggregate concrete with a density of 3.5 grams per cubic centimeter and an assumed allowable dose rate of 0.2 mrem per hour.

F.W. Albaugh

Manager, Reactor and Fuels Research
and Development

FW Albaugh:kb

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

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FISSIONABLE MATERIALS - 2000 PROGRAM

FUELS

Nuclear Safety in FPD

A meeting was held with Engineering Operation personnel (L. E. Kusler, J. E. Ruffin, and W. R. Kirk) to discuss nuclear safety in the 306 and 333 Buildings. The specifications for handling 0.95% U-235 enriched I and E and NPR fuel elements were reviewed. Other topics discussed were: 1) interpretation and application of geometry control, 2) handling and storage requirements for the NPR billets; 3) the handling of scrap, 4) spacing requirements between arrays, and 5) the probability of water flooding in each building.

The primary basis for nuclear safety control in the handling and storage of fuel elements will be the "safe mass per unit area" limit. Using this limit, spacing between arrays of the same enrichment is not necessary, and array height is not necessarily restricted.

The safety of all arrays is based on the assumption that flooding with water can occur.

REACTOR

Exponential Measurements for NPR

The material buckling of the NPR condensed lattice was measured with natural uranium fuel elements and water coolant. The final material buckling was $-135 \times 10^{-6} cm^{-2}$. The extrapolation lengths were 1.0 inches perpendicular to the process tubes and 1.2 inches parallel to the process tubes.

The density of approximately 10 percent of the graphite used in the NPR mockup has been measured. The resulting batch density is 1.695 gm/cc.

NPR Fuel Temperature Coefficient

An internal report which is titled The Variation of k_∞ with Fuel Temperature for the NPR, HW-69343, is being prepared. The measured change in k_∞ with fuel temperature, $\Delta k_\infty(T)$, and the uncertainty in that quantity due to spectral and adjoint mismatches have been derived.

Exponential Measurements of Large Diameter Fuel Elements

Small source theory has been used to analyze horizontal traverses taken in the exponential piles. The theory predicts an oscillation in the flux in addition to the normal cell fine structure. The magnitude of the peaks of this oscillation varies from zero at the pile center to 13% near the pile edge. Comparison of the experimental traverses to the calculated results shows good agreement within the normal experimental errors of 1%.

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Lattice Parameters and Neutron Temperature for Large Diameter Fuels

Cadmium ratios for various foil materials have been measured (Table I). The foils were irradiated on the rotator in the core of the TTR. Ten sodium foils were irradiated to determine the normalization requirements necessary for the interpretation of the measurement. The uncertainty in the specific activity for the sodium foils was ± .74%. The following table shows the degree to which sodium may be used as a "1/v" detector:

TABLE I

Material	Thickness Mils	Cadmium Ratio	Equivalent "1/v" Cadmium Ratio
Copper	5	15.10	24.84
Manganese	2	15.09	26.19
Sodium	15	24.07	

The analysis of data from lutetium foils irradiated in a 10½" graphite lattice containing 2½" solid fuel has been continued. Application of effective resonance integrals for each foil position, using fluxes calculated by HFN and resonance integrals calculated by ACE, has produced values of g^{176} (Table II) from which the spectral index may be obtained. The slowing-down flux at the cell edge has been assumed to be ϕ_o/E, except near the thermal cutoff where it is greater than ϕ_o/E. The values of g^{176} and spectral index obtained are given in Table II.

TABLE II

Foil Position	g^{176} Wet	T°K Wet	g^{176} Dry	T°K Dry
Fuel Center	1.96	330	2.07	345
Fuel Edge	1.93	326	1.98	335
Midway Graphite	1.84	313	1.81	309
Cell Edge	1.78	304	1.74	298

Digital Computer Programs for Reactor Analysis

Development of HFN, the multi-group neutron diffusion theory code, is continuing. The option which allows suppression of portions of the output has been used successfully. Changes presently being incorporated are:

1. Improved arrangement of output on the output sheets. (Coding 90 percent complete)

2. Extension of code to handle calculations in spherical one-dimensional geometry. (Coding complete)

3. Improved formulas for calculation of direct and adjoint flux gradients, for use in perturbation theory analyses of output. (Coding complete)

4. Extension of criticality search feature so that any one diffusion parameter, region radius or outside boundary condition may be varied in an attempt to reproduce an input specified multiplication factor. (Coding complete)

5. Change error indications from a printed code number to an explanatory message. (Coding 95 percent complete)

In addition to the above changes, a start has been made on the project of changing the input format, which presently uses all 80 columns of the input cards. This is being cut to 72 columns, in order to facilitate the future use of other codes in preparing HFN input. This is desirable to avoid the special handling procedures which must be used on FORTRAN monitor programs punching more than 72 columns of a card. Coding of this change is about five percent complete.

FIT-1, the few group neutron diffusion theory code for analysis of experimental detector traverses has been readied for a final report. A test case, to be used in the report, has been run. The report is now being polished.

Neutron Thermalization Studies

An approximate method has been formulated for determining the effective neutron temperature incident on a fuel element for the case of a temperature discontinuity in the surrounding moderator. This method is based on an extension of the temperature discontinuity work of Kottwitz to annular cylindrical geometry and uses the "effective temperature" approximation to this work. At the request of Nonmetallic Materials Development, the method has been utilized in a kinetics calculation of the effect of a temperature transient propagated radially outward through the graphite.

Computational Programming Services

An HW document on the exponential data processing code VTOCL is in final form, and will be issued within the next few days. HW documents on COFIT 2 and INELASCAT are in preparation. The binary input-output subroutines WTBX/RTBX are being revised to handle both arrays and single items of data.

Instrumentation

One of the two combined quasi-logarithmic and multi-range linear prototype experimental scintillation beta-gamma area monitors has undergone continuous stability tests with good results for better than two weeks. The second unit was slightly modified to produce better logarithmic scaling. The linear ranges, 0-10 mr/hr decaded to 0-10 r/hr (4 decades), gave reading accuracies to within ± 10 percent of the true dose rate. The original "breadboard" circuit and chopper performed nearly four continuous months with no accumulated drift errors and with day-to-day readings varying by less than ± 10 percent. Final tests on the improved logarithmic circuit portion will be accelerated.

The design drawings, drawn by CE&UO personnel, for the transistorized NPR Beta-Gamma Scintillation Air Monitor were reviewed and corrected. The unit continues to perform satisfactorily in the field.

Comments and corrections were made concerning the CE&UO specifications for the slow-scan portion of the NPR Fuel Failure Monitor.

Experimental circuitry development is nearing completion for the experimental Fast and Slow Scanning Type Fuel Failure Monitor. The rotating portion and the

slip-ring assembly, in constant rotation now for two months, continue to perform correctly with no change in the original 50 microvolt slip-ring noise level.

Planning is under way for experimental studies of fuel failure detection problems in conjunction with operation of the PRTR Rupture Loop. These will be aimed at determining optimum adjustments for initial operation of the NPR monitor, at obtaining basic information regarding detection of failures in NPR type fuel, and at developing and applying instrumentation for studying the mechanisms of fuel failure by analyses of the radioactivities released to the coolant. Specifications were prepared for a gamma spectrometer multichannel analyzer to be purchased by IPD for this work. Specifications for a delayed neutron detector and a gross gamma detector are currently being prepared.

A prototype experimental high temperature ceramic tube pulse amplifier, using General Electric Company type 7462 ceramic triodes, is being fabricated for testing in reactor and other high temperatures environments.

The X-Y Gamma Scanning system for reactor shield studies, originally designed to scan 121 points in an 11 x 11 matrix, was modified to permit either 11 x 11 or 6 x 6 scanning as desired by the operator. The unit continues to perform satisfactorily.

The special IPD ionization chamber specification HWS-8127 was revised and issued jointly with members of Instrument Development, IPD.

A detailed proposal was made to improve the shielding effectiveness of the octant monitor experimental facility at 105-DR in conjunction with the proposed new ionization chambers.

The optical and mechanical components of the radiation ratio pyrometer for reactor moderator temperature measurements were assembled. Since the electronic unit had been completed earlier, the pyrometer is now complete (except for distance focusing optics) and ready for shop testing.

Systems Studies

Progress is being made on the NPR Plant Simulator. The primary loop pressurizer equations have been simplified to where only three amplifiers rather than fifty are required to simulate it. The requirements placed on this model (simulation) require that new techniques be used in simulating the reactor. An attempt is being made to transform the reactor and heat transfer equations to a form that will allow the reactor to be simulated from source level to ten times normal operating power. This will allow the operator to bring the reactor all the way up with no discontinuities. If successful, this could be of major benefit to future reactor studies. New equations have been obtained for the secondary loop. These equations will consider the effects of producing electrical power on the over-all operation of the reactor. The secondary loop will first be studied in detail before incorporating it in the plant simulator.

Progress on the reactor control experiment at 100-D reactor has been retarded due to occurrence of several reactor shutdowns just prior to planned tests.

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However, two short term tests were made using six temperature control zones, one in the top-center and the other in the bottom-center of the front face plane. A constant sampling period (48 seconds) and constant rod travel per sample ($\frac{1}{2}$-inch) were used for both tests.

It was found that the location of the temperature measuring points with respect to the control rod tips was more critical than when only four points were used. Two interesting situations developed during these tests. During the first test, the four "corner" points were left in the positions set by the chief operator and the two new points were added approximately midway between the corner points. After a time, it was found that the effect of one rod on its assigned temperature zone was about the same as its effect on the adjacent temperature zone and vice versa. During the following see-saw battle between these two rods, the heat started to shift to one side and the test was discontinued to allow correction of this situation. This situation was improved for the second test by moving the "far" corner points back four tube rows to increase the separation between zone measuring points.

During the second test, a disturbance occurred which could not be adequately compensated with the prescribed control rules ($\frac{1}{2}$-inch rod movement per 48 seconds period, maximum). This possibility had been predicted by the analog computer studies made previously.

Some difficulty has been experienced in obtaining a stable temperature recorder for the additional two points. A control deadband of one-half degree Centigrade or less is desirable and this requires a measurement deadband of no greater than 0.1 degree Centigrade for comparatively accurate results. For copper constantan thermocouples, a 0.1 degree Centigrade temperature change causes a voltage change of approximately four microvolts, which is less than the threshold sensitivity of most available recorders. Reliable resistance thermometers would probably be more satisfactory for this application.

A new reactor speed of control simulation has been initiated to afford a more detailed examination of reactor behavior following loss of primary coolant. Reactor speed of control studies have been made in the past, and will continue to be made, to determine whether the production reactors are being operated within limits as set by the speed of control criteria. As presently interpreted, these criteria stipulate that the reactors are to be operated in such a manner that no credible accident will result in fuel melting during a nuclear excursion. It is assumed that the maximum credible accident is total loss of primary coolant water. Previous speed of control studies have assumed an entirely homogeneous pile, with a single, over-all rod function to simulate insertion of vertical safety rods upon loss of coolant. In the new simulation, the reactor is divided into 19 side-to-side regions, with a different rod function for each region. This provides representation of the effects due to malfunction of safety rods in one or more regions at a time, where the over-all pile may be operating within limits, but fuel melting may occur during an excursion in a single region due to improper functioning of safety rods.

SEPARATIONS

Plutonium Critical Mass Facility

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Solution Systems

[redacted]olution transfer system was leak tested by pressurizing with freon. A number

of leaks were found, and with one exception, these leaks were repaired by tightening fittings, backwelding or replacing faulty parts. A leak in the flexible line of the dump system requires the welding on of a new piece of stainless steel tubing and ordering a new piece of flexible tubing to fit properly at both ends. The piping to the second hood and the direct sampling lines have been disconnected and capped. Calibration curves, volume versus liquid level meter readings are being taken.

The thickness of the vessel walls has been measured at several points in order to test the uniformity of the walls and provide an average thickness. The volumes of the reactor vessels have been measured and curves prepared giving volume of fluid versus fluid height.

Solid Systems

The framework of the split-table machine has been assembled at Technical Shops. Assembly of the motor drive and control rods has begun. Preliminary contacts with CE&UO have been made to obtain electrical design help.

In Situ Neutron Multiplication Measurements With Plutonium Metal

During April, the first in situ critical approach experiment with Pu metal was conducted at Hanford. The measurements were made in the 234-5 Building, utilizing Hood HC-21A. The measurements were conducted on two successive week-ends at times when regular shift personnel were absent from the building. Personnel of CPD made the arrangements for the experiments, and performed the measurements with instrumentation borrowed from Critical Mass Physics. R. L. Stevenson of CPD planned the experiments. E. D. Clayton served as technical director during the conduct of the experiment.

In the first experiment, a cylindrical array of Pu was built from Pu metal disks 2.75-inches in diameter. A total of 6.19 Kg of α-phase Pu was used in the assembly. The estimated critical mass obtained from extrapolation of the multiplication curves was about 10.5 Kg Pu. The system was unreflected except for the adjacent hood walls and steel floor of the hood on which the assembly rested. From shape factor conversions, the estimated critical mass for a completely unreflected Pu cylinder with the above diameter is expected to be about 15 Kg Pu. The preliminary results indicate an appreciable reduction in the critical mass as the result of partial reflection by the hood walls and adjacent material, etc.

A critical approach was also made with a pair of simulated, plastic hands around the assembly. The results indicated the plastic hands to be approximately the equivalent of adding $\frac{1}{2}$ Kg of Pu to the assembly.

Measurements were also made with a second cylindrical assembly with the 2.75-inch Pu metal disks positioned in a 3/32-inch thick tantalum crucible, which was partially reflected by a graphite holder. A total of 7 Kg of Pu was used in the array. The lower portion of the cylindrical assembly (which contained 4.1 Kg of Pu) was reflected by a 1.78-inch thick layer of graphite. From the multiplication measurements, the estimated critical mass for the assembly was about 10.5 Kg Pu.

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Further experiments are planned in the series of in-plant multiplication measurements.

The purpose of these experiments is to obtain critical mass estimates for the Pu under various conditions of partial neutron reflection as encountered during operations with the Pu metal.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

Critical Mass Calculations

The computation of the critical mass versus plutonium concentration for PuO_2-H_2O homogeneous systems, with 5 and 10 percent Pu-240, have been completed for spherical geometry. Table I is a compilation of the data for these systems, including data given last month. PuO_2 density is taken as the theoretical density, 11.46 gm/cc, and the H_2O density as 0.99 gm/cc.

The same kind of calculation has been carried out for Pu-H_2O homogeneous bare systems. The purpose was to check against previous calculations performed at Los Alamos Scientific Laboratory. The agreements with other results is generally good except for the Pu-240 effect. Efforts to explain and correct our difference continue. The two principal difficulties with the Pu-240 effect are that we find the effect to be smaller, and the maximum effect to occur at a lower Pu-239 concentration.

The results are summarized in Tables II and III. In Table II are given the pertinent composition data, and Table III summarizes the critical masses, critical radii and H/Pu ratio.

Monte Carlo Code - HISMC

The time requirement for running the HISMC code (a Monte Carlo code to study the behavior of neutrons in homogeneous systems) has been improved by a factor of approximately twenty; a recent run of 1000 histories, in a solution of hydrogen-plutonium with an H/Pu ratio of 300, was completed in three minutes and ten seconds. The value of the age for fission neutrons to indium resonance (1.44 ev) computed from the 1000 history sample was 27.1 cm^2, very much in line with recent measurements of the age in water. There still appear to be a few clerical errors in the code that should be easily corrected. Additional debugging is continuing to thoroughly check the code for other errors.

Interaction of Subcritical Systems

The study of the interaction of moderated subcritical systems by an approximation method was continued. In slab geometry, earlier work was extended to include the examination of the dependence of criticality on fuel concentration and on size of the individual systems. In cylindrical and spherical geometry, the effect of separation on criticality was determined for two and three component systems of fixed concentration and several sizes. A check of the approximation method against diffusion theory results was devised for cylindrical gometry, by comparing, (a) the approximation method results for 51 cylinders in contact in a ring with, (b) diffusion theory results for an annular fuel region chosen to preserve volumes.

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TABLE I

Critical Masses for Bare and Reflected Spheres of PuO_2-H_2O Mixtures with 0, 5, and 10 Percent Pu-240

	Bare Spheres						Reflected Spheres	
	0%-240		5%-240		10%-240		0%-240	
H/Pu	Rc(cm)	*Mc(Kg)	Rc(cm)	Mc(Kg)	Rc(cm)	Mc(Kg)	Rc(cm)	Mc(Kg)
0	7.79	20.0	8.02	20.75	8.20	21.01	6.7	12.74
.38	8.54	23	8.75	23.50	8.94	23.75	7.2	13.67
1.25	9.52	25.5	9.74	25.96	-	-		
1.66	10.0	25.9	10.24	26.37	10.48	26.77		
2.37	10.5	25.6	10.72	25.99	11.01	26.67		
3.36	10.8	24.5	11.30	25.32	11.64	26.22	8.8	12.58
4.85	11.7	23.5	11.99	24.20	12.37	25.17	9.1	11.06
7.33	12.2	20.0	12.83	22.24	13.30	23.47	9.5	9.56
12.3	13.1	16.5	14.03	19.39	14.69	21.08	10.2	7.80
27.2	14.5	11.2	15.90	14.10	16.79	15.73	11.2	5.23
57.1	15.2	6.5	17.4	9.24	18.4	10.36	12.2	3.11
117	16.0	3.77	17.2	4.47	18.1	4.89	12.3	1.70
295	16.9	1.78	17.85	2.00	18.6	2.13	13.4	0.897
395	17.3	1.44	18.2	1.60	18.9	1.69	13.8	.72
594			18.6	1.13	19.4	1.21	14.4	.55
660	18.2	1.00	19.1	1.09	19.8	1.17	14.8	.54
742	19.2	1.02	19.8	1.08	20.4	1.13	15.3	.531
849	19.5	.951	20.4	1.04	21.3	1.12	16.0	.533
991	20.4	.945	21.4	1.03	22.4	1.12	17.0	.540
1189	21.9	.965	23.0	1.07	24.2	1.18	18.5	.582
1487	24.3	1.06	25.8	1.20	27.4	1.35	20.9	.676
2977			62.8	8.67	88.8	23.3	52	5.16

* All critical masses are given in Kg-Pu-239.

TABLE II

Compositions of Pu-H_2O Systems for Criticality Calculations *

H/Pu Ratio	Pu-Concentration (Total Pu, gm/cc)	Atoms Pu (Per cc x 10^{24})	Molecules H_2O (Per cc x 10^{24})
0	19.6	.04939	0
.86	12.0	.03024	.01296
1.3	10.0	.02520	.01638
2.0	8.0	.02016	.01979
3.1	6.0	.01512	.02320
5.3	4.0	.01008	.02661
11.9	2.0	5.0402 (-3)	.03002
25.2	1.0	2.5201	.03173
31.8	0.8	2.0161	.03207
42.9	0.6	1.5120	.03241
65.0	0.4	1.0080 (-3)	.03275
131	0.2	5.0402 (-4)	.03309
264	0.1	2.5201	.03326
529	0.05	1.2600 (-4)	.03335
872	0.03	7.5622 (-5)	.03338
1325	0.02	5.0402	.03340
2652	0.01	2.5201	.03342
3536	0.0075	1.8903 (-5)	.03342

* Pu density is taken as 19.6 gm/cc (0.04939 x 10^{24} atoms/cc) and H_2O density was taken as 1.000 gm/cc (.03343 x 10^{24} molecules/cc).

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TABLE III

Critical Masses for Bare Spheres of Pu-H_2O Mixtures
With 0, 5 and 10% Pu-240

	0%-240		5%-240		10%-240	
H/Pu	R(cm)	M(kg)	R(cm)	M(kg)	R(cm)	M(kg)
0	4.90	9.66	4.99	9.69	5.09	9.74
.86	6.88	16.37	7.02	16.52	7.20	16.89
1.3	7.59	18.32	7.74	18.45	7.93	18.80
1.96	8.41	19.94	8.62	20.39	8.82	20.69
3.07	9.40	20.87	9.60	21.12	9.96	22.35
5.28	10.65	20.24	11.10	21.77	11.47	22.76
11.92	12.50	16.36	13.40	19.15	14.03	20.82
25.2	14.12	11.79	15.46	14.70	16.33	16.42
31.8	14.60	10.43	16.03	13.11	16.95	14.69
42.9	15.18	8.79	16.67	11.06	17.60	12.33
65	15.43	6.16	17.18	8.07	18.11	8.96
131	16.05	3.46	17.25	4.09	18.04	4.43
264	16.61	1.92	17.78	2.24	18.53	2.40
529	17.65	1.152	18.88	1.339	19.60	1.42
872	19.70	.961	20.61	1.045	21.55	1.132
1325	22.97	1.015	24.23	1.132	25.59	1.263
2651	40.68	2.82	46.5	4.00	55.5	6.44
3536	111.3	43.3	-	-	-	-

$k_\infty = .989$

Agreement to within about 1.25 percent was obtained. This compares favorably with the agreements obtained in slab geometry and strengthens confidence in the order of accuracy obtainable in the approximation method.

Criticality Hazards Specifications

Nuclear Safety in HLO

1) A meeting was held with Fuel Fabrication Development Operation personnel (R. G. Nelson and R. S. Kemper, Jr.) to discuss the nuclear safety aspects of fabricating Th-232 - 2.5 w/o U-235 fuel elements, which is to begin within the next few months. The process will require the casting of 93% U-235 enriched uranium metal with thorium metal, after which the alloy castings will be machined, clad, extruded, and cut into fuel rods. Nuclear safety specifications will cover the handling and storage of both the 93% U-235 enriched uranium and the Th-232 2.5 w/o U-235 alloy. For the thorium alloy, nuclear safety will be based on the critical parameters for 2.5% U-235 enriched uranium, until more exact data are available. The 2.5% U-235 data will be conservative because k_∞ for the thorium-U-235 fuel rod system is lower than for the U-238-U-235 system. Not only is the density of thorium 11.2 g/cc compared to 18.9 g/cc for uranium, but σ_a^{th} is 7.9 barns for the Th-232 compared to 2.7 barns for U-238. The etas thus compare as follows:

$$\frac{\eta^{th}}{\eta^{u}} = .48$$

The fast fission factor for the thorium alloy is also lower because the high energy fission cross section for thorium is 0.1-0.2 barns compared to 0.4-0.5 barns for U-238. Thermal utilization may be slightly higher for the thorium alloy and resonance escape probability is about the same.

2) A meeting was held with Programming Operation personnel (L. D. Turner, K. E. Schneider, J. G. Bradley and R. W. Dascenzo) to discuss the nuclear safety aspects of the Fuels Recycle Pilot Plant (FRPP). The main topics discussed were the sizes of the bursts that have occurred in past non-reactor accidents, and the probability of accident occurrence (for estimating shielding requirements) and the variables that will affect the nuclear safety of the FRPP.

3) Evaluation for Nuclear Materials Operation

The nuclear safety of 1989 Kg of 1.25% U-235 enriched uranium fuel elements was reviewed and approved for shipment to ORNL.(1) For the packaging, handling, and shipping limits specified, this shipment represented less than 25% of a critical mass. Under optimum conditions of moderation and geometry, the fuel elements would have represented 1.6 minimum critical masses.

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(1) Letter, P. F. Gast to F. J. Zelley, Nuclear Safety of 1.25% U-235 Enriched Uranium Shipment, April 4, 1961.

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Mass Spectrometry

Studies were made to determine the cause of a bias in the U^{235}/U^{238} abundance ratio for natural uranium as measured on the heavy element mass spectrometer. The primary cause of the bias was isolated to a nonlinearity in the electron multiplier part of the ion current measuring system. The U^{235}/U^{238} ratio was observed for several sample loadings of natural uranium at various ion beam intensities and current gain settings of the electron multiplier. In all cases the observed U^{235}/U^{238} ratio was below the accepted value for natural uranium and appears to be most strongly correlated with the magnitude of the output current of the multiplier for the major isotope. The departure of the observed U^{235}/U^{238} ratio from the accepted value varied from about 1.3 percent at an output current of 3×10^{-8} amperes to about 4.2 percent at 1.4×10^{-7} amperes. An extrapolation of these measurements to zero multiplier output current yields a U^{235}/U^{238} ratio about 0.5 percent below the accepted value. At present the mechanism of the nonlinearity of the electron multiplier with output current is unexplained.

Instrumentation and Control

Investigations continued on the tracer lathe control system for CPD. Six of these lathes were delivered by the manufacturer and found unable to meet the desired tolerance. Stability studies are aimed at synthesizing the proper compensating networks to provide stable operation with the desired tolerance. A measuring technique was established which allows a suitable determination of the linear and non-linear transfer functions of the system.

Several resonances have been found which have not all been identified. One may be due to a vibration of part of the lathe structure itself. Others seem to be sub-harmonics which arise because of nonlinearities in the system. As first trials, mostly by guess, some simple corrective networks appeared to help. An analysis from accurate test data will be needed to eliminate the guesses.

The addition of dither at 300 cps, as recommended by the General Engineering Lab, did not seem to help. However, this frequency is beyond the capabilities of the Brush recorder, and it is not certain if reliance can be placed on this conclusion.

As an interim measure, to get the lathes in operation in June, CPD is adjusting them, increasing the size of the hydraulic piping, adding accumulators, and shielding as many electrical leads as possible. Dither at 60 cps does help some, and will probably be used. The results of this work will be that the lathes can be used, but at reduced accuracy and at reduced cutting speeds. Modifications to the electronic portions to obtain a more acceptable system can be made after the lathes go "hot". It is planned to keep one lathe "cold" for the development work to continue.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Cross Sections

Tests were made on the newly prepared fission chamber to be used in the remeasurement of the Pu^{239} fission cross section in the vicinity of the 0.3 ev resonance. An "edge effect" or the falling off of detected fission activity observed as a

1/8 inch diameter neutron beam is scanned across the fission foils was eliminated by increasing the chamber gas pressure from 5 pounds to 15 pounds absolute. The fission counting rate is observed to be about a factor of 100 below what is anticipated even after realigning the aluminum crystal of the spectrometer.

The evaluation of the low energy neutron cross sections of the fissile nuclides for an invited paper at the Neutron Physics Symposium at Rensselaer Polytechnic Institute, May 5-6, 1961, was completed. Provisional values for the 2200 m/sec parameters for U^{233} and U^{235} were reported last month. Provisional values for Pu^{239} have now been derived on the assumption that the values obtained for eta for Pu^{239} are the most probable source of the four percent discrepancy which exists in the derived parameters. The provisionally recommended values for Pu^{239} at 2200 m/sec are: $\sigma_{nT} = 1018 \pm 5$, $\sigma_{nn} = 10 \pm 3$, $\sigma_{nx} = 1008 \pm 6$, $\sigma_{n\gamma} = 254 \pm 11$, $\sigma_{nf} = 754 \pm 9$, $\alpha = 0.337 \pm 0.017$, $\nu = 2.89 \pm 0.05$, and $\eta = 2.16 \pm 0.05$.

Fast Neutron Cross Sections

Investigation of malfunctions in the chronotron system occupied a major share of the month. Two interrelated difficulties in the uniformity of channel width were studied. One was cured, and the other tentatively attributed to trouble in the 256-channel analyzer. In a thorough overhaul of the analyzer, more than 20 badly-soldered joints have been discovered and repaired, but correct operation in conjunction with the chronotron has not yet been re-established. The recording of events by the chronotron in the absence of an "accept" pulse in the side channel was traced to a chance-coincidence phenomenon and cured by revising the times required for various circuit operations.

A transit was obtained from Field Survey Operation on indefinite loan. It will be used in Van de Graaff alignment. Scintillating materials capable of pulse-shape discrimination in addition to fast time resolution were received from the vendor. Orders were placed for a special 5-inch photomultiplier for the time-of-flight program and for a Hall-effect gaussmeter to be used in demagnetizing the analyzing magnet on the Van de Graaff.

Slow Neutron Scattering Cross Sections

A set of measurements to determine the relative sensitivity of the analyzing spectrometer at 0.05, 0.1, 0.15, 0.2, 0.25, and 0.3 ev final energy has been completed. The results obtained are not completely consistent, however, and further work is being done to identify the cause of what appears to be a large systematic discrepancy between upscattering and downscattering.

The series of scattering measurements at 0.2 ev incident neutron energy has continued. Energy analysis runs have been made for the 13 mil water sample at 10° scattering angle, the $\frac{1}{4}$ inch vanadium sample at 10° and 50°, and for an empty water sample holder at 10° and 30°.

Work is still under way on the construction and testing of a cryostat to be used in resolution function measurements employing vanadium at liquid nitrogen temperatures.

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Instrumentation

Considerable time was spent trouble shooting the fast neutron time-of-flight vernier chronotron and the 256-channel memory. The troubles with the vernier chronotron may have been cured, but this will not be certain until the instrument technician finishes clearing up all the many troubles in the 256-channel analyzer.

A more conveniently adjustable circuit is being developed for pulse shape discrimination against gamma rays. The present scheme requires access to the photomultiplier unit for adjustment. This is not considered convenient, especially while the accelerator is running.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

The Critical Facility of the PRP

An appropriation request has been approved for experimental equipment to be used with the PRP-CF. Two scalers, a tuning fork oscillator, and the necessary components for two additional transistorized scalers will be purchased. The oscillator and two scalers will be used as an electronic timer for measuring periods. The transistorized scalers will be assembled by the Physical Measurements Unit. These scalers will be used to obtain data from fission chambers and BF_3 counters. Specifications for the purchase of some of these items have been written.

The description of the MTR-ARMF experiment has been distributed as HW-69169. The distribution was limited because it is written for the benefit of the personnel who will be making the reactivity measurements in the ARMF. Eventually a formal document (HW-69169 Rev.) will be issued with a larger distribution.

It is planned to replace the samples which are to measure the sensitivity of the ARMF to absorbers. As originally planned boron tape was to be fastened on to samples which contain the same composition of plutonium. However, it may be possible to mix the required boron with the fuel. If this can be done a more accurate calibration of the ARMF could be made.

PRTR Startup

Summaries of the results of the PRTR Critical Tests for Series I and II have been distributed to interested personnel. The results are not complete or final. As other results become available, they also will be distributed. Analysis of void coefficients has presented some conceptual problems. A revision of the cell homogenization technique used in the SWAP code was recommended, which may help in the resolution of these problems.

Participation in Series III experiments was begun April 21, 1961. The reactor was loaded to critical with a three zone loading which will probably be the loading for the power tests. A traverse of the flux in a plutonium lattice cell and a UO_2 lattice cell were made with lutetium foils. In addition, data to determine β/L by the noise analysis technique and the final calibration of the shims were obtained. The reactor was shut down on April 26 in order to prepare the elements

for the power tests.

Analysis of the data from lutetium foils which were irradiated during Series II has begun. The analysis is being made with a modified version of LULU. Activities of the foils at the end of the irradiation have been obtained for both Lu-176m and Lu-177. Before a spectral index can be obtained from the data the activities must be corrected to saturated activities. The analysis is complicated by the fact that the foils were irradiated during three period measurements rather than at a constant power level.

Low Exposure Plutonium Lattices

The measurements of k_∞ and f for 19-rod clusters of 1.8 w/o Pu-Al fuel in a $6\frac{1}{2}$ inch graphite lattice were begun on April 20, 1961. The first two days of experiments were observed by Pierre Bacher of Saclay, France. Collection of data is proceeding on a two-shift basis and will continue into the second week in May.

The neutron spectrum in this lattice is quite under-moderated, with a cadmium ratio at the cell boundary of about 1.7, using .006" Au foils with .040" cadmium covers. Cadmium ratio measurements are being made with detectors of Cu, Au, Pu^{239}, U^{235} and lutetium in an effort to define the shape of the neutron spectrum throughout the lattice cell.

Plutonium Fuel Temperature Coefficient and Pu-240 Effective Resonance Integral

A cost estimate has been received from Plutonium Fuels Development Operation for fabrication of high (16% Pu-240) and low exposure Pu-Al 19-rod clusters for the fuel temperature coefficient experiment, and for the fabrication of the rods for the Pu-240 effective resonance integral experiment. Some modifications of the specifications have been made that will reduce the cost without reducing the value of the experiments. A work order has been written to start work on both jobs.

Neutron Spectrum Studies

The shape of the Pu-239 fission and absorption cross sections which Westcott used for his calculations (CRRP-960) does not agree with the shape of the curves (TNCC(US)-58) which best fit all of the measured data. Since the proper shapes for these cross sections is important for neutron spectrum studies and calculations which involve plutonium, the program ACE is being used to find the function which will generate the proper cross sections. Westcott obtains his cross sections by fitting a function which is the sum of single-level Breit-Wigner equations to the experimental data. The parameters which he obtained from fits are being modified until a fit is obtained to the data in TNCC(US)-58. The fit to the Pu-239 fission data is completed and the modifications to the absorption data have begun.

Neutron Rethermalization

The multithermal group diffusion model introduces the concept of rethermalization in a description of the space-energy distribution of thermal neutrons. If the rethermalization cross sections are set equal to zero or infinity this model reduces to previously used diffusion models. Comparisons have been made between these reduced models and the multithermal group model. The results illustrate the superiority of the multithermal group model. The results have been included

in a NPRO Quarterly Report for January, February, March, 1961.

The experimental apparatus for experiments with a 5-5/16-inch diameter copper rod has been fabricated and is ready for use. Completion of the apparatus for the 1-1/2-inch diameter rod experiment is expected by May 5, 1961.

Europium oxide has been received for fabrication of Europium-resin detectors which are also to be used in these experiments.

Effective Radii of Neutron Detector Pins

The question of the resolution of an irradiated pin traverse, or the effective radius of neutron detection of a cylindrical detector in a cylindrical rod, has been of concern for some time. This problem has been formulated and solved exactly under the assumption that the unperturbed neutron flux in the rod is the I_0 Bessel's function.

The result is that the effective radius of detection is the physical radius, independent of the size of the detector pin. The detector is assumed to have the same diffusion properties as the rod. The effects of spectral hardening have been neglected.

A correction has been calculated for the case of an unperturbed neutron flux with a quadratic radial dependence. The correction is radius dependent and is a function of pin size.

Analysis of Uranium Oxide Temperature Coefficient

Additional work has been done on the fit of the fuel temperature coefficient data to a better extrapolation formula. The errors that are attached to the numerical values reflect all uncertainties except those due to flux and adjoint mismatch. These are being determined. For the 42-minute heating cycle, from 322 to 767°K, the fitted equation and the required expressions thus far obtained from this equation are

$$\ln p(T_0) - \ln p(T) = -(23.5 \pm 0.6) \times 10^{-3} + (1.32 \pm 0.03) \times 10^{13} \sqrt{T(°K)},$$

$$\frac{1}{p(T)} \frac{dp(T)}{dT} = \frac{1}{k_\infty(T)} \frac{dk_\infty(T)}{dT} = -(6.6 \pm 0.2) \times 10^{-4}\, T^{-\frac{1}{2}}(°K),$$

and

$$\Delta k_\infty(T) = (27.0 \pm 0.7) \times 10^{-3} - (1.51 \pm 0.04) \times 10^{-3} \sqrt{T(°K)} \quad .$$

The results for the 65-minute heating cycle, from 323 to 789°K, are the same within the errors of the measurements.

Effect of Neutron Rethermalization on the Fuel Temperature Coefficient of Reactivity

The method described last month for determining the rethermalization cross section of aluminum as a function of temperature did not take into account spectral hardening. In order to include this effect, the spectral model becomes both cumbersome and arbitrary. In order to circumvent this complication, a new approach

is being considered whereby the spectral effects due to heating the aluminum are lumped into the thermal blackness of the rod.

Slowing Down Models

A study of various slowing down models has been undertaken to determine the appropriate models for calculating spectra to use in determining group constants. Particular emphasis is being placed on the range of validity in terms of energy and types of material.

The simpler slowing down models, obtained by assuming the incident neutrons are scattered isotropically in the center of mass system from a stationary scattering nucleus, have been compared. The COVEYOU-MACAULEY slowing down model is obtained from a second order Taylor series expansion in the diffusion equation. The Selengut slowing down model is obtained by a similar expansion in the slowing down density. In both schemes, the resulting equation for the flux correspond to second order differential equations. The two schemes may be compared by calculating the neglected third order term. The COVEYOU-MACAULEY model has the smaller third order term for all materials except hydrogen, in which case the Selengut model has the smaller third order term.

Plutonium Fuel Value Study

Analysis of the Advanced Pressurized Water Reactor is now in the final stage, with production runs currently scheduled for the computer. Several boron concentrations were studied earlier; the effect of boron poisoning is, as expected, almost entirely in the saving of required reactor control capacity. The effect on attainable exposure and plutonium composition is very small.

Cross Sections

New values of the Westcott g and s factors have been fitted with polynomials by the least squares methods, and are now being used in the MELEAGER code. The RBU Basic Library edit routine is now finally complete, and a routine was written to allow the Library to exist in column binary card form. This routine will punch cards from the binary tape, and also write a binary tape from the cards. The Library itself is now apparently free of formal errors.

Supercritical Water Reactor Study

Analysis of resonance capture in this lattice by the IDIOT code appears unsatisfactory. A set of curves suitable for use in manual calculations of the external and internal Dancoff correction factors was developed.

Code Development

Fuel Cycle Codes

C. H. Westcott's analysis of the relationship of cross sections to the neutron spectrum in modified one-group approximations has been criticized as inconsistent with neutron conservation in the epithermal region. A modification of the MELEAGER code was formulated to further explore this question.

A new code, Wessex II, has been formulated to evaluate the closed-form solutions of the linearized burnup equations. It is now being written by personnel of the Electronic Data Processing Operation.

The thermalization routine used in RBU proved to be inadequate and was completely reformulated. The revised routine was being debugged at the end of the month.

C-6

Debugging of the Hanford version of the spectrum code C-6 continues. In a few test cases which can be solved analytically, the C-6 results agree with the analytical solutions. Debugging other portions of C-6 introduces additional difficulties because of the lack of C-6 test cases. One solution currently being tried is to use test cases for C-5, a predecessor code possessing most of the C-6 features. At present, some disagreement remains between these results under conditions in which apparently identical operations are being performed. An additional modification to C-6 has been made which permits the break point between the slowing down calculation and the thermal group to be an arbitrary input parameter. This feature is needed to adapt C-6 to a thermal spectrum code. Several output subroutines have also been recoded to provide a more complete and easily read presentation of the output.

Instrumentation and Systems Studies

The PRPCF "last ditch" safety fuse system was reviewed. It was concluded that it will be adequate for all reactor periods of 100 milliseconds or greater for an assumed flux of 10^4 nv. For "normal" flux levels of 10^6 nv, the fuse will be satisfactory for periods greater than 200 milliseconds.

Experiments were temporarily suspended, and an interim report issued concerning gamma scanning methods for investigation of PuO_2 concentration variations in fuel rods containing both PuO_2 and UO_2. Tests, to date, showed that two percent by weight of PuO_2 discontinuities, in comparison to normal 0.5 percent by weight PuO_2, can be located and measured using gamma scanning methods measuring the 0.384 Mev Pu gammas. Autoradiograph tests of all supplied test rods proved the approach method accuracy; however, the tests also proved that the packing uniformity (density variations) and the dispersion uniformity were both quite poor. The experiments will start again when more uniform sample rods can be prepared by Fuels Fabrication personnel.

The special instrumentation for the PRTR critical tests was reactivated for the final set of tests. The cell traversing mechanism was used with success. This device was used to place a set of foils in a horizontal position between process tubes inside the calandria. At the termination of the critical tests, all detectors were removed from the reactor and all special instrumentation was removed from the PRTR control room.

Considerable attention has been applied to the PRTR Fuel Failure Monitor. Several faulty conditions have been corrected in experimental form and the appropriate circuit modifications are being incorporated in all channels. All 85 scintillation probes were tested to determine proper gain settings. A number of checks remain to be made to determine if the total system can be adjusted or modified for proper performance.

Engineering support was furnished PRTR Operations to assist in certain phases of the instrumentation design testing during the first two weeks in April. Special assignments completed during this period include:

1. Process tube flow monitoring system. The performance of five 0-10 psig flow monitor units was examined in the laboratory, and the results were reported in Physical Measurements Memo 61-10. The data obtained during the initial flow monitor system tests (Design Test 2, Section 4b) were reviewed, and the conclusions (trip settings were not properly adjusted prior to the test) and recommendations forwarded to PRTR Operations.

2. A design change, to convert the existing D_2O storage tank level measuring system to a bubbler type liquid level measuring system, was generated, submitted, and approved.

3. A method of increasing the time constant in the trip circuit of the building exhaust air activity monitor system was designed, submitted, and approved.

4. A design change which will add a third channel to the existing exhaust air activity monitor was generated and submitted for approval. This design change will include converting the present air monitor safety circuit to a coincident type safety circuit.

Two methods of recording neutron flux were used to obtain kinetics data on the PRTR. The first used an ionization chamber to measure the statistical variations of flux level, identical to the method used on the TTR. The second method used a proportional counter, a high speed (one megacycle) scaler and a count rate meter to obtain the signal. This method has not been reported as far as known and is being tried here for the first time. These data have just recently been recorded and the analysis necessary to obtain neutron lifetime is yet to be completed.

Fabrication of the probe assembly for measuring the wall thickness of PRTR process tubes is approximately 50 percent complete, but further work on this project has been temporarily discontinued. Four ultrasonic transducers having active surface areas of 1.0 x 0.5 inch have been received. Preliminary tests indicate that these large area transducers exhibit greatly improved acoustic coupling characteristics over the small area units used heretofore.

Assembly and calibration were completed on the Mark II (radiation resistant) probe for measuring the inside diameters of PRTR process tubes. Final leak testing awaits the delivery of special "O" ring seals for the linear variable differential transformer shafts.

The PRTR gas balance system simulation is in progress. Under certain operating conditions, the enclosed gas system may become oscillatory. The gas pressure oscillation will, in turn, cause an oscillation in the moderator level and consequently, a power level oscillation. This study has been initiated in an attempt to determine the necessary system changes to eliminate the possibility of oscillation. The preliminary work has been completed and the problem is ready to go on the computer.

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NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

The first quarterly report was received on a study of signal analysis applied to nondestructive testing being made under a research contract by The Johns Hopkins University. The first report is titled "Nondestructive Testing Signal Analysis: On the Identification of Multiparameter Systems" by W. H. Huggins and L. G. Wolsey. The problem considered is that of specifying an optimized driving or probing waveform and the instrumentation for the simultaneous and independent determination of deviations of test specimen system parameters from their nominal values. The use of a set of growing exponentials as an optimum probing signal is discussed. It is shown that the test system may be decomposed into a number of parallel component systems, each associated with various combinations of the system parameters. Requirements concerning selection of optimum probing signals and the independent measurement of parameters are explored, and suggested means to apply the theory developed to lumped circuit models are given.

Means for stabilizing the temperature of eddy current test coils are being evaluated. Eddy current coils experience a temperature rise due to current flowing in the windings, and when brought near a test specimen, can be subjected to additional heating or cooling affecting the impedance of the test coils. Such changes can cause undesirable drifts in instrument readings which are most objectionable in the case of instruments with direct current readout such as those used for conductivity, inductive thermometry, thickness and other dimensional measurements.

An automatic probe coil temperature control circuit has been tested which utilizes the eddy current coil for both temperature sensing and heating functions. Coil temperature changes were reduced to one-tenth of that experienced without the control. Closer control is anticipated by optimizing control circuit adjustment.

A report titled "Eddy Current Device for Detecting Anisotropic Conditions", HW-69269, by H. L. Libby was prepared, issued, and submitted as an invention disclosure.

Heat Transfer Testing

Evaluation of plasma arc jet heating for application to heat transfer testing has indicated that it is in some ways superior to induction heating. Purchase specifications for a plasma arc have been written. Zircaloy-clad uranium heat transfer standards have been designed. Tests have shown that emissivity variation of as-welded aluminum self-supports is too great to allow heat transfer testing. Autoclaving to produce more uniform emissivity has been completed.

Initial evaluation of the plasma arc jet as a heat source for heat transfer testing has been completed. The main difficulty found in the present series of tests is occasional failure of the arc to start, and the requirement of approximately two seconds for the arc to reach full equilibrium power after it is started. However, these difficulties should be overcome by using a water-cooled copper shutter to interrupt the arc, rather than switching the electrical power on and off. Power transferred to the test piece from the arc is stable enough that no variation in surface temperature due to arc flicker has been found above the noise level of either the infrared radiometer or the eddy current thermometer.

The plasma arc jet has an important advantage over induction heating in that it is not so sensitive to spacing between the heat transducer and the test piece. Therefore, small changes in spacing due to eccentricity, ellipticity, and other irregularities of the test piece surface do not cause detrimental variations in surface temperature. This is very important in testing of coextruded Zircaloy-clad uranium fuel elements, self supports, and other test pieces having projections or surface non-uniformities.

A Zircaloy-clad coextruded uranium fuel element was tested using a plasma arc jet heat source, and infrared surface temperature radiometer. Surface temperatures on one side of the test piece were consistently higher during testing than at other points. Several Zircaloy-clad uranium heat transfer standards have been designed, and are now being fabricated. These heat transfer standards should allow better interpretation of data from Zircaloy-clad uranium fuel elements.

An attempt to test self-support bonds on X-8001 aluminum alloy clad uranium fuel elements showed that emissivity variations between different self supports in the bright "as welded" condition were too great. These fuel elements have been autoclaved to provide a more nearly uniform emissivity.

The plasma arc jet in the present series of tests has been on loan from Ceramic Fuels Operation and must be returned in the near future. Purchase specifications for a plasma arc for application in heat transfer testing development have been written.

Variation in surface emissivity of test pieces is the limiting factor in sensitivity of heat transfer tests when using infrared detectors as the surface temperature monitors. An attempt is being made to develop a new type of high speed emissivity independent radiometer.

A lathe has been obtained for application in a heat transfer tester for immediate application and further evaluation of existing techniques. A plant forces work review has been completed, and this heat transfer testing equipment is being installed.

Zirconium Hydride Detection

Fast neutron scattering measurements were conducted using the Van de Graaff generator. Fourteen-Mev neutrons from the $T(d,n)He^4$ reaction and five-Mev neutrons from the $D(d,n)He^3$ reaction were used. The Li^6I scintillation detector was shielded by surrounding it with two inches of lead and six inches of lithium-loaded paraffin.

Preliminary measurements indicated the neutron and gamma background presents a serious problem in detecting neutrons scattered from the sample. The shielding was found to be inadequate to resolve the signal produced by neutrons scattered from even a sample of paraffin above the background signal. Direct neutrons from the target and scattered neutrons from nearby objects completely masked the signal due to elastically-scattered neutrons from the sample. It is believed secondary effects within the scintillation crystal itself in addition to its gamma ray sensitivity are contributing to the background signal.

Presently a circuit to be used with a stilbene scintillation crystal is being designed and checked. Previous investigators have successfully used this crystal

as an efficient fast neutron (1 to 10 Mev) detector while providing a rejection of 99.9 percent of gamma and beta rays. The gamma and beta ray pulses are separated from the neutron pulses through use of the pulse shape characteristics of the stilbene crystal. The pulse shape is different for neutron pulses than for gamma and beta pulses. When the circuit is complete, neutron scattering measurements will again be scheduled at the Van de Graaff generator.

A low noise, narrow bandwidth, high gain amplifier has been designed and constructed for Hall voltage measurements. The noise level has been reduced to 0.004 microvolts, referred to the input, through the use of a special purpose low noise input transformer driving a triode circuit. The bandwidth was reduced to approximately one to two cps through the use of two parallel tee filter networks in feedback loops in following stages. Gain at the center frequency is approximately 10^7.

The Hall Effect sample holders have been completed, and present efforts are toward eliminating stray pickup due to magnetic and electrostatic coupling.

Consideration is being given to the nuclear magnetic resonance method of detecting hydrogen in zirconium, and as an initial step a simple autodyne circuit is being fabricated.

NEUTRON FLUX MONITORS

Consideration is being given to several possible experimental techniques for testing the response of prototypical Pu isotope extended lifetime neutron detectors. It is desired to develop experiments which will test the validity of the computational models which have been used in the analyses to date. Possible composite foil sensitivity measurements using the Thermal Test Reactor are currently being evaluated. The TTR flux spectrum can be shaped similar to that in the Hanford production reactors, although, of course, the flux level is much lower.

For in-core flux mapping applications, it may be advantageous to have a detector with a 1/v cross-section. This gives an output independent of the thermal spectrum and proportional to the neutron density. Since the Pu isotope detectors do not have a 1/v response, they may have to be surrounded by a shield or filter for certain flux mapping applications. It has been determined that the Meleager computer code cannot be used to examine the feasibility of shielding the Pu isotope units to obtain 1/v response. The shielding problem will require a multigroup approach and a "least squares" fit to find an appropriate shield.

The effects of varying neutron temperatures upon the responses of the Pu detectors are being further examined. In a given reactor application it may be possible to alleviate such effects by judicious placement of the detectors; in the center of coolant channels, for example.

PHYSICAL RESEARCH - 5000 PROGRAM

Mechanism of Graphite Damage

Samples of graphite were irradiated with 0.018 coulombs of 2 Mev electrons at dry ice temperature. No change in resistance was observed. Equipment is being prepared to permit irradiation at liquid nitrogen temperature.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Results of studies of deposition of zinc sulfide tracer material utilizing the 1959 diffusion data were summarized with publication of HW-69292. The report includes estimates of deposition from mass continuity determinations, comparison of exchange parameters with those found by other investigators, and discussion of a gaussian diffusion model that accounts for loss of material from the air due to deposition. No firm conclusions were presented because of the limited data available for the analysis. Instead, the significance of the deposition phenomena was pointed out and methods of experimentation that will ultimately lead to clarification of the complex interactions between the important physical variables were discussed.

Calibration of the rain-droplet sampler for use in studies of precipitation scavenging processes was completed for the droplet size range 0.25 to 4.6 mm. equivalent diameter. Quantitative measurement of the efficiency with which raindrops scavenge zinc sulfide tracer particles from the air as a function of drop size, and determination of raindrop-size spectra to smaller sizes than have been previously reported in the literature will result from this development. Microscopic examination of 681 droplets collected during a diffusion experiment in natural rain provided preliminary estimates of scavenging efficiency for purposes of experimental design. The values found were greater than 20% and 12% for the size ranges 0.22-0.65 mm and 0.65-1.2 mm, respectively, confirming that the estimates used in our feasibility study were reasonable.

Three additional diffusion experiments were attempted during the month, with two successes, bringing the totals for the year to nine successes in thirteen trials. One successful experiment was conducted using an elevated source located at 200 feet height on the meteorological tower with dosage measurements at 1.5 meters height to a distance of 1600 meters on a horizontal grid. A similar experiment failed when the wind shifted shortly after startup, carrying the tracer material off the sampling grid. The second successful experiment utilized a source near ground level with dosage measurements on both the horizontal and vertical sampling grids to a distance of 3200 meters.

Activities in Air Force supported programs increased during the month in preparation for conducting diffusion experiments at Cape Canaveral, Florida, during May and June. Scheduled startup date is May 15 with completion of the first series by June 30. A second series of experiments is scheduled for November. Startup at Vandenberg Air Force Base, California, is scheduled for June 5 with completion of this series in eight weeks. Extensive climatological summaries were prepared for both sites for use in scheduling field operations. Instructional material was prepared for orienting and training field crews. Field engineering and technical assistance was provided to Air Force contractors responsible for preparing the field sampling grids. Shipment of all special materials (fluorescent pigment, calibrated orifices, sampler assemblies and accessories) supplied by Atmospheric Physics Operation for the first Canaveral series was completed.

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DOSIMETRY

The P-32 subject obtained last month was studied again. A slow redistribution of the P-32 is taking place from the center of the body to the extremities. During the first month the higher counting rates were obtained over the lower chest area. Now the higher counting rates are obtained over the upper chest and the pelvis.

Another P-32 subject was studied. He is a plant employee who received P-32 for diagnostic purposes. The distribution of the P-32 has been similar to that of the first subject.

Radiation Protection Operation was assisted in the identification of an unusual isotope found in a subject during their routine counting program. The isotope was identified as Sb-125. Identification was made through measurement of gamma ray energies. Detection of a 27 kev conversion X-ray with the plutonium X-ray counter confirmed the identification.

Studies were begun of the elimination of Sb-125 from the above subject. Studies were continued of the elimination of Co-60 from a subject in a case reported previously. Studies are being made of the elimination of Zr-Nb-95 and Ru-106 from a subject whose contamination status was discovered during the routine counting program this month.

The positive ion Van de Graaff was out of operation half of the month. Part of this time was due to failure of supporting instrumentation. The rest was required to repair a water leak in a mercury diffusion pump. The accelerator operated satisfactorily during the rest of the month. The grating floor of the laboratory was covered with thin sheets to give a smooth working surface. Better storage facilities were provided in the laboratory.

The work to date on the precision long counter was summarized in a report presented to the American Physical Society.

Some careful studies were made with the double moderator of thin targets of deuterium adsorbed in titanium or zirconium and bombarded with deuterons. These studies showed that the neutrons produced from these targets were not as monoenergetic as we had supposed. A gas flow target now being fabricated should eliminate this problem. The use of a potassium iodide scintillation counter for energy measurements of the sort required for this problem was investigated.

The gamma ray calorimeter was placed in operation again. It is intended to measure the half-life of the Sb-124 neutron sources.

A large moderator was designed in cooperation with Radiological Development Operation. They have completed fabrication of the moderator. It will be placed around the Van de Graaff target and be used in neutron activation studies and source strength measurements.

INSTRUMENTATION

Final prototype fabrication continues on the experimental scintillation airborne plutonium monitor which uses coincident counting techniques to eliminate interference from radon-thoron buildup. Circuitry fabrication is 75 percent completed.

Experimental fabrication continues on the miniature alarming personnel dosimeter which uses a modified "pencil" ionization chamber, a quartz fiber illuminator, a CdS cell, and transistorized circuitry. The breadboarded model worked satisfactorily in tests throughout the month.

Two new approaches are being investigated, using quartz fiber ionization chambers, for personnel alarming dosimeters. One method uses an automatic recharging technique with one pulse out for each 4.5 mr of dose received. The second method employs a contactor-type, aquadag coated fiber and alarm circuit. The coated fiber unit worked satisfactorily in tests and carried 10 microamps of current, for later amplifying and alarming, without difficulty. For all miniature personnel alarming dosimeter work, stress is being placed on the use of ionization chamber detectors in order to obtain a reasonably proper measure of accumulated dose and dose-rates. The miniature G.M. tube detector unit, although successful in prototype operation, has poor energy response characteristics for use in measurement of dose-rates and dose.

Variations in gamma background levels in the 200-West Medical Building were investigated in conjunction with the imbedded-plutonium Wound Monitor in use at that building. Variations of twice normal, or average, levels were obtained on a number of occasions during the month. Such level changes adversely affect the Wound Monitor effective sensitivity.

Development of a new pulse height selector circuit, using silicon transistors, was completed and a prototype unit is being fabricated. Operation of 0° F to + 150° F is satisfactory by simple adjustment. At any one adjustment, ambient temperature variations of ± 10° F do not affect calibration.

Final development was completed on a miniature "palm-size" alpha survey monitor using a silicon surface-barrier diode detector and transistorized amplifying and gated oscillator annunciator circuit. Two prototype units will be fabricated. Some progress was made concerning the use of the surface-barrier diodes for alpha energy analysis work with completion of a small vacuum chamber. Efforts continue concerning the use of Li^6F with the detector diodes for use as neutron detectors.

Investigative work was started concerning tritium monitoring detector techniques for both portable and line-operated instrument applications. The initial work concerns the use of two matched phototubes with 0.002 inch thick terphenyl-in-polyvinyltoluene sheet detectors over each tube with a cover over one detector to eliminate tritium betas. The detectors will have a light tight housing with a miniature blower. The method used will integrate the difference between the two tubes with periodic (chopper) discharge to produce a variable decay time pulse. The decay time of the pulse will be used, with transistor circuitry, to drive a meter. The present sampling period is 0.5 seconds at present. This is a challenging problem to obtain suitable meter indication at 0.1 MPC or less of airborne tritium, and the technique being investigated appears to be new.

All necessary circuit development was completed on the low-power consumption decade (binary-quinary) transistor scaler and other required circuits for a prototype gamma energy analysis portable instrument with both scaler and count-rate-meter readout. One prototype unit is being fabricated for eventual use by Biology Operation personnel. The instrument, by probe selection, is expected to be extremely versatile for many low-level monitoring problems throughout the plant.

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SECRET DECLASSIFIED

Continued developmental progress was made on the Automatic Film Badge Densitometer system. The programmer unit was fabricated and is now being tested. Slight revisions of power supply circuits proved necessary to improve regulation. The system circuitry design-development effort is now 90 percent complete. Several offsite purchases still have not arrived.

Technical progress continues on the circuitry for the personally carried portions of the Integrated Radiological System with methods of readout and transmission under investigation.

Investigations with a moving tape air filter head and our transistorized circuitry for use as a beta-gamma (mixed fission products) air monitor produced the following results:

Radionuclide	Continuous Concentration	Time to Alarm	Efficiency	Air Flow
1. Sr^{90}-Y^{90}	3×10^{-10} μc/cc	61 minutes	28%	15 CFM
2. Mixed Fission Products	1×10^{-9} μc/cc	25 minutes	20%	15 CFM

The results were obtained with the alarm level set at two times the maximum radon-thoron levels. This level equates to the same meter deflection as from a 10 mr/hr gamma field in which the lead shielded detector head is placed. Thus, similar alarm times would be obtained for operation in a 10 mr/hr gamma field. The complete system was installed for use in the 327 Building. This instrument is about ten times more sensitive than the portable, fixed filter units in use on plant primarily because of the heavier shielding. It is also more expensive.

Accelerated experiments continue on the thermoluminescent dosimeter (CaF_2:Mn) problem in an effort to improve the low-gamma energy response and the angular response. By using a 1/8-inch-thick lead "Button", lined with 3-mil bronze, as the finely ground CaF_2:Mn holder, the detector was determined to be gamma-energy independent to ± 10 percent from 17 Kev to 1 Mev except for a region centered near 70 Kev. Both glass container thickness and bronze lining thickness will be varied in an effort to flatten the energy response curve.

The new-design lucite light pipes were nearly completed for use in the experimental combined alpha-beta-gamma transistorized hand and shoe counter.

The material for building a spectrum data storage device for the whole-body counting facility was purchased. The proposed system will be capable of storing up to four 400-channel pulse-height spectra on a magnetic drum and transmitting the data back to the analyzer memories in either binary or binary-coded-decimal form. In this way, spectra may be sent from any of four analyzers to the same decoder, printer and tape punch, making possible considerable saving in the cost of readout equipment.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis

The mass spectrometer for this program provided isotopic analyses of the program samples received this month. The program sample load processed was again about 200 percent of the goal.

A study was made of the nature of the low ion current background which exists throughout the uranium mass region and limits the detection of minor isotopes in a sample. Evidence was obtained indicating that this background is composed mainly of Re^+ ions which are reflected by the walls of the analyzer tube into the ion detecting system. Re^+ ions are evaporated from the hot rhenium ionizing filament of the source and, depending on sample size, are from 10 to 1000 times more abundant than uranium sample ions.

To reduce the reflection of Re^+ ions and minimize this background a set of baffles was designed and installed between the magnet and ion detection system of the mass spectrometer.

TEST REACTOR OPERATIONS

The cleanup of the plutonium spill was completed and the PCTR was loaded to critical April 19, 1961. Final adjustment of the moving face rails still remains to be done. There was one unscheduled shutdown due to faulty bypassing technique.

The plutonium-aluminum fuel in a 6-1/2-inch lattice experiment was started during the month.

Two groups of foils were irradiated in the TTR during the month. One group was for Cd ratio comparisons of various materials and the other was Lu_2O_3 pins to determine the amount of Lu_2O_3 that would give a 1 percent self-shielding factor in 0.050 inch diameter pins.

Reactivity measurements of 8 samples (consisting of 4 sets of 2 each) of stainless steel fuel element jackets were made for Reactor and Fuels Research and Development Operation. These measurements were made to calibrate the samples for a future experiment and to determine if any contamination with elements of high neutron cross sections were present.

The data for the neutron lifetime experiment in the TTR have been analyzed. The experiment was performed three times, twice using air to insert the poisoned piston into the core and once using helium. The resulting lifetimes were 0.263 and 0.271 milliseconds using air and 0.287 milliseconds using helium.

The results indicate that the effect of using air to insert the poison is not significant and the prompt neutron lifetime in the TTR is 0.274 milliseconds if the value of the delayed fraction is 0.00755.

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CUSTOMER WORK

Weather Forecasting and Meteorological Service

The second in a series of three scheduled reports on prospective 1961 crests of the Columbia River flow at Hanford was issued on April 20. As of April 1, 1961, snow water in the Columbia River watershed above Hanford, although substantially above that on the same date of 1960, was still slightly below the 1943-57 average. The peak flow rate is expected to be about 100,000 CFS greater this year than last, resulting in crest elevations at least one foot above those of last year, as shown in the table below.

		1961 Forecast	1960 Observed
Peak flow (units of 10^3 CFS)		370-450	311.4
Peak stage (feet MSL) at:	100-B	405.0-408.0	403.4
	100-K	400.0-403.0	397.7
	100-D	394.0-396.5	392.2
	100-H	386.0-389.0	384.0
	100-F	381.0-383.5	378.8
	Richland	349.0-352.5	346.5

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

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	83.9
24-Hour General	60	87.4
Special	178	83.7

Temperatures were a little below normal and precipitation a little above. However, 0.21 inch of the 0.48-inch precipitation total occurred in only twenty minutes during a thunderstorm on the 29th.

There were numerous windy days, although the average speed for the month was only a little above normal.

Instrumentation and Systems Studies

Design has been completed for the installation of the hydrogen detecting system in the 333 Building autoclaves. Autoclave Engineers, the present construction contractor, has estimated $7,000 installation costs for the detection system as against a $2,500 estimate by General Electric. For this reason the project engineer has asked J. A. Jones for an estimate.

A circuit was developed to generate a precisely shaped pulse to activate a trap in the IBM-7090 computer. The pulse generator, which has a repetition rate of one to one-hundred cycles per second, will allow the timing of selected sections of a 7090 program. At present there is no other way economically to determine the time required for the 7090 to perform involved sub-routines.

Electronic circuitry fabrication is 80 percent complete on a combination alpha-beta-gamma Stack Air Monitor for use by Chemical Research Operation, 325-A Building. The mechanical portion is scheduled for fabrication completion within two weeks.

Discussions were held with Radiation Protection Operation monitoring personnel concerning recommendations for an airborne alpha filter monitor for the Fuel Recycle Pilot Plant. Our developed and tested coincident-count alpha air monitor was strongly recommended.

Advice was rendered to 308 Building personnel concerning fabrication of two alpha shoe monitors (vertical wall mount) with transistorized circuitry.

All development and design work was completed on a special sensitive scintillation Beta-Gamma Portable Field Monitor for use by Biology Operation personnel. The unit will be fabricated in the 328 Building Electronics Shop.

Development of the logic circuitry for the Panellit-Heise gage readout device for IPD has been started. It is planned to use commercially-available, plug-in, computer components once a satisfactory circuit is developed. All the major equipment, except the computer components, is on order and should be delivered in time to complete the project by the June 30 deadline. Delivery of the computer components by that time may be difficult.

An existing edge-control amplidyne control unit was modified for testing as a possible speed control device for a swage machine feed-rate drive. Laboratory testing of a mocked-up speed control system indicated that the drive speed could be controlled to well within one percent of the desired speed with this device and the proper compensating circuits. As a result of these tests, Ceramic Fuels Development Operation decided to purchase the necessary conversion equipment and use the amplidyne control units on two of their swage machines. A memorandum (SR-61-10) was issued on this work.

Difficulties with a High Level Alpha Air Monitor at 231-Z and with a Scintillation Criticality Alarm Instrument in the 325 Building were traced to inadequate maintenance attention. Both incidents gave emphasis to the need for proper instruction of maintenance personnel and a well-planned routine maintenance program for developed instruments placed in field use.

Calibration of micro-displacement readout systems to be used by Physical Metallurgy for in-reactor creep measurements has continued during April. To date, calibration of the Schaevitz DRS-100 system is 63 percent complete. Runs completed during April include drift tests on the 0.4-inch scale at 100°C, 200°C, 300°C, and 400°C; calibration runs on the 0.04-inch scale at 20°C, 100°C, 200°C, 300°C, and 400°C; and calibration runs on the 0.004-inch scale at 20°C, 100°C, 200°C, and 300°C. The DRS-100 has continued to exhibit inconsistent non-linearities with a continuing deterioration of operating characteristics.

Non-Metallic Materials Development, HLO, has indicated an interest in utilizing the high temperature calibration facilities for the calibration of similar transducers presently on order. The transducers are to be used for an in-reactor creep measurement of graphite in support of the Oak Ridge gas-cooled reactor program. Adapting the present reference system to accommodate these transducers will be necessary but should involve only minor changes.

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The Pulsed Extraction Column Dynamics Simulation has been completed. This study was initiated in an effort to determine the dynamic characteristics of an extraction column for various frequencies and types of driving pulses. The information desired consisted of the displacement of the column interface as a function of frequency and amplitude of the air pulser. It was also desired to determine the natural frequency of the system. This information was obtained satisfactorily.

Physical Testing

A total of 7,816 tests were made on 5,945 items representing 125,412 feet of material. Of the footage given, by far the largest was accounted for by NPR reactor process tubes and fuel element sheath tubing. Test work included: autoclaving; dimensional measurements (mechanical gaging); eddy current; magnetic particle; penetrant (fluorescent OD and ID); radiography (gamma-ray and X-ray); stress analysis; surface treatment (alkaline cleaning, pickling for autoclaving and conditioning, steam detergent cleaning, and vapor degreasing); and ultrasonic (flaw detection and thickness measurements). Work was done for 31 organizational components representing most of the operating department and service organizations at HAPO. Advice was given on 49 different occasions on general testing theory and applications.

Full production and treatment of the NPR process tubes has been achieved and is proceeding routinely. Improvements in the penetrant testing are encouraging. The additional ultrasonic flaw detection test for discontinuities transverse to the longitudinal axis is now being used on a routine basis. Successful operation of the two autoclaves has resulted in the realization of substantial throughputs. By utilizing two shifts for pickling, it has proved out that the tubes can be pickled faster than they can be autoclaved. To be able to accommodate the full production output, it has been necessary to add additional personnel for the duration of NPR tube work.

Field testing work proceeded routinely with continued effort on the reactor nozzle modification program for the bumper fuel element, followup of the 1706-KER loop pipe failures, and the strain measurement programs at the H and DR reactors. Assistance was rendered to the 100-N area in connection with NPR construction, and special assistance was given in connection with the HUICO pipe shop at Big Pasco.

A radiographic investigation was completed formulating an optimum technique suitable for accurate, economical, and rapid inspection of the inner and outer welds of production I&E fuel elements. In addition to the continuing work on Zircaloy sheath tubing, an increased amount of work was done on various sizes of stainless steel fuel element tubes. To allow accurate evaluation of fuel sheath tubing, electro-machined standards are being prepared for both ultrasonic and eddy current testing. The standards will contain longitudinal, transverse, and 45-degree notches in both the outer and inner surfaces. The notches will be from 1 to 10 mils deep and from 1/16 inch to 3/8 inch long and will have widths as small as possible. Defect-free tubing as evaluated by current testing methods was selected for the manufacture of the standards. The exact depth of the notches is being measured by replication techniques.

The preliminary evaluations made on the two eddy current instruments available indicate they vary in ability to detect wall thinning. Abrupt changes due to holes or notches are equally apparent to both machines. Work will be concentrated

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on the instrument capable of detecting gradual changes as well as abrupt changes.

Several new Parker fittings were received from IPD on the nondestructive test program to detect fittings with suspected cracks. The fittings were defected by electromachining, and these simulated defects were reliably detected by an ultrasonic technique. A longitudinal wave was made to traverse just under the threads to pick up the simulated defects; one in the thread relief and one in a thread root. It should be possible to apply the technique by contact methods. A memo giving results and recommendations for further work is being prepared.

The first functional tests of the 2-Mev Van de Graaff unit were made. The tank was successfully pressurized after all leaks were sealed. However, upon applying a voltage no tube current could be obtained. To ascertain the trouble, the tank was opened and the tube observed. It was apparent from the discharge in the tube that a sizable leak existed in the sealed X-ray tube. For the next tests an evacuated tube will be used utilizing the recently acquired ion pump.

Optics

A traversing mechanism is being developed for determining the contour of the centerline of process tubes and reactor channels in three dimensions. The present methods for obtaining the information are only partially satisfactory. The mercury manometer gives accurate information about the contour in a vertical plane. Surveying methods, using a transit and a moving target, give the contour in all planes but are cumbersome to apply and fail when the process tube or channel is distorted more than about one-half inch from straight.

The traversing mechanism will be read out with a borescope and will give complete contour information within its limits of accuracy.

The first development unit, made for 2" x 3" channels, has been fabricated and tested. Fabrication and assembly revealed the need for some change in design. These changes are currently being made. A field lens has been added to increase the field of view. Tests have shown the centering action of the springs is very good. The sensitivity is at least ± 0.005 inch per eight inches of channel length, as expected.

The method of treating the data given by the mechanism to obtain the contour of the channel has been studied and is discussed in Physical Measurements Memo 61-14. This memo also suggests other optical systems having characteristics differing from those of the development unit. Mechanisms can be built which are sensitive only to parallel displacements of sections of the channel and not angular displacements. They can also be built to be sensitive to angular displacement only.

Wooden test channels are being fabricated to further test the unit in the Optical Shop before field tests are performed.

The design of a unit suitable for use in process tubes has been completed. A work order has been requested to cover the fabrication and testing of such a unit.

A total of 440 manhours' shop work was performed during the four-week period (April 2 to April 30) included in this report. The work included:

1. Fabrication of parts for an ultrasonic wall thickness probe for Physical Measurements, HLO.
2. Fabrication of a traversing mechanism and modifications to it.
3. Repair of one borescope cross arm for Irradiation Testing, IPD.
4. Fabrication of two condenser lenses for the 105-C Fuel Examination Facilities.
5. Repair of two borescopes for IPD.
6. Fabrication of components for a radiation ratio pyrometer.
7. Polishing one lead glass window for CPD.
8. Repair of two crane periscope heads for Purex.
9. Fabrication of five filters for Physical Testing Operation.
10. Evaporation of stainless steel on 20 borescope lamps for Fabrication Shop, NPR.
11. Servicing of two Rod Room periscopes for 105-B.
12. Polishing of eight CaF spectrometer windows for Chemical Research.
13. Resurfacing of 12 pump seals for PRTR.

Analog Computer Facility Operation

The major analog computer problems considered during April include:

1. NPR Plant Simulator.
2. Reactor Speed of Control.
3. PRTR Gas Balance System.
4. Pulsed Extraction Column Dynamics Simulation.

The computer program for the speed of control of the old reactors is presently being reorganized to more efficiently use computer time. The computer circuits are being redrawn to conform to the present circuit being used. The installation of new equipment will allow the entire problem to be run on the EASE computer; i.e., it will no longer be necessary to use both computers to solve the problem. All arbitrary functions used in the problem are being tabulated and filed for ready access to the computer. Test cases will be run to cut down the checkout time on the computer. These improvements will reduce the computer time involved and the cost to the customer.

The computer operation was as follows:

GEDA	14 hours up	EASE	66 hours up
	69 hours scheduled downtime		63 hours scheduled downtime
	69 hours unscheduled downtime		39 hours unscheduled downtime
	16 hours idle		0 hours idle
	168 hours total		168 hours total

Instrument Evaluation

Evaluation tests were started concerning rechargeable small batteries for possible portable instrument application. To date, eight complete charge-discharge cycles, with care taken to prevent complete discharge which could damage the batteries, have been run without difficulty.

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Purchase specifications were reviewed concerning the IPD Instrument Development Operation designed Transistorized Dose Totalizer wherein the measured dose-rate, as measured by a suitable portable or other instrument, is set, by dial adjustment, on the Totalizer. The dial controls an internal oscillator to drive an electro-mechanical register at a particular rate to indicate accumulated dose at the specified dose-rate. Four of the units are in use at PRTR but apparently none is functioning due either to lack of charging facilities for the incorporated rechargeable battery or due to circuitry malfunctioning.

Evaluation tests were continued on two developed portable Scintillation Dose Rate Meters using a chopper input and transistorized circuitry. To improve beta response, the organic detector thickness was reduced by a factor of five while retaining full-scale first range sensitivity of 5 mr/hr or less.

Evaluation tests were continued on the experimental Scintillation Beta-Gamma (line operated) transistorized Log and Linear Area Monitors. Accuracies on the linear ranges to within ± 10 percent of the true dose-rates were obtained.

Advice was given concerning the twelve portable Sentinel Alarming Instruments for use on reactor elevators. Field personnel now want a full-scale first range of 200 mr/hr, and this necessitates using RCA 6655-A phototubes and 2" x 3" terphenyl-in-polyvinyltoluene detectors in place of the smaller phototube and detector used to meet the original requirements.

Brief evaluation tests were made on a Victoreen Portable (Vibrating Reed) Dose Rate Meter Model 440. The unit was temporarily borrowed but had to be returned. One production unit was ordered for complete tests. Initial tests on the loaned unit seemed reasonably good with accuracies to within ± 15 percent of true dose-rates over all ranges. Maximum reading error with temperature approached -0.3% per degree F, and a battery voltage change of 1% produced a reading error of 0.75%. Full scale first range is 3 mr/hr.

Tests were made of random samples of commercial double-aluminum-coated Mylar in use at the plant. The quoted weight is 0.9 mg/cm^2; whereas the tests showed consistent weights of 1.5 mg/cm^2. Such added weight reduces the possible geometry when the material is used for alpha monitoring light shields. A letter was dispatched to the manufacturer to inquire of the condition.

One prototype, of 30 total units ordered, of a Model II Scintran instrument designed by HLO, was received from GE-APED, the off-site fabricator. Except for minor wiring errors and layout difficulties the unit was most satisfactory. An addenda (prototype) cast-plastic head alpha probe, also of our design, was received and tested. The light-shield, consisting of double-aluminum-coated Mylar and aluminum dutch leaf had been glued together resulting in low geometry. Proper application of light-shielding material corrected the problem. Comments on both the Model II Scintran and the alpha probe were dispatched through Radiation Protection Operation and Purchasing to the manufacturer.

Acceptance tests were nearly completed on 75, 50-r and 75, 10-r pencil dosimeters of the self-reading type. Rejection rates of the two models were 7% and 21%,

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respectively. Further testing continues on 100 dosimeters of the 200 mr type and 20% of these have already been rejected for poor performance.

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Uranium Oxidation and Fission Product Volatilization Studies

Evidently some form of vaporization is the principal mode of particulate generation from uranium oxidized at 1200 C. First of all, the (weight) majority of collected particles actually consisted of agglomerated submicron particles, some of which probably seeded the formations. Secondly, rate of collection at that oxidation temperature depends relatively less upon air velocity. For example, the rate varied as the square root of velocity at 1200 C, directly as velocity at 1000 C, and as almost the square of velocity at 800 C. Finally, rate of collection was constant during oxidation and, incidentally, remained constant at the same value even after oxidation had become complete.

New Production Reactor Effluent

The region of any phosphate discharge to the Columbia River will be more than five miles downstream from the reactors, should phosphate decontamination wastes be discharged to ground just north of Gable Mountain. Such southeasterly ground water movement was reaffirmed with the installation of appropriate well points. The movement is significantly affected by the irregular surface of a several hundred feet thick, relatively impermeable Ringold clay deposit resting on the basalt bedrock. Five wells are being drilled generally north of the Mountain to help complete geologic and hydrologic knowledge of the area.

Reactor Effluent Treatment

Suspended algae growths in the 107-D reactor effluent basin were confirmed to be an important source of pressure drop increase in the pilot scale aluminum bed decontamination facility. A 14 x 18 mesh screen placed in the inlet was coated in 50 hours to a depth of about 1/4 inch, which required reduction of flow to about 2 feet per minute to avoid tank overflow. If such growths prove to be insignificant in the effluent pipe line or in the aluminum bed itself, the algae should not pose a problem.

Promising designs were reviewed for an As-76 monitor for reactor effluent. The monitor is to be used to help control reactor coolent influent treatment with alum for reducing As-76 (and P-32) formation.

Continuing laboratory study of mineral beds for removing P-32 showed that fluorite, galena, goethite, microcline and apatite removed a constant 30 to 40 percent of the radioisotope from 1900 bed volumes of 0.01 uc P-32/ml, 80 C tap water having a 2.9 minute residence. Approach of saturation was not evident. Calcite, scapolite, dolomite and hornblende, on the other hand, exhibited a finite adsorption capacity; the fractional removal of P-32 was reduced nearly to zero after passage of 500 to 1200 bed volumes.

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X-Ray Techniques for Measurement of Zircaloy Cladding Thickness

Calculations have indicated X-ray fluorescence methods to be probably workable for monitoring cladding thickness on extruded NPR fuel rods. Excitation of uranium K_{alpha} fluorescence will be necessary and will require at least a 140 KV source. The method is obviously less applicable to Zircaloy than to aluminum cladding but it has been estimated that Zircaloy clad thickness could be measured to a precision (two sigma) of about ± 0.75 mil at a total thickness of 20 mils, ± 0.9 mil at 30 mils, and ± 1.2 mils at 40 mils, or about ± 3 percent over the entire range.

SEPARATION PROCESSES

Purex Studies

Evaluation of Diluents - Three diluent materials, Shell E-2342, Soltrol 170 and dodecane, were made 30 percent in TBP, washed with sodium carbonate, equilibrated with 3.0 M HNO_3 - 0.05 M $NaNO_2$, and irradiated to 10^8R in the 100 KE Co-60 source. The irradiated solvents were washed (equal-volume contacts) successively with 0.025 M $KMnO_4$ - 3 percent Na_2CO_3 at 60 C, 1.0 M HNO_3, 3 percent Na_2CO_3, and 1.0 M HNO_3. They were then subjected to "use tests" (batch contacts simulating Purex extraction, scrub and strip operations). The solvent containing Shell E-2342 extracted about four times as much activity as those containing Soltrol 170 and dodecane. However, extracted activity stripped more readily from the latter solvents. In consequence, the overall decontamination factor from feed to final aqueous was less with these solvents than with Shell E-2342 as the diluent. Extraction of activity was relatively high for all three solvents indicating the severity of the radiation exposure given.

Soltrol 170 recently obtained from the vendor was nitrated and compared in "use tests" with Soltrol 170 used in previously reported studies. The older Soltrol has been on the plant several years. A new diluent, Soltrol 130, was also tested in this series. The new Soltrol 170 appeared slightly inferior to the old in the "use tests." Improvement of solvents with aging has been noted before. The Soltrol 130 appeared superior to old Soltrol 170 but it has a low flash point (Tag-closed-cup value 127 F vs. 186 F for Soltrol 170).

Fractions obtained by distillation (E. Martin, Chemical Research Operation) of Shell Code 82,000 were combined to give three fractions containing principally (1) undecane, (2) dodecane, and (3) tridecane. These three fractions were degraded by nitration and subjected to the "use test." Successively poorer performance with increasing boiling point of the fraction was observed. This is consistent with observations by other workers that "do-bads" are associated with higher-boiling fractions of diluents. All three fractions, and particularly the two low-boiling fractions, were superior to non-fractionated Shell Code 82000.

Evaluation of Purex Water - A series of runs was completed in the C-Column Facility to compare column performance when the 1CX water source was shifted from 321 Building condensate water to Purex sanitary water and to Purex demineralized water. Comparisons were made of the uranium distribution throughout the column and of the organic holdup throughout the column at comparable conditions of flow rates, stream temperatures, feed compositions, pulse amplitude and three values of pulse frequency (40 cycles per minute, 60 cycles per minute, and the instability frequency). Column instability was indicated by a fluctuation of the column density instrument and a fluctuation of the interface position indicating instrument. Column instability

frequencies were approached by increasing the frequency at a rate of 5 cycles per minute per hour. These comparisons will be continued on a monthly basis to assist the Purex Process Technology personnel in studying process column performance and apparent water quality.

Observation Wells

Changes in ground water contamination patterns in the vicinity of the 200 Areas were insignificant; although the past year saw a 20-fold concentration of gross beta emitters as monitored in well 699-50-53, 0.6 mile north of the abandoned 216-BY scavenged waste cribs.

Tritium in Redox Tank Condensate Waste

Apparently from fission, a significant amount of tritium was found in a Redox tank condensate. The several mc/l concentrations anticipated in some wastes may permit identifying those streams by ground water analysis. Fission product tritium was reported in Savannah River Plant wastes.

Analysis of High Purity Plutonium

The formal report, "Spectrochemical Analysis of High Purity Plutonium for Metal Impurities Using Anion Exchange," HW-69199 was issued April 11, 1961.

WASTE TREATMENT

General

A report, HW-68752, "Comparison of Waste Calciners," was completed and issued.

Batch Calcination

Studies of the batch calcination of simulated Purex high-level wastes were continued on a bench scale.

Foaming was studied in two sizes of annular pots. The smaller was fabricated from 6-inch and 3-inch standard pipe, and the larger was fabricated from 8-inch and 4-inch standard pipe. The problem of foaming during the boil-down step was less severe in the larger pot. A waste solution that foamed badly in the 6-inch diameter pot presented only a mild problem in the 8-inch pot. The use of silicone anti-foam agents proved to be helpful in reducing foam.

The weights of the calcines obtained in the majority of the studies made to date in which the sulfate content was in excess of the stoichiometric sodium equivalent indicate that a portion of the excess sulfate is retained in the calcine. Two runs were made in 3-inch diameter pots to study this further. A mixture of sodium sulfate and aluminum sulfate crystals were used in both runs. The dry mixture was heated in the first run. In the second run, the salts were dissolved in a small amount of dilute nitric acid and recrystallized prior to heating. Both pots were maintained at 950 C until the evolution of sulfur oxides was no longer evident. Weight differentials indicate that the aluminum sulfate decomposed to alumina or equivalent in the first run. The calcination of the sodium sulfate-sodium aluminum alum mixture, however, did not result in the same products. A weight loss equivalent to about one-quarter a mol of sulfur trioxide and six-tenths of a mol of oxygen per original mol of charge was experienced. Long-term stability of the excess sulfate in the calcine was not studied.

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Thermal Effects in Solidified Radioactive Wastes

The temperature perturbation caused by a partial lack of bond between waste and container wall was estimated. The maximum temperature within the waste is only nine percent higher than that within a completely bonded cylinder in a system where an unbonded longitudinal strip has an angular width of ninety degrees upon the surface of a one-foot diameter cylindrical storage vessel, the overall surface heat transfer coefficient on the unbonded strip is zero and that on the remaining surface is 10.7 $Btu/hr^{-1}/ft^{-2}/(°F)^{-1}$, and the solidified waste has a thermal conductivity of 0.6 $Btu/hr^{-1}/ft^{-2}/(°F/ft)^{-1}$. Proportionally smaller temperature excesses are noted for smaller and/or partially conductive unbonded strips.

A general solution to the Poisson's equation for infinite slab geometry has been derived to facilitate the estimation of thermal parameters in annuli having radii much larger than the annular (slab) thicknesses. The solution is simpler than the rigorous one for annuli; thus, permitting more rapid estimation of the relationships between heat generation rates, inner and outer coolant temperatures and overall surface heat transfer coefficients, thermal conductivities, annular thicknesses, and the temperature distributions within the self-heating core.

Thermal Conductivity of Underground Stored Waste Sludges

An apparatus for determination of underground stored waste sludge thermal conductivity was developed. The device includes a "Line Heat Source" conductivity system which can be installed in a waste tank prior to filling. Thermal conductivity can be measured as the sludge accumulates and ages by measuring the transient rate of heat dissipation from an electrically heated wire.

Waste Transfer Program

A test program aimed at studying removal of underground stored waste sludges has been developed. The program includes supernate removal, soaking of the sludge for removal of soluble salts, followed by an in-tank submerged sluicing test. The problem of thermal shock to the tank liner and concrete structure is currently being studied.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium Recovery Program

325-A Strontium Purification - Strontium purification run No. 4 was begun on April 10, and completed on April 20. The chemical flowsheet was similar to that previously employed; however, the feed was clarified at Purex (by centrifugation) and was free of troublesome solids. Some 3,600 curies of re-work strontium-90 (from the previous runs and Decalso effluent) as well as 12,000 curies of fresh feed was processed. Twelve thousand four hundred (12,400) curies were recovered as purified product plus 1,400 curies of semi-refined strontium for re-work, compared with 8,000 curies of product on the previous run. Run No. 5 is scheduled to begin May 1, and like run No. 4, will use Purex centrifuged feed.

Operation was generally very smooth and uneventful, and the use of clarified feed and 20-40 mesh resin allowed high pumping rates to be maintained throughout the loading cycle. The only difficulties were caused by aluminum contamination in the

re-work and by the high sodium and ammonium contents of the new feed. The aluminum (presumably leached from Decalso or left from run No. 3 resin removal) absorbed preferentially and served as a barrier to cerium and rare earths when fresh feed was introduced. The aluminum and absorbed cerium and rare earths were successfully removed with an HEDTA wash. A premature strontium breakthrough was next experienced due to the high ammonium and sodium content of the feed. However, a two-fold dilution overcame this effect and allowed all of the remaining feed to be loaded.

Product elution was with 5 M ammonium nitrate (which laboratory experiments had shown to be somewhat superior to nitric acid) rather than with HEDTA, since the Decalso cask was not available for filling and HEDTA solutions undergo radiolysis on storage. Almost all of the strontium (160 grams) was eluted with only six liters of ammonium nitrate. HEDTA elution will be used on run No. 5, if the Decalso cask has returned from Oak Ridge by then, since this technique maximizes the amount of strontium which can be loaded on a limited volume of Decalso.

Rapid Strontium Analytical Method - A streamlined strontium method applicable to samples of effluent during column loadings was developed. This method is similar to the cation exchange-alpha hydroxyisobutyrate method reported earlier. The significant difference is in the higher flow rates used during the loading, washing, and elution steps. A total strontium value can be determined within one hour after receiving the sample.

This method is limited to samples which contain Zr-Nb-95 activities in the same order of magnitude as strontium. This condition is met in the feed being used in strontium recovery runs in 325-A and in Hot Semiworks.

High Strontium Glasses - Sintered strontium titanate pellets are used as the fuel in the current generation of strontium-powered SNAP devices. Although strontium titanate is very dense and quite insoluble, it is difficult to prepare and requires the use of ceramic fabrication techniques which are troublesome to perform remotely with radioactive material. The formation of strontium glasses is being investigated in the expectation that these would be easier to prepare, would have satisfactorily low solubility, and would have the added advantage of being castable. Five glasses containing 34 to 70 weight percent strontium oxide were successfully prepared. These had melting points ranging from 1000 to 1400 C and densities to 3.6 g/cc, corresponding to a strontium content of 1.8 g/cc. Measurement of solubility and melting point and efforts to prepare glasses with even higher strontium content are continuing. The thermal conductivity of glasses in general is about one-half that measured for strontium titanate; however, this should be quite adequate. The strontium glasses are visualized as a product form which could be readily produced and cast directly into the customer's heat source for off-site shipment, thus obviating the shipment of solutions or powders.

Strontium Purification Development - Laboratory experiments, with tracer-level synthetic solutions, aimed at improving the 325-A, Hot Semiworks, and future B Plant processes have continued. The use of ammonium nitrate as an elutriant has already been mentioned. Use of HEDTA, vice EDTA, in the chromatographic ion-exchange purification cycle was explored and has certain advantages, particularly for one-column Semiworks use. Separation of strontium from barium and calcium was almost complete at pH 7, but less so at pH 8 or 9. Radiation stability studies, in the cobalt-60 source, of EDTA, HEDTA, and citrate solutions have shown the latter to be much the

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more stable. Column experiments, simulating the 325-A loading cycle, showed that citrate and HEDTA complexed feeds were identical at pH 4 with respect to amount of strontium loaded and completeness of cerium rejection. At pH 3, strontium loadings were still identical, but all of the cerium also loaded from the citrate solutions, versus 30 percent from HEDTA. Thus, the allowable pH range is narrower with citrate, but the greater radiation stability could be an important advantage in some cases.

Radiation decomposition of strontium-containing EDTA or HEDTA solutions produces a precipitate which was identified as strontium carbonate. This reaction, depending on the kinetics and degree of completion, might be useful in preparing strontium for filter cask shipment since it would permit elution from the Semiworks ion-exchange column with HEDTA rather than sodium nitrate.

In other experiments, the liquid "ion exchanger" dinonyl naphthalene sulfonic acid was briefly evaluated as a strontium extractant (as a possible replacement for di-2-ethylhexyl phosphonic acid) and found relatively unpromising. The extraction coefficient (E_A^o) of strontium from a synthetic feed increased from 0.06 to 0.04 molar extractant (in Amsco-125) to 0.95 at 0.47 molar and was very nearly constant over the pH range 1 to 10.

Solvent Extraction Flowsheet Studies - Further miniature mixer settler and miniature pulse column studies were made to define the optimum flowsheet for the startup of the Hot Semiworks. Traced synthetic feeds were used in some runs and Purex plant "crude cut" solution for others. Good agreement on strontium recovery and fission product decontamination was obtained for the two types of feeds. The flowsheet currently considered optimum specifies a first column feed at pH 4.7 and containing sodium acetate and EDTA for buffering and for complexing. The scrub is 0.6 M citric acid. Extractant is 0.4 M D2EHPA - 0.2 M TBP - Shell E-2342. Flows are 1.84/0.1/0.50 for feed/scrub/organic. Good strontium recovery (> 95 percent) was obtained in both tracer and high level runs using this flowsheet. Cerium, ruthenium and zirconium-niobium decontamination factors of about 20-75, 1000 and 1500, respectively, were obtained.

In the second column (1B), 1.0 M citric acid is used to strip strontium from the IAP. Aqueous to organic flow ratio is about 0.25. Strontium recovery in a high level run was poor (ca. 60 percent) probably due to some difficulty in maintaining proper flows. Tracer studies indicate strontium recovery of 95 percent or better should be obtained. Cerium decontamination factors of about 50 were obtained.

Solvent Washing - Preliminary solvent washing studies were made using a portion of 1BW remaining from an earlier high-level run. One equal-volume wash with three molar nitric acid removed 99.75, 93.3 and 7.7 percent of the strontium, cerium, and zirconium-niobium, respectively, remaining in the solvent. Ruthenium was below detection after the first wash. Two equal-volume acid washes and one water wash produced a solvent containing 0.74 curies Sr-89-90, 0.006 curies Ce-144, 0.010 curies Ce-141 per gallon. Zirconium-niobium was below detection. Detection of ruthenium was doubtful. These washing studies were made 12 days after the solvent was used in the high-level run.

Waste Concentration - A sample of synthetic 1AW waste was concentrated by a factor of seven; boiling point, density, pH and solids formation were observed as a function of concentration factor. The waste was free of solids at the boiling point and at

room temperature at concentration factors up to 4.7. Solids, which appeared to be sodium nitrate, formed at the boiling point at a concentration factor above 4.7. Iron hydroxide formation did not occur showing strong complexing by the EDTA in the waste.

Ion Exchange Isolation - Batch equilibration studies pertinent to the loading of strontium and cerium onto Dowex 50-X 12 resin from 1BP solution indicate higher loading of the resin with strontium can be obtained by diluting the 1BP to reduce the sodium concentration. However, cerium adsorption increased more rapidly than strontium adsorption with dilution and cerium decontamination would be decreased by dilution.

Batch equilibration studies were also made to compare sodium nitrate, nitric acid and mixtures of these reagents as elutants for removing strontium from Dowex 50 resin. At comparable concentrations, smaller strontium distribution coefficients were obtained with sodium nitrate than with nitric acid indicating greater elution effectiveness for sodium nitrate. Mixtures of sodium nitrate and nitric acid appear to be slightly better elutants than sodium nitrate alone at equal total nitrate concentrations.

Destruction of Ion Exchange Resin - Chemical means of dissolving Dowex 50-X 12 ion exchange resin were studied. A means of destroying the ion exchanger before discarding it to underground waste tanks was desired because of possible lowering of the pH of the waste (with consequent increased corrosion of the tank) during radiolytic decomposition of the resin. Dissolution of the resin in HNO_3-Mn(II) and potassium permanganate solutions was studied. Both solutions will solubilize the resin. The reaction with HNO_3-Mn(II) is somewhat easier to control.

One liter of 13 M HNO_3 - 0.4 M $Mn(NO_3)_2$ held at boiling will dissolve about 180 ml of dry resin (Dowex 50-X 12, 20-60 mesh) in ca. 4.5 hours. Adding acid at this point permits additional resin dissolution but results in the formation of a cake on the container walls. The reaction is moderately exothermic. Nitric acid consumption is about 0.9 mole per 100 grams resin. Destruction to carbon dioxide and sulfate is not complete. When a solution containing dissolved resin is evaporated to dryness, a solid remains which chars and evolves gas on further heating. Short term tests indicate a corrosion rate for 304-L of about 4.5 mils/mo in the 13 M HNO_3 - 0.4 M $Mn(NO_3)_2$ solution.

Strontium Carbonate Filter Cask - Construction of the strontium carbonate filter cask simulator was completed and initial hydraulic studies undertaken at Hot Semiworks. Bulk density of carbonate deposited on a flat mock-up filter was 0.55 gram strontium carbonate per cubic centimeter of cake. Precipitation was performed with potassium bicarbonate.

In other studies, exhaustive washing of strontium carbonate precipitates lowered the sodium contamination to 0.5 weight percent of strontium carbonate. Precipitations were made from solutions simulating Hot Semiworks product.

Instrumentation in Support of Hot Semiworks - Ion chambers designed for high intensity measurements were installed on the HAP, HCP, and HCW lines in "B" cell. The ion currents from these chambers will be read on the "B" system micro-micro ammeter. Final calibration of the units will be made by comparing measured ion currents with laboratory analysis of grab samples taken during hot runs.

The shielding and collimators for the gamma scintillation probes have been further modified to match the expected radiation levels. These monitors will read out on the "A" system recorders and will also be calibrated during hot runs. Fluorothene cells are now installed in the sampling systems for these scintillation monitors. Stainless steel cells also have been fabricated in case the plastic cells deteriorate prematurely in the high radiation fields.

Hot Semiworks Operation - The preparation of the Hot Semiworks for strontium-90 processing continued with the completion of two "cold" runs, with feed pH's of 4.75 and 5.25. The equipment performed satisfactorily with a few minor exceptions. In the first run (pH 4.75), limited analytical results indicated that the strontium loss was less than four percent and the calcium separation factor was about 14. The cerium decontamination factor for solvent extraction in both runs was apparently greater than 2,000 and possibly greater than 4,000 in the second run. Some uncertainty exists due to the limited analytical accuracy at such low cerium concentrations. Other analytical results from the second run are not yet available. Both the pH control and pH indication by line monitors were very satisfactory in both runs.

Bulk Fission Product Packaging - Studies of the filter canister shipping container continued with demonstration of built-in automatic shut-off of filtration. Strontium peroxide is precipitated at room temperature by addition of hydrogen peroxide and slow neutralization to pH 11. Following a brief room temperature digestion for crystal growth, filtration to a cake density of 0.20 to 0.25 grams strontium per cubic centimeter is accomplished in less than 30 minutes. Conversion of the peroxide to the oxide was largely accomplished by heating the cake to 400 C for two hours. Considerable strontium carbonate was found in this product, indicating that inert gas blanketing will probably be required to prevent reaction with atmospheric carbon dioxide.

Radiation decomposition studies by Chemical Research indicate strontium-90 peroxide will decompose at a rate on the order of 5 percent per hour under its own radiation field.

Other Fission Product Recovery

Cesium Decalso Loading - Design is currently under way (CPD-FEO) on a replacement for the Decalso filled, Oak Ridge STT's. If the capacity of Decalso for cesium (from Purex tank supernates) could be increased, the size of the cask could be proportionately reduced. Decalso loading experiments were accordingly run to determine the effect of dilution and pH adjustment on total cesium loading from synthetic 103-A supernate. Neither dilution nor pH adjustment resulted in any increase in capacity. A two-step process "absorption on Decalso, displacement with a divalent ion, and re-absorption on a second bed) was also ineffective.

Technetium Anion Exchange - The recovery of technetium from Purex tank supernate by passage through a Dowex-1 column was reported earlier (HW-66738). Although excellent recovery and purification was obtained, experiments have been performed to determine whether feed dilution would increase total loading and whether any other anion exchange resin would be superior to Dowex-1. Of 13 resins tested (including both strong- and weak-base exchangers), none were significantly better than Dowex-1. The three best were Dowex-1, Duolite A-101, and IRA-400 with distribution coefficient values (Kd) of 340, 370, and 410, respectively. Dilution (up to four-fold) had no significant effect on distribution coefficient.

Cask Closure Development - Studies of closures for HAPO I and II shipping casks continued. In general, "Snap Tite" primary closures leak "vigorously" under vacuum or slight pressure but can be made to hold vacuum by installing elastomer O-rings in place of the V-groove packing provided.

Tests of 2-3/4 inch diameter metal O-rings showed that none are completely satisfactory at temperatures over 300 F, although suitable for 1000 psig hydrostatic service at room temperature. Silver coated stainless steel rings appear to offer some slight advantage over simple stainless steel. Similarly, O-ring sealing between clamped rather than screwed surfaces are preferred.

Cesium-137 Loss From a Shipping Cask Accident - Laboratory examinations were performed in support of an evaluation of the hazards involved in shipping casks of Cs-137 adsorbed on a synthetic zeolite. Laboratory beds were loaded to 12 mc Cs-137/g zeolite. Cesium source was 103-A tank supernatant solution. The loaded zeolite was washed with tap water and used in experiments simulating shipping accidents.

To estimate the leaching rate of the Missouri River in the event of a Cs-137 cask immersion, leaching with 20 bed volumes of synthetic river water (about 8.6 meq cation/l) was performed. Some 0.63 percent of the cesium was removed from the loaded zeolite.

Various cesium volatilization studies were made to simulate a high temperature incident. Two hours in separate atmospheres of air and helium at 1350 C resulted in release of 0.35 and 0.71 percent of the cesium loaded on the zeolite. Cesium release stopped after 100 minutes' heating in either atmosphere. A programmed temperature increase to a maximum of 1500 C within two hours was employed in both helium and air. Respective releases were 0.31 percent and 0.25 percent. Cesium was not released below 1200-1300 C, near the fusion temperature of the zeolite.

Clinoptilolite, a natural zeolite, would reduce the risk of accidental spills enroute if used as a carrier for radiocesium. Clinoptilolite's capacity was found to be more than 2.5 times that of a synthetic zeolite for adsorption of cesium from synthetic Purex waste tank supernatant solution. A leaching comparison was even more favorable with synthetic river water removing only one-tenth as much cesium from clinoptilolite per volume of leach water passed through.

Clarification of Underground Stored Waste Supernates - A concept involving the use of a submerged canned motor pump discharging to a hydroclone was developed as a means of providing a source of clarified Purex tank farm supernatant liquid for recovery of cesium-137 and technetium-99. Fabrication of a pump and test hydroclone is in progress.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Determination of Thorium-232 and Thorium-230 in Uranium Ore and Mill Tailings

The thorium-230 found in uranium ore is of potential importance as a starting material in producing uranium-232 for compact power sources. The accompanying natural thorium, thorium-232, is undesirable. Another set of uranium ore samples and some materials expected to be somewhat enriched in thorium-230 (ionium) were analyzed for both isotopes, Th-232 and Th-230. Previous dissolution methods (HW-66220) were used. Thorium was separated by the common lanthanum fluoride coprecipitation and 2-thenoyltrifluoroacetone extraction methods. Two measurement

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techniques were used for each isotope to increase the confidence in reliability of results. Thorium-230 was measured by alpha scintillation counting and by mass spectrometric (thermal ionization) analysis. Alpha counting results averaged 97.5 percent of the spectrometric results. The detection limit for Th-230 is estimated to be 4×10^{-4} microgram by alpha counting and 10-50 micrograms by spectrometer. Thorium-232 was determined by emission spectrographic (HW-66220) and neutron activation methods. The 0.31 Mev gamma activity of the protactinium-233 produced (Th-232 $\xrightarrow{n,\gamma}$ Th-233 $\xrightarrow{\beta^-,\gamma}$ Pa-233) was measured by gamma scintillation-energy analyzer technique. Duplicate thorium standards were irradiated with each group of samples to obviate flux and cross-section measurements. Duplicates differed by 0.72 percent. Pile irradiations were made directly on ore and on separated thorium fractions, with comparable results. Protactinium-233 was separated from irradiated and dissolved ore samples by co-precipitation with lanthanum fluoride and extraction into a 2:1 mixture of 2,6 dimethyl-4-heptanol in benzene. The detection limit for Th-232 is estimated to be 1.2×10^{-4} microgram by activation and one microgram by emission spectrograph. Some of the selected material contained as much as 5 percent Th-230.

Precision of Coulometric Analysis of Uranium-Plutonium Alloy

The precision of direct coulometric analysis of unirradiated U-Pu alloy for plutonium was determined. Sampling was performed carefully. Four samples were taken from each of two alloy bars, differing in plutonium content, by making bevel cuts. Each sample was treated with nitric acid to remove surface oxide, washed, dried and weighed to ± 0.0005 gram. The samples were dissolved by an initial treatment with dilute (1:4) hydrochloric acid followed by a nitric acid boil-down to clarify the dissolver solutions. The final 50 milliliter solutions were 4-8 molar in nitric acid and 0.3 molar in uranium. Four aliquots from each 50 milliliters were titrated according to a direct, controlled-potential, coulometric method (HW-58491). The 32 titrations were performed over a five-day period by two analysts. The order of sampling was random and various sample sizes were used; that is, 100 to 200 micrograms of plutonium. The average results and standard deviations obtained were:

	Average % Plutonium	Standard Deviation
Bar 1	0.1510	0.0024
Bar 2	0.0886	0.0009

EQUIPMENT AND MATERIALS

Mechanical Dejacketing of Production Fuel Elements

Initial tests were performed with encouraging results on a concept for mechanical stripping of production element jackets. Tests with both aluminum and Zircaloy clad slugs were performed with a device involving rolling axial jacket cutters followed by peeling. The system readily removed greater than 99 percent of the aluminum jacket, penetrating at the AlSi bond layer. Essentially no uranium was removed with the jacket. In a test with a coextruded Zircaloy clad element, the oversize core fractured the peeling die.

Air Driven Pulse Generator Study

Hydrodynamic equations were derived for the Recuplex prototype air pulse generator. Analog computer solutions to the equations have been obtained and are being correlated.

It appears that the system will be stable to process upsets. Analog simulation of hydraulic systems of this type is a highly flexible tool.

Continuous Centrifuge

Batch preparation of cerous oxalate slurry followed by processing in the 6-inch continuous centrifuge was used to compare performance of the machine with the vendor's laboratory tests. Using a centrifuge and test conditions which were presumably identical to those employed in the HAPO machine, the vendor's machine produced a solid product containing 15 percent free moisture as compared to HAPO experience of 35 percent free moisture.

Corrosion Studies

Galvanic Corrosion Test on 1020 Steel in Purex Waste - Samples of 1020 steel, one of which is coupled to a 304-L stainless steel sample of about equal surface area, are being exposed to synthetic Purex underground waste (pH 12). The test is being made to evaluate galvanic corrosion effects which may occur if stainless steel valves are used in 1020 steel lines handling this waste. No galvanic effects have been noted. The test will be continued.

Griscom-Russel I.D. Welded Joints - One of several Griscom-Russel I.D. welded tube-to-tube sheet joints (stainless steel tube to stainless steel tube sheet) exposed to boiling synthetic Purex 1WW waste (6 M in nitric acid) failed after only 54 days exposure. The failure occurred in the tube sheet area of the joint and was due to severe end grain attack. This type of joint is not suitable for use under the exposure conditions.

Nitric Acid-Oxalic Acid Systems - Samples of A-55 titanium have been exposed to oxalic acid-nitric acid solutions initially 0.5 M in oxalic acid and ranging from zero to five molar in nitric acid. After one four-hour period, liquid-phase corrosion rates decreased from 190 to 80 mils/mo as nitric acid increased from 0 to 0.25 M. Rates at HNO_3 concentrations of 0.5 M and above were in the one to two mils/mo range. Vapor phase samples all corroded at rates of 0.01 mil/mo or less. Visible decomposition of oxalic acid occurs at nitric acid concentrations of one molar or greater.

Studies in Progress - The following corrosion testing programs are in progress. Because month by month progress on these studies is slow, results will be reported only at the conclusion of the study or when it is considered that unusually significant facts have been noted: (1) Corrosion of 304-L stainless steel in HNO_3-HF-$Al(NO_3)_3$ solutions, (2) corrosion of 304-L stainless steel, Hastelloy-C and Zircaloy-2 in nitric acid-oxalic acid solutions, and (3) corrosion of various alloys in calcined waste with phosphate additives.

Non-Metallic Materials

After 45 days at room temperature in a 75 percent carbon tetrachloride - 25 percent TBP solution, a glass reinforced polyester sample was undamaged. A similar sample showed some edge attack in a 1 M HF - 1 M HNO_3 solution but no finished surface damage. Transparent and opaque polyvinylchloride samples both softened somewhat in the organic solution but showed no other effect. Both PVC samples were undamaged in the mixed acids.

A sample of "Pluton," a woven organic fiber material produced by Minnesota Mining and Manufacturing Company for high temperature use was irradiated to 10^9 r total integrated dose. There was no obvious physical damage.

A second Minnesota Mining product, "Crystal M," a synthetic mica bonded in sheet form with a silica or silaceous material was also undamaged by exposure to 10^9 r total dose. The chemical compatibility of these last two materials is still being determined.

PROCESS CONTROL DEVELOPMENT

Time Response of Continuous Density Monitor

The design of an automatic density control system such as may be required for salting strength control in Recuplex requires that the time response of the measuring element be determined.

The transient response of a "Densitrol" continuous density monitor to a step change in density was measured with a high speed Brown Recorder. Although the lag time observed corresponded with theoretical calculations the response with respect to changes in flow rate did not. This is possibly due to resistive forces in moving the chain or limited recorder response.

The observed time response to a step change in density at the Densitrol input is of the order of one minute at flow rates greater than 700 milliliters per minute.

Measurement of Aqueous to Organic Ratio Within a Column

The use of electrical capacitance to measure organic to aqueous ratios and/or as an empirical index to predict flooding conditions is being investigated. Tests with probes for insertion through 3/8-inch diameter ports are underway on the experimental C-column in the 321 Building. A zirconium probe with a burned on oxide coating has produced the most favorable results to date. Tests are continuing to determine the usefulness of the observed readings, the effect of changing solute concentrations, temperature dependence and stability of the oxide coating.

C-Column Runs and Instrumentation

A series of four runs were completed establishing the upper limit for the pulse frequency for the forthcoming studies.

The 1CF flow transmitter was repaired and recalibrated. The repair of the transmitter improved the sensitivity of the flow measurement to the point where the pulsating flow due to the pulsating pressure at the 1CF distributor was being seen and interfering with the flow control. A small surge pot, installed on the 1CF line satisfactorily absorbed the pulse and smoothed the flow at the rotometer and the operation of the flow controller. The calibration data obtained from the 1CF flowmeter and pressure to voltage transducer has been reduced to flows and integrated average output voltages and has been submitted to "Operations Research" for processing. These data will provide the standard calibration of the 1CF flow accounting for uranium concentration.

The redundancies in the measuring circuitry of the Data Scanning Programmer which were incorporated last month failed to operate satisfactorily under the 321 operating

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gallery conditions. All measuring circuit switching has now been converted to mercury wetted relays. A substantial increase in reliability of the measured voltages is expected. The debugging of the necessary wiring changes is now proceeding.

The circuitry used in transmitting the sampled port number from the canyon to the Programmer has been converted to 6 VAC from 110 VAC line current to achieve safer operation.

The measured frequency response obtained for the micromicro ammeter used with the mid-column photometer has indicated that alternately measuring the "Read" and "Standardize" voltages at 0.75 second intervals as described last month would give errors. The time interval has thus been lengthened to 2.4 seconds to allow the micromicro ammeter to settle within 0.01 percent of its ultimate reading.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Uranium Chemistry in NaCl-KCl Systems - Further studies have been made of the effect of atmosphere on uranium species in molten NaCl-KCl systems.

Prior electrochemical studies had revealed the existence of a "cut-off" point beyond which cathodic potentials in excess of those required to deposit alkali metals out of the NaCl-KCl melt would be required to further deplete the uranium content of the melt. The location of this cut-off in terms of residual melt uranium concentration could be varied by altering the gaseous atmosphere over the melt during the electrolysis.

These effects have been subjected to further study and additional experimental techniques utilized in an attempt to elucidate the effect of such manipulations on the number and nature of uranium species existing in the melt.

Starting with NaCl-KCl melts containing 3.5 weight percent uranium (as uranium(VI) species) electrodeposition under an air sweep (the condition normally utilized to "co-deposit" PuO_2 with UO_2) allowed the total uranium concentration in the melt to be reduced to ca. 0.5 w/o before the total cell resistance doubled. By contrast, operation under an anode-generated chlorine blanket (conditions normally utilized to selectively deposit UO_2 away from plutonium) allowed the melt uranium content to be reduced only to 1.9 w/o before the cell resistance had doubled. In this case the uranium(IV) content of the terminal melt was only 0.03 w/o. The implication is therefore strong that reactions other than the "chlorination" of UO_2Cl_2 to UCl_4,

$$UO_2Cl_2 + C + Cl_2 \longrightarrow UCl_4 - CO_2$$

are responsible for altering the concentrations of easily reduced uranium species in the melt.

Some parallel effects are seen in the water solubility and the infrared and visible absorption spectra of the uranium species in the melts.

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In these experiments the "water-insoluble" uranium in the frozen melt samples is defined as that which did not dissolve in the time required (five to ten minutes at room temperature) to effect complete dissolution of the NaCl-KCl. The "water-insoluble" uranium(VI) solids were readily soluble in acids and are presumed to be of the nature of oxides or oxychlorides.

Direct dissolution of U_3O_8 with chlorine resulted in melts containing no water-insoluble uranium(VI). The absorption spectrum of a mull of the solidified melt in petrolatum showed an absorption peak at ca. 435 mu with shoulders at ca. 425 and 450 mu. Either sparging this melt with chlorine plus hydrogen chloride (with graphite electrodes in place) or conducting an electrolysis in the absence of air resulted in increased absorption at 425 mu and decreased absorption at 450 mu (relative to the principal absorption peak at 435 mu). These changes are in the direction of closer conformity with the spectrum of synthetic compounds containing $UO_2Cl_4^{=}$ as have been prepared and studied by J.L. Ryan.

Sparging such a melt with either dry or moist air resulted in a visible absorption spectrum consisting of a single peak at 460 mu but of greater apparent molar extinction coefficient. With air saturated with water vapor (at 0 C) the water insoluble uranium(VI) was equivalent to 8 and 20 percent of the total uranium after 1.5 and 2.8 hour sparges, respectively. The total amount of uranium present was 0.5 moles and the air sparge rate was such that ca. 0.3 moles oxygen per hour were introduced into the melt.

These preliminary data are obviously not capable of conclusive interpretation. However, it may be noted that they are consistent with an hypothesis involving the formation of polymeric (possibly colloidal or actually precipitated) uranium species capable of inclusion in solid UO_2 cathode deposits via chemical adsorption phenomena or electrophoresis. Such a feature is likewise not inconsistent with prior observations regarding the relative efficiency of inclusion of plutonium in UO_2 deposits made under different atmospheres, apparent UO_2 deposition current efficiencies in excess of 100 percent under moist air, etc.

Electrochemical Studies - The potential - current relationship has been studied for the electrolysis of a NaCl-KCl solution prepared by dissolving non-stoichiometric $\overline{UO_2}$ (O/U = 2.1) with HCl. Three distinct reductions are seen in this system (which presumably contains both uranium(VI) and uranium(IV) initially). The three waves have been tentatively assigned to the $UO_2^{++}/UO_2(s)$, the U(IV)/U(III), and the U(III)/U(s) couples. The deposition potentials (against a Ag/AgCl (one molal), NaCl-KCl reference electrode) were + 0.36 and -1.35 volts for the $UO_2^{++}/UO_2(s)$ and U(III)/U(s) reductions, respectively. The half-wave potential for the U(IV)/U(III) reduction was -0.42 volts. The first and third reduction waves correspond to the theoretical shape for a reduction producing a solid (i.e., constant activity) product while the second wave has the correct theoretical shape for soluble oxidized and reduced species.

With the aim of completing the picture on effect of salt type on the deposition and properties of $\overline{UO_2}$, studies have been initiated on the NaCl-$MgCl_2$ salt system. This system, it is hoped, will exemplify lower-melting salts of high available chloride activity and will thus fill the present gap between the high-melting, high chloride activity NaCl-KCl system and the low melting, low chloride activity KCl-$PbCl_2$ systems. One potential advantage of such a system is the possibility of stabilizing plutonium(IV via formation of $PuCl_6^{=}$ at a temperature below its decomposition temperature.

The first electrodeposition of UO_2 out of a relatively dilute (ca. 8 w/o U) uranium(VI)-bearing melt yielded a deposit the gross appearance of which was intermediate between products obtained in the NaCl-KCl and KCl-$PbCl_2$ systems. It comprised a "mace" of needle-like crystals (of maximum length ca. 7 mm) intermediate in shape and appearance between the "spear points" and "Christmas trees" produced in the NaCl-KCl system and the needle deposits obtained in KCl-$PbCl_2$ at low uranium concentrations.

Exploratory studies have verified that the technique of chronopotentiometry will be a highly useful tool in elucidating electrode processes in molten salt systems. The basis for the method lies in applying a short-duration (millisecond to second) voltage pulse to an electrode (at constant current density) and recording the potential-time behavior of the electrode against a reference electrode immersed in the bulk solution. If the cathodic voltage pulse covers a short time interval relative to the time required for diffusion to replenish the concentration of reducible species in the double layer then a series of waves is seen corresponding to species reducing at progressively larger cathodic potentials. The "transition time" required to complete the coulometric titration of each species can be related to the concentration and the diffusivity of the species in question.

The crude read-out arrangement used to date has prohibited the acquisition of quantitative data. However, some noteworthy qualitative observations have been made. Titration of a NaCl-KCl solution prepared by injection of Cs_2UCl_6 (and therefore presumably containing only uranium(IV)) showed two reduction waves at about -0.4 and -0.56 volts. Only the first reduction proved to be reversible. This would seem to imply the existence of two reducible species of substantially different nature in a supposedly simple system.

The expected effects were evident to a gratifying extent in "titrations" of solutions prepared by dissolution of U_3O_8 into NaCl-KCl with chlorine. An overvoltage was seen for deposition of UO_2 on clean platinum (as compared with deposition of UO_2 on UO_2). On a clean platinum electrode at low current density only a single reduction wave is seen (corresponding to the $UO_2^{++}/UO_2(s)$ reduction). Increasing the current density discloses a break in the curve at about -0.05 volts. The product $\tau^{1/2} i_o$ ((transition time)$^{1/2}$ x current density) was constant for the $UO_2^{++}/UO_2(s)$ reduction, as expected by theory. After treatment of the melt with dried air the deposition potential was more positive by about 0.05 volts and it was necessary to increase the current density by a factor of 9 to achieve the second break in the curve. The residual current was also increased. The $\tau^{1/2} i_o$ product was again constant but at a lower value than before air treatment. Treatment of the melt with moist air resulted in a high residual current but no discernible reduction wave. These observations can be interpreted as representing a progressive decline in the concentration of reversibly reducible species (for which $\tau^{1/2} i_o$ is constant) as the melt is treated with dried air and then with moist air. Viewed in the context of other experience on UO_2 deposition and plutonium behavior as a function of atmosphere these observations suggest that the accumulation of uranium oxides on a cathode can proceed simultaneously by two independent routes, one being a reversible electrolytic reduction, the other being possibly an electrically non-reversible chemical precipitation or electrophoresis process. Ability to differentiate between such simultaneous processes could answer a number of pertinent questions (e.g., relating to the mechanism of incorporation of PuO_2 in "electrodeposited UO_2") and motivates a strong interest in continuation of chronopotentiometric measurements in more refined apparatus.

Growth of UO_2 Crystals in NaCl-KCl System - Recent efforts in this area have been concentrated on evaluating the effect of various parameters on the manner of growth of UO_2. Conditions have been found which vary the rate of growth and the physical aspect of UO_2 deposits in a predictable fashion. The "spectrum" of UO_2 deposits which have been grown may be described as follows:

(a) Loosely packed "Christmas tree" dendrites
(b) Loosely packed "fluted spear point" dendrites
(c) Solid masses with randomly oriented laminar crystal faces
(d) "Maces" of closely packed randomly oriented cubes
(e) Smooth-surfaced, very tightly packed compacts of radially oriented columnar grains.

This order is consistent with the rate of growth also. The "Christmas tree" dendrites grow very rapidly and the growth rate declines progressively as the packing of the crystallites becomes tighter and their orientation more systematic.

Variables which have shown qualitatively consistent and reproducible effects in altering the growth rate and character of the UO_2 deposit include the following:

(a) Increased agitation of the melt reduces the growth rate and favors more compact deposits.

(b) Increased HCl content in the sparge gas reduces the net growth rate and favors more compact deposits.

(c) Increased dry oxygen content in the sparge gas increases the net growth rate and favors the production of more loosely packed randomly oriented deposits.

(d) Increased chlorine content in the sparge gas decreases the net growth rate and favors smoother-surface, tightly packed deposits.

(e) Momentary reversal of current gives the expected decrease in net growth rate and favors smoother-surfaced, tightly packed deposits.

(f) Increased melt uranium content increases the net growth rate and favors more random growth.

Experience indicates that smooth (or abrupt) transitions can be made from one manner of growth to another. Thus, although these observations testify to a complex deposition process, possibly involving several inter-dependent parallel routes for simultaneous deposition and redissolution of UO_2, they also suggest an ability to vary the properties of "electrodeposited" UO_2 over a rather wide range "at will." Such versatility may prove quite beneficial in preparing fuel-grade UO_2 powders "to specification" or in introducing impurities (e.g., PuO_2) in controlled zones of close-packed ceramic pieces, etc.

Growth of UO_2 Crystals in KCl-$PbCl_2$ Systems - The KCl-$PbCl_2$ systems continue to show promise as media in which to "electrodeposit" coarse-grained UO_2 powders, the individual grains of which are generally smooth-surfaced, have apparently little closed porosity, and are therefore of interest as feeds for vibratory compaction

techniques. The effect of variation in $KCl/PbCl_2$ ratio in the melt was investigated in experiments employing ratios of 2.0, 2.5, and 3.0 and electrodeposition at 520 C out of a 25 w/o uranium solution. No gross differences were noted although the particles tended to be more smooth-surfaced and crystalline in outward appearance at the higher K/Pb ratios. The range of the sieve analyses of the gross products in these three systems was as follows:

Mesh Size	Percent Retained
+ 10	50 - 58
10 - 20	24 - 31
20 - 35	8 - 13
35 - 60	5 - 7
60 - 100	1.8 - 2.5
- 100	1.3 - 2.7

Properties of the largest single grain yet produced (which was formed in the $3KCl-PbCl_2$ system) were as follows:

O/U Ratio: 2.005; ppm Pb:200; ppm K:100
Density : 10.7 g/cc by CCl_4 displacement, 10.88 g/cc by Hg displacement
Total Weight: 0.64 gram

The individual grains prepared in the 2.5 $KCl-PbCl_2$ and $3KCl-PbCl_2$ systems exhibited smooth, lustrous surfaces in which the 100 and 111 planes predominated, although small 110 planes showed on some particles. Imperfections when visible appeared to be concentrated on the 100 surfaces and appeared to develop only after the exposed 111 surfaces had become quite small. X-ray data indicate the better-formed grains to be single crystals or at most fused aggregates of a few large crystals.

Plutonium Behavior in $KCl-PbCl_2$ Systems - No great success has yet been had in controlling plutonium behavior in electrolyses conducted in $KCl-PbCl_2$ systems. Electrolyses under "partition" conditions are much less successful in effecting separation of uranium from plutonium in this system than in the NaCl-KCl system. For example, conduct of a UO_2 electrodeposition at 600 C with an HCl sparge resulted in a plutonium decontamination factor of only 12. Raising the temperature to 700 C in several experiments gave decontamination factors averaging about 25.

Likewise, it was found that uranium(IV) formed in such melts was less readily oxidized to uranium(VI) with air than was the case in the NaCl-KCl system.

Despite the fact that partition of uranium from plutonium is less readily accomplished in $KCl-PbCl_2$ systems than in NaCl-KCl systems, attempted "co-deposition" of PuO_2 with UO_2 is likewise less efficient, yielding "enrichment factors" of the order of 0.5 vice factors greater than unity in the NaCl-KCl system.

These differences are believed to stem from lesser complexation of solutes in the $KCl-PbCl_2$ systems (vice NaCl-KCl systems) and prompt interest in lower-melting alkali or alkaline earth melts as the most effective means of duplicating the attractive features of plutonium behavior in the NaCl-KCl system at a lower temperature.

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Rare Earth Behavior in NaCl-KCl Systems - Continued search for means of selectively precipitating rare earth elements away from uranium in molten NaCl-KCl disclosed pyrophosphate to be the most promising of several precipitants tested, $La_4(P_2O_7)_3$ being considerably less soluble than $(UO_2)_2P_2O_7$.

Possibility of effecting such separations by cation exchange was shown in an experiment in which a NaCl-KCl solution containing both UO_2Cl_2 and $LaCl_3$ was percolated through a column packed with 100-200 mesh $(UO_2)_2P_2O_7$ mixed with twice its weight of 60 mesh alundum. Exchange quite evidently occurred since the lanthanum content of the salt was reduced from an initial value of 0.7 mg La/g salt to a final value of 0.073 mg La/g salt in its two-minute passage through this bed.

Engineering Development on Salt Cycle - A 20.2 lb. UO_2 deposit was obtained during a single pilot plant electrolysis in a molten salt system, $PbCl_2$-2.5 KCl. After addition of UO_3, the bath was chlorinated for 12 hours at 675°C and a chlorine flow rate of 2.5 liters/min. The salt was then electrolyzed for 27.6 hours at 550-585 C, an average cell voltage drop of 1.0-1.3 volts, and an average current density of 6.5 amp/dm^2. The average cell resistivity was initially 3.5 ohm-cm but increased to 5.5 ohm-cm at the end of the run. The material balance for the run was as follows:

	g mol	%
Input to Electrolysis:		
Dissolved U	32.0	76.8
Undissolved U	9.7	23.2
	41.7	100.0
Output from Electrolysis:		
Deposit (UO_2)	34.0	81.5
Dissolved U	5.3	12.7
Undissolved U	2.4	5.8
	41.7	100.0

The UO_2 was deposited as a polycrystalline sheet about 7 mm thick, consisting of very fine crystals near the electrode inner surface but with the outer 60 percent of the thickness occupied by large, dense columnar crystals. A current efficiency of 87 percent was indicated.

The utility of the recirculating gas lift apparatus was demonstrated with the NaCl. KCl salt system in two 20-liter salt baths. An electrolysis was carried out in one bath until depletion of the uranium and buildup of uranium(IV) increased the cell resistance prohibitively. Then the contents of the first bath was mixed for 20 minutes with the undepleted second bath by gas lift recirculation. Air was used in the lift from the first bath to destroy uranium(IV). Chlorine was used as the gas in the return lift. The electrolysis was then continued successfully until the bath was again depleted. A second run demonstrated the mechanical feasibility of recirculating continuously during the electrolysis.

The application of Fiberfrax® coating cement (an aqueous slurry of Al_2O_3-SiO_2 with a thermosetting inorganic binder) to the electrode surface at the salt-air interface has eliminated corrosion of graphite electrodes in the NaCl-KCl system.

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Materials of Construction - A locally fabricated 90 percent magnesia, 10 percent titania crucible which was not oxidize-fired was tested with a barium-potassium-sodium chloride melt mixture with the addition of metallic aluminum at 800 C for 100 hours. At the end of the test salt had percolated through the crucible wall and bottom; 0.04 g of aluminum was lost. There was no detectable damage to the crucible.

A second crucible similar to the above was tested with the same salt mixture but without metallic aluminum. Chlorine was percolated through the salt for ten of the eleven-day test. Salt had percolated through the crucible after eleven days. Inspection at the end of seven days revealed no penetration.

Two samples of titanium diboride were tested in a molten bath of barium-potassium-sodium chloride at 800 C with chlorine bubbling through the melt. One sample disintegrated completely while the second lost only 2 percent weight. A difference in chlorine concentration is thought to account for the difference.

Continuous Ion Exchange Contactor Development - Jiggler Contactor

A modification of the pulsed bed contactor incorporating the new resin pump (see March 1961 report, HW-69062 C) has been built and is now undergoing preliminary tests. The apparatus is in the form of a loop made mainly from 4-inch glass pipe and some 4-inch stainless steel pipe. The 4-inch channel is completely open except for the screened liquid introduction fingers for feed, scrub, wash and elution streams. This design minimizes resin friction as well as shape changes in the resin plug. The resin pump is located in the upper end of one of the two parallel columns so that all of the process streams can be introduced under the pump. The "A" column is located directly under the pump with the "C" column occupying a section of the remaining parallel column.

Initial measurements on resin circulation with no countercurrent flow of liquids indicate correlation between the pulser displacement rate and the quantity of resin moved. Typical rates for 20-40 mesh resin at a pulser frequency of 4 CPM are:

Resin Moved ml/min	Pulse Amplitude Inches	Pulse Displacement ml/min
180	1	824
515	1-3/8	1133
773	1-11/12	1586

Maximum pressure drop per foot of resin bed was 0.6 psi. The finer 50-100 mesh resin yielded data similar in magnitude.

The ball check valves in the pump are practically leak-proof when pumping liquid alone. Resin slurry and/or water, however, as may be deduced from the data above, apparently leaks back through the valves. The quantity of leakage depends on the hydrodynamic conditions in the pulser chamber arising from the nature of the pulse wave and the pressure drop across the pump as well as the nature of the slurry.

Resin transport studies (again in the absence of countercurrent liquid flow) give indication that resin finer than the standard 20-40 or 20-50 mesh may be usable.

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Particularly in anion exchange in a plutonium-nitric acid system, where particulate diffusion varies inversely with the square of the diameter of the resin bead, the smaller resin would product substantial mass transfer benefits. Experiments with overhead pneumatic pulsing in a 3-inch glass loop more or less confirm the hydraulic pumping tests reported above; that is, friction between the particles in the resin bed and glass column walls is practically the same for both ranges of resin particle size. Furthermore, the pneumatic testing showed that in a practically open loop that 50-100 mesh resin could be pushed even more readily than the coarser material. This may be explained by the greater pressure drop of liquid in moving through the fine resin tending to move it as a plug rather than permitting passage of "slip" water before solid phase movement begins.

Studies are underway to establish the engineering practicality of applying these observations in a countercurrent system.

RADIOACTIVE RESIDUE FIXATION

Spray Calcination

Further tests of the Fiberfrax (ceramic cloth) filters have shown a decrease in efficiency, from decontamination factors of about 1000 to a few hundred, with continued operation and with water flushing, although the filters remained soft and pliable. It is probable that the increased penetration is caused by progressive saturation of the cloth with powder or by gradual loss of the fiber mat as a result of wetting the fibers. Following washing, effectiveness increases with time, as a firm cake builds up, although there is no noticeable increase in pressure drop (Δ p less than 1-inch Hg at 2 ft/min gas velocity). During these tests, blowback was found to be more effective from concave or flat surfaces, which have enough slack to "give," than from convex filter surfaces.

Evaluation tests were run on several scrubbers, including a novel new design, to determine their relative effectiveness for removing the small (sub-micron) particles which pass through the filter and condenser. A single plate Peabody scrubber and a 2-foot Raschig ring packed scrubber gave equivalent performance (decontamination factors of about 1.5). The new cataphoretic bubble scrubber gave factors ranging from 2 to 18. The latter scrubber is still in an early state of development and may be capable eventually of even better performance. In this unit, the gas stream is passed through a corona discharge (to charge the particles) and then bubbled through a scrubber where the charged particles are attracted from the inside of the bubble to the bubble wall there they contact the liquid of opposite charge and are removed. Quite graphic results are obtained with cigarette smoke and with nitrogen pentoxide fumes. Certain deficiencies in the initial unit are being corrected and further tests are planned.

The Eco gear pump with Hastelloy-C gears has been used quite successfully during ten runs. It is being used in place of the Eco pump with teflon gears previously employed (which would be susceptible to radiation damage) and shows promise of successful operation in A Cell.

Mineral Reactions

Clinoptilolite's adsorption capacity for cesium in molar sodium nitrate solution was permanently doubled by four hours' preheating at 400 C. The reason for the

temperature effect, a maximum at 400 C, is not evident. The mineral changed color at moderate temperatures and finally fused to a white glass at 1200 C.

Condensate Wastes

Ammonium (ion) from 0.01 M ammonia solution depressed both cesium and strontium distribution coefficients for adsorption on sulfonated polystyrene resin and, more recently, on a synthetic zeolite and clinoptilolite. At pH 3, with its relatively abundant ammonium, all coefficients were lower than at pH 10. Cesium adsorption was highest and less pH dependent for clinoptilolite, known to have unique cesium adsorption capacity. Conversely, the synthetic zeolite and particularly the resin showed high strontium affinity even at pH 3.

Moreover, with Purex condensate waste of similar ammonia concentration, strontium adsorption by the resin was even higher at the lower pH, 87 percent adsorption at pH 3 and 20 percent at pH 10. Corresponding results for the 0.01 M laboratory ammonia exceeded 99.9 percent strontium adsorption at either pH. Lower and more pH dependent strontium adsorption from plant waste may be due to the accompanying organic material's forming a non-adsorbable strontium species.

The effectiveness of an actual plant adsorption process for decontaminating Purex condensate waste with regard to radiostrontium is best demonstrated by column experiments. Strontium decontamination factors of about 100 were maintained in the laboratory for more than 20,000 column volumes of that waste adjusted to pH 3 and passed through a resin column.

The Micro Pilot Plant's effectiveness for mineral bed adsorption of cesium and strontium was hampered by organic material and ammonia in Purex tank farm condensate. The organic fouled the beds and ammonia dissociation inhibited ion exchange adsorption especially with respect to radiocesium. While organic was successfully removed by adsorption on activated carbon, the treatment was complicated. Removal of both organic and ammonia by a steam stripping process appeared feasible. In fact, a small steam stripper was tested with a feed having organic and ammonia contents similar to those of Purex tank farm condensate. Feed contained about 180 ppm tri-n-butyl phosphate, 30 ppm hydrocarbons, and 50 ppm ammonia. Feed rate was about 100 ml/min and distillate rate about 5 ml/min. The effluent bottom stream from the reboiler contained 4 ppm tri-n-butyl phosphate, 2 ppm hydrocarbons and 5 ppm ammonia. The steam stripper is being modified to prepare actual condensate waste for the Micro Pilot Plant.

BIOLOGY AND MEDICINE - 06 PROGRAM

Geology and Hydrology

The stratigraphy of the basalt series in the upper about 1500 feet of the Standard Oil Company of California Rattlesnake No. 1 test well was correlated to the sequence in the Benson Ranch - Yakima Ridge area and to that beneath 200 East Area. Based upon this correlation, confined or artesian aquifers exist in the basalt series beneath the central part of the Hanford Works. Large, continuous supplies of well water probably will have to come from depths of 1000 feet or more, however. Some local, highly permeable zones above that depth may produce large volumes for short periods. The shallower aquifers (above about 500 feet depth) appear to be recharged locally. One recharge area lies above Snively Ranch at the head of a large landslide.

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The correlation also shows that the fanglomerate lying on basalt beneath the Separations areas is in turn overlain by at least one basalt flow to the southwest and west and perhaps similarly is overlain to the southeast and east. A low head outside the Hanford Works area and a high head inside the area (caused by high ground water mounds) may force waters carrying wastes into the upper part of the basalt series. In the Columbia Basin Irrigation Project area, however, water table levels in the basalt have risen more than 200 feet in places. This is recharging aquifers in the basalt that in turn may be reflected in changes in the Hanford Works. Either the head in the confined aquifers will increase there, or discharge into the unconfined waters may take place; in either situation at least potentially significantly altering the hydrology of the Hanford Works area and emphasizing the interrelationship of the Hanford Works and adjacent areas.

Drilling exploration continued at Columbia River mile 348 for dam site studies. Nichols and Thompson Core Drilling Company, contractor to the Corps of Engineers, completed one hole to basalt at a depth of 183.5 feet. A few thin beds of silts and clay were encountered to 156 feet, where pebbly clays were encountered extending to basalt. Sands and gravels of varying degrees of cementation were the only other materials penetrated. The sequence was as predicted. Basalt was encountered 30 feet deeper than predicted.

Development was completed on a computer program entitled "Multi-Dimensional Steady State Flow in Soil." It permits solution of a wide variety of ground water problems that involve equilibrium systems (in contrast to the non-equilibrium case developed for such problems as that posed by a leaking waste storage tank). The development also permits solving problems in equilibrium flow systems under different conditions of saturation and heterogeneity. Up to 8000 points including fifteen different soils may be calculated under the program. Its first problem will be to predict the effect of a waste disposal crib on a near-by tile field to be constructed at 100-N Area.

Much of the geologic and hydrologic information obtained from the field is collected at random points over the study area. Some applications require estimating corresponding data at the intercepts of a rectangular grid by interpolating between the random points. Various interpolation methods were investigated, including Newton's "Divided Difference" method, an application of the Lagrange formula, and the use of Tchebysheff polynominals. Testing of the latter method is not complete but it appears to hold promise of being superior to the other methods.

Soil Chemistry and Geochemistry

Preliminary investigation of natural zeolites for selective adsorption of strontium from solution was initiated. Initial experiments were conducted with clinoptilolite and a commercial zeolite previously shown to be strontium-selective. An experimental design amenable to statistical analysis for evaluating the influence of system variables was devised and tested with the above zeolites. Within the range of experimental conditions studied only sodium ion concentration and column residence time of the variables examined were statistically significant. The results of current column experiments were in good agreement with earlier strontium equilibrium adsorption measurements utilizing those zeolites.

Research was continued for clarifying mineral reaction mechanisms whereby a mineral such as pyrite (FeS_2) or chalcopyrite ($CuFeS_2$) in contact with zinc solution is

partially replaced by sphalerite (ZnS). Evidently, replacement is not the primary mechanism since a smaller fraction of zinc at 10^{-2} M concentration was incorporated into the mineral than at 10^{-4} M and 10^{-3} M levels examined earlier. Oxygen continues to be an unimportant factor.

Field Apparatus Development

The recently developed orifice-diaphragm flowmeter was calibrated in an artesian well and used to measure very low vertical flows in several project wells. Vertical flows were definitely detected in eight wells and possibly in two others. The sensitivity remained constant during tests in 13 wells, and only small zero drifts needed compensation. The ability to measure very low vertical currents will refine ground water pressure patterns and will qualify each project well's usefulness for monitoring radioactivity.

Techniques and equipment were investigated for installing small diameter wells for obtaining geologic and hydrologic information. Jet-washing of small tubes into the soil proved successful only to depths of about ten feet. Well points were driven to a depth of 40 feet in one location, but in most areas a penetration of only about 10 feet was attained. A portable, inexpensive rotary drill was demonstrated by the manufacturer and holds much promise for quickly drilling small-bore wells to depths of 60-100 feet.

Radioisotopes in Columbia River Sediments

Satisfactory core sampling of sediments from the floor of the MaNary Dam reservoir has been performed. Quantitative gamma-ray spectrometric measurements of these sediments show relatively large amounts of Zn-65 (245 days), Co-60 (5 years), Sc-46 (85 days), and Cr-51 (27 days) at the surface while only Zn-65 and Co-60 were observed one to two inches below the surface. Measurements of a few core samples to date indicate sediment depths of 8 to 14 inches and that the material at various depths can be precisely dated from the Zn-65 to Co-60 ratios.

Radioisotopes in Biota Near the Mouth of the Columbia River

Samples of diatoms and seaweed from the ocean near the mouth of the Columbia River were found to contain Sc-46, Cr-51, and Zn-65 in quantities about the same as or larger than the oysters previously measured as containing the largest concentration of Zn-65. Diatoms contained about the same concentration of Zn-65 as oysters but much more Cr-51 (by about two orders of magnitude). The seaweed contained over twice as much Zn-65 as the oysters or diatoms. The largest concentrations yet found of Sc-46 were in diatoms (15.9 d/m/g). These interesting findings will be further investigated.

Chemical Dosimetry

In previous work no evidence was observed for post-irradiation effects on Erioglaucine in aqueous solutions; however, it was felt that a more critical examination should be made. Five solutions covering the concentration range from 1×10^{-6} to 6×10^{-6} M were irradiated with gamma-radiation at 25 C and 37 C, and their absorbances were measured periodically from 1 hour before to 167 hours after irradiation. The solutions absorbed from 650 to 2600 rads, and the apparent bleaching rate constants were calculated from data at various time intervals. These constants were

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found to have 95 percent confidence intervals extending ± 5 percent on either side of the mean. With this precision, a significant increase in the apparent bleaching rate was detectable at the 95 percent level only after the full 167 hours, and then only for the two most dilute solutions. It can thus be concluded that even a week's delay in measurement will not affect the radiation dose indicated by the absorbances of these solutions by more than ± 5 percent. This should be quite satisfactory for many dosimeter applications.

L. P. Bupp

Manager
Chemical Research and Development

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A. ORGANIZATION AND PERSONNEL

No significant changes occurred during April.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Effect of Reactor Effluent on Aquatic Organisms

Effluent monitoring was continued at the 1706-KE laboratory with the exposure of young salmon to untreated effluent and to like concentrations of effluent passed through a bed of aluminum turnings. Fish exposed to the aluminum-bed treated, 4 per cent effluent showed a slight increase in mortality but no deleterious effects to growth rate.

I^{131} in Rabbits

Thyroids from twenty-five rabbits and fifty vegetation samples collected from the White Bluffs region on March 28 were analyzed and compared for I^{131} content. All thyroids contained measurable amounts, with a mean of 700 $\pm$ 320 pc/g wet weight in glands from adult rabbits. The thyroid/vegetation I^{131} ratio was approximately 600. Thyroids of fifteen full-term fetuses contained concentrations of 1.02 $\pm$ 0.5 times those of their parents.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Strontium and Calcium

During the Sr^{90}-Y^{90} chronic feeding experiment, four out of twenty control fish died during the 21 weeks of test. It was assumed that none of the mortalities was due to the method of force feeding. Since the sample size was relatively small, however, and because the feeding method will likely be utilized in future tests, the technique was further tested by sham feeding one hundred fish five times a week. After ten weeks no mortalities were observed.

The effect of oxygenization on the uptake of calcium and water transpiration by barley seedlings was studied. Anoxia depressed calcium uptake and transpiration. Dinitrophenol further depressed both processes but this depression was less in the case of the anoxic plants.

The effect of anoxia on content of calcium in roots was variable. Mild anoxia caused a reduction and severe anoxia, produced by bubbling with nitrogen, increased calcium concentration. Dinitrophenol changed the magnitude but not the direction of the effect.

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Preliminary data on the transfer of Sr^{90} from the diet of swine to their milk was obtained from three female swine fed 125 μc/day. The Sr^{90}/Ca ratio of the blood was one-fifth and of the milk one-tenth that of the swine's diet. The same magnitude of discrimination from diet to milk is described for man. The chemical analysis of the milk of swine showed that the calcium concentration was about 200 mg/100 ml compared with about 30 to 40 in human milk and 125 in cow's milk. Measurements are made once each week for a 24-hour period. Based on the first eight measurements, the daily milk production appears to be about one liter.

Six offspring from two swine fed 125 μc of Sr^{90}/day were weaned. They appeared normal in every respect. (At the present time 116 females and 14 males are receiving Sr^{90} daily. All of the females are to be retained for lifetime feeding or sacrificed after one year of age.)

Iodine

Eight lambs were administered I^{131} in two successive oral doses (at birth and at one week of age) to determine if the thyroidal uptake of I^{131} in very young lambs was unusual and to detect possible changes in the metabolism of I^{131} during this period. The amounts of I^{131} in both the lambs and their thyroids were followed using the whole-body monitor. Only small differences were noted between the two ages, both the gastrointestinal absorption and thyroidal uptake being slightly greater for the week-old lambs. At both ages the time of maximum thyroid uptake was comparable to that for adult ewes (24 to 48 hours following administration). The maximum thyroid uptake of I^{131}, corrected for radioactive decay, was about 30 per cent for newborn lambs and 40 per cent for week-old lambs as compared to 20 to 35 per cent for adult ewes.

Of particular interest were the observations that for both age groups the I^{131} content of most of the lambs' thyroids approached a constant fraction of the I^{131} in their bodies (60 to 75 per cent) by three to five days after administration and that the endogenous excretion of I^{131} was very low (estimated between 1 and 4 per cent/day). This implies that the rate of turnover of I^{131} in the thyroids of young lambs is very rapid, and that the controlling factor for the rate of loss of I^{131} from the thyroid is the rate of endogenous excretion.

The whole-body monitor proved very useful for obtaining the body and thyroid burden of I^{131} and should prove useful also in contemplated studies on I^{131} metabolism.

Comparative Toxicity of Strontium, Plutonium and Radium

Radiographs taken of animals approximately 18 months after plutonium injection revealed only minimal change, except in the animals injected at six weeks of age. A progression of those changes noted at 14 months post-injection was seen. These included thickening of the cortical bone, increased trabeculation of the spongiosa and loss of definitive medullary canal.

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Five animals were sacrificed 18 months after being placed on the experiment. These included two injected with Pu^{239} (at 6 weeks and 6 months of age), one injected with Sr^{90} (at 6 weeks) and one injected with Ra^{226} (at six weeks). No significant gross lesions were detected. Tissues from these animals will be studied for detection of possible early damage.

Plutonium

Tests of the new chelating agent 2-(B-Aminoethoxy) cyclohexylamine-N, N,N',N'-tetraacetic acid were continued. The indications reported last month were confirmed; namely, that this agent is slightly less effective than DTPA. When administered one hour following intravenous injection of plutonium citrate, retention of plutonium in the total animal, after four days, was 8 per cent of the injected dose in DTPA treated animals and 12 per cent of the injected dose in animals treated with the new agent. Control animals retained 77 per cent of the injected dose. When treatment was delayed until 18 days after plutonium injection, DTPA was effective in reducing the retention to 75 per cent of control while the new agent effected a reduction to only 90 per cent.

In a single preliminary study, employing intestinal perfusion techniques, it was indicated that plutonium appears in the intestine at sharply increased levels within 20 minutes following intravenous DTPA administration. The rat upon which this study was made had received its plutonium injection six months prior to the experiment. Plutonium excretion into the intestine was maintained at about the same level for two hours following DTPA administration. This level averaged about 20 times the pre-DTPA level.

The nature of plutonium excretion into the intestine and the effect of DTPA on this excretion was studied in bile duct-cannulated rats. Plutonium was administered to these rats 60 days prior to the cannulation and DTPA treatment. The results indicate that approximately one-fourth of fecally excreted plutonium arrives in the intestinal tract via the bile. The effect of DTPA was not clearly shown in these experiments; the combined insults of plutonium burden, surgical cannulation and DTPA treatment tending to cloud the interpretation. There was an indication, however, that both the biliary and non-biliary excretion of plutonium is increased by DTPA treatment

Eight months following the intradermal injection of Pu^{239} in swine, the fraction of the original dose that still remained varied from 15 to 35 per cent. Eschars were noted at all sites previously injected with 0.04 to 5 μc of Pu^{239} nitrate, the size of the eschar related to the dosage given.

To check the effect of the depth of an intradermal injection on the external count from a scintillation probe, a white miniature boar was injected at 27 sites, to a depth of from 2 to 12 mm. The injection sites were removed and monitored utilizing our own scintillation detector and also the one in the internal dosimetry group for a correlative count. Following this, radiochemical analysis was performed on each site. A few injections were made prior to sacrificin the animal in order to determine if detectable amounts of plutonium appeared in the blood. Results from this study should be available next month.

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Radioactive Particles

Tests were continued to develop a therapy procedure for inhaled radioactive particles. When rats inhaled ionized air, negative ions appeared to slightly increase the clearance of Ce^{144} from the lung. No effect was obtained with inhalation of carbon particles.

Three beagle dogs were exposed to plutonium nitrate aerosols and three were exposed to plutonium dioxide particles (MMD 1 μ) for further studies of the retention, translocation, and excretion of plutonium. Previous experiments showed that particles with a Mass Median Diameter of 1.7 μ were cleared from the lungs more rapidly than 3.0 and 4.3 μ particles. Other dogs will be exposed to aerosols of plutonium dioxide particles with Mass Median Diameters greater than 4.3 μ.

One of the major problems associated with the use of dogs in research is the accumulation of heavy deposits of tartar on the teeth. Periodically it is necessary to scrape off the tartar with the dog under anesthesia to prevent inflammation and infection. Tartar is now being removed by semi-weekly feeding of oxtails to the dogs. The dogs seem to enjoy the "therapy" and appreciable savings in labor will be realized.

Microbiological Studies

Positive identification of nuclear material in yeast was obtained by staining with toluidine blue stain. Preliminary data suggest that the nuclear material from the parent cell does not pass into the daughter bud until the bud is about half grown. This correlates with previous observations using tritiated thymidine autoradiography. This observation of the time of passage of nuclear material to the bud is of interest because of the high radioresistance of the immature buds.

Preliminary studies on the biological effects of deuterium on yeast were started. Effects of deuterium on respiration, glucose uptake, and potassium transport were noted. The data suggest that these effects may be due to a decrease in permeability of the cell membrane.

Effects of Radioactivity upon Populations

Stock cultures of two species of flour beetles (Tribolium) were obtained and developed to study effects of radiation upon populations.

Waterfowl Ecology

The annual nesting survey of Canada geese showed 7-1/2 per cent fewer pairs of geese on the nesting islands, and total nests observed were 6 per cent less than last year. A greater percentage of the nests appear to be successful however, which will probably result in gosling production nearly equal to that of 1960.

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Project Chariot

Sorting of samples for ecological analyses of terrestrial invertebrate communities of the Cape Thompson, Alaska region was completed. Species determinations of the Mollusca, Orthoptera, Copepoda and Cladocera were obtained from taxonomic specialists.

J J Davis

Acting Manager
BIOLOGY LABORATORY

JJ Davis/es

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C. Lectures

a. Papers Presented at Meetings

Schiffman, R. H., "Strontium Uptake and Excretion by Rainbow Trout," Midwest Benthological Meeting, Whitewater, Wisconsin, April 9, 1961.

b. Seminars (Off-Site and Local)

George, L. A., "Mechanisms of chemical protection from radiation," In-service Institute in Radiation Biology, University of Washington, Seattle, Washington, April 5, 1961.

Hungate, F. P., "Genetic Effects of Radiation," In-service Institute in Radiation Biology, Univ. of Washington, Seattle, Wash., April 13, 1961.

Kornberg, H. A., "Use of Radioactive Isotopes in Biological Research," Seminar Institute of Forest Products, University of Washington, Seattle, Washington, April 21, 1961.

Thompson, R. C., "Strontium-calcium interrelationships in the rat," Washington State University, Pullman, Washington, April 27, 1961.

c. Seminars (Biology)

Case, A. C., "Biology's large animal counter facilities," April 19, 1961.

Olson, P. A., "Effect of variable river flow on reactor effluent toxicity," April 19, 1961.

Dr. Noe Higinbotham, Department of Botany, Washington State University, "Recent advances in ion uptake by excised higher plant tissue with particular reference to electropotential, calcium, and auxin," April 26, 1961.

d. Miscellaneous Lectures

Bustad, L. K., "Radiobiology at Hanford," Brotherhood of Southside Protestant Church, Richland, April 4, 1961.

Hanson, W. C., "Project Chariot," Central United Protestant Church Brotherhood, Richland, April 3, 1961.

Hanson, W. C., "Project Chariot," HLO Finance Group - 300 Area, April 6, 1961.

George, L. A., "Biology Activities at Hanford," Project Engineers - 100-B Area, April 13, 1961.

Sweany, H. A., "Project Chariot," Benton City PTA, April 18, 1961.

George, L. A., "Biology Activities at Hanford," Biology Class, Kennewick High School, Kennewick, Wash., April 19, 1961.

Davis, J. J., "Project Chariot," Kiwanis Club, Kennewick, April 25, 1961.

c. Miscellaneous Lectures (continued)

Bustad, L. K., "Radiation and Aging," Golden Age Club, Richland Community House, April 25, 1961.

Bustad, L. K., "Radiobiology at Hanford," Northwest Computing Association Banquet, Richland, Washington, April 29, 1961.

D. Publications

a. HW Documents

None

b. Open Literature

George, L. A., S. Marks, and L. K. Bustad, "Fibrosarcoma in a Rabbit Following B-Irradiation of the Skin," Nature 189, 770-71 (1961).

Dockum, N. L., "Autoradiography of tissue," in Encyclopedia of Microscopy, p. 1-13, Reinhold Publishing Corporation (1961).

George, L. A., S. Marks and L. K. Bustad, "Electron microscopy and autoradiography," Science 133, 1423-24 (1961).

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - APRIL, 1961

ORGANIZATION AND PERSONNEL

There were no changes in personnel during the month of April.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Model

Work continued on a highly aggregated HAPO model in an effort to segregate the learning pattern in the production process from that in design and construction of new facilities.

Objectives, Goals, and Measurements

A review has been made of the major criteria used for planning and evaluation of progress at HAPO and the first draft of a report was prepared.

OPERATIONS ANALYSIS STUDIES

Fuel Element Performance

Estimation of the parameters in the empirical models expressing fuel element distortion as functions of reactor variables was completed. By comparing the variation between fuel elements within cells of comparable power, temperature, and residence time with the residual variance computed about the regression line, it was concluded that there is little room for improvement as far as goodness of fit is concerned. This is especially true for warp. Based on these models, calculations were performed giving the combinations of reactor variables which will result in a given average amount of distortion, thus enabling one to easily construct contour lines of the response surface.

Observed averages of fuel element distortion were plotted as a function of canning date, and of Fernald shipping date which leads by about 25 days. Values predicted by the empirical models were also calculated and plotted. These showed that the distortion environment in the reactors has been essentially constant over the past two years, but that there have been definite cycles in observed warp accompanied by trends in diameter growth. These are of sufficient magnitude to be of practical importance.

The relationship between warp and hot spots previously found for the initial 2000 Quality Certification fuel elements has been confirmed. This is now based on some 7000 fuel elements. A difference between reactors was found in the tendency to exhibit hot spots for a given amount of warp, but the reactors do not differ significantly in the amount of warp experienced by the fuel elements charged.

Assistance was given in determining "control limits" for pre-irradiation data.

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Initial measurements performed on the bare cores of irradiated fuel elements stripped in C-basin prior to measuring have indicated that an increased number of bare core measurements must be made. This program is being undertaken to determine if post-irradiation measurements performed on the canned fuel element are truly indicative of bare uranium distortion.

An evaluation was made of dingot uranium fuel elements based on the ten tubes of dingots thus far measured under the Quality Certification program.

Some 60 tubes of data will be analyzed by using orthogonal polynomials to describe the fuel element profiles in addition to the present method. Programming to accomplish this is under way. It is felt that this technique will give a truer picture of the types of distortion experienced in the reactors.

Optimization of Reactor Operations

Further work was done on the problem concerned with determining fuel clip requirements for use in charging the reactors. Nomographs were prepared which enable optimum solutions to be located for a wide variety of conditions.

Optimum sizes for supplemental crews are being determined for the period when bumper fuel elements will have been charged in all old reactors. Formulas developed last summer are being used with minor modifications. In this connection, it was shown that the problem of determining the probability of simultaneous reactor outages can be approached using available multi-channel queuing theory results. An unscheduled outage can be regarded as the "customer" who awaits service at one of the reactors, or "channels." The probability of simultaneous outages is then the probability that several "channels" are busy at any time. Very good agreement was found between results predicted by this model and observed data.

Process Tube Leak Detection and Replacement

An attempt is being made to describe internal corrosion along a process tube by polynomial expressions. Initially, an investigation is under way to determine if minimum thickness and location of same will result in roughly the same pattern of corrosion along the tube. This should be helpful in future studies of fuel element behavior.

Z-Plant Information Systems Studies

The new specifications for the General Electric 312 computer memory were received from Phoenix during the month. Because the new memory is divided into two unique portions, it was therefore necessary to segregate two unique and self-sufficient program routines to use the second portion of memory. This presented a difficult problem because the over-all computer program is comprised of many interdependent functional subroutines designed to optimize memory usage. Two basic routines, the computer diagnostic and the daily receipt and disbursements report section, were redesigned to include other functional routines sufficient to make them self-sustaining. These modifications were coded and put into the over-all structure.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Data had been collected to test the hypothesis that at least 90% of the fuel elements which would fail in a 50 hour autoclave cycle will have failed by the end of a 20 hour cycle. Assistance was given in the interpretation of the data.

Some further work was done in evaluating factors associated with pre-irradiation warp in NPR fuel elements.

Irradiation Processing Department

Several more curves were developed expressing fission product decay in a reactor.

A study is being made of thermocouple variation in monitoring tube outlet water temperatures. Results will be useful in determining limits of operation based on safety considerations.

Given different ranges for permissible goal exposures, plus a knowledge of front-to-rear flux patterns, a determination was made of the variation in average exposures for a group of fuel elements selected randomly from those discharged. Further results were found assuming the tubes involved are selected at random, but that each tube is sampled completely.

Work was begun on (1) the problem of providing an optimum (in the sense of minimum cost) sampling scheme for in-pile detection of neutron sinks; (2) the problem of providing statistical analysis of data on acceptance testing of new tube fittings for NPR; and (3) the design of a testing program to determine reliability parameters of panellit gauge switches.

Chemical Processing Department

The required calculations were made for demonstrating conformance to specifications of parts shipped during the first quarter of 1961. Since this represented the first application of the recently adopted part by part technique, a detailed description of the calculations was included in the report. Calculations required to maintain control over the parameters of importance are being performed by CPD personnel.

Available data were analyzed to evaluate the potential sources of variation affecting the radii of fabricated parts. Conclusions reached on the basis of these data were used to design future experimentation.

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An experiment was designed to evaluate the effects on product purity and density of the iodine booster used in the reduction of plutonium fluoride. Data from this experiment were analyzed, and the results reported. Further experimentation concerned with optimizing the production of buttons is being planned, and current data are being analyzed to aid in designing these experiments.

Some results were found in connection with evaluating potential smoothness of fabricated parts subject to limitations in the radius of the cutting tool and the feed rate.

Further comments were given in connection with the potential hazards involved in shipping strontium and cesium to Oak Ridge.

Contract and Accounting

Mathematical assistance was provided in obtaining a series expansion for a definite integral.

A sampling scheme was provided showing the proper sampling of various line item categories in order to cover 7-8% of line items in this year's inventory. The limits of error were predicted for such an inventory using past years' results.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Chemical Development

A preliminary analysis was completed of mid-column photometer calibration data and the results used to guide a machine calculation to determine the best mathematical method of correcting for the temperature differential between calibration and experimental runs. Output from the machine analysis of the test data is currently being evaluated. Data from the calibration experiment for the rotometer, which will be used to measure the flow rate of the pulse column feed streams, are currently being analyzed. Data from five individual test runs covering a range of uranium concentrations have been analyzed to determine the form of the mathematical relationship between flow rate and bob translation and the influence of solution density. An experimental program was designed to calibrate the gamma absorptiometer, which will be used to measure the uranium concentration of the organic phase within the pulse column proper. The absorptiometer uses a standard cell containing pure water, two five-centimeter long cells for low uranium concentrations, and two one-centimeter long cells for high uranium concentrations. The experimental schedule allows for the estimation of the average characteristics of the two cell sizes as a function of uranium concentration and also the differences between pairs of cells. In addition, any systematic time trends occurring during the experimentation period can be estimated and subtracted out.

Materials Development

Further calculations were performed on the graphite physical properties test data. The components of variance analyses on tensile strength measures, load and

 [redacted]

deflection, electrical resistivity, thermal conductivity and coefficient of thermal expansion were used to construct tolerance statements describing the population of graphite bars currently under consideration for use as NPR moderator.

Corrosion Studies

Further analysis was performed on M-400 and X-8001 alloy corrosion data from an experiment to investigate corrosion rate of aluminum alloys as a function of certain heat treating variables. A new method is being used to estimate corrosion penetration during the break away stage of the corrosion pattern which is independent of any assumption on the pre-induction time corrosion mechanism.

4000 Program

Swelling Studies

Several discussions were held with personnel of Physical Metallurgy Operation to consider the utilization of the IBM 7090 to analyze fission gas pore size distributions from the irradiated uranium samples. All micrographs in the current study have been read on the Zeiss particle size analyzer and a total in excess of 50 pore size distributions are ready for analysis. These distributions are now being transcribed onto IBM cards. Void fraction and void density estimates as well as the fundamental distributional characteristics properties can be machine calculated and correlated with irradiation and annealing variables.

Plutonium Recycle

Data from the experiment designed to investigate high energy uranium oxide impacting as a function of the independent variables, oxygen uranium ratio, Dynapak piston pressure, and oxide temperature are currently being analyzed. Response function techniques are being used to maximize oxide density as a function of these variables. An IBM program is being written which will calculate quadratic response functions for nonorthogonal factor levels of the independent variables, estimate the stationary point of the fitted surface, and calculate a confidence region for the position of the "true" stationary point.

Comparison of results obtained from actual particle packings using pre-calculated particle sizes and size ratios with those determined by pure geometrical theory are not yet complete. In the meantime, an empirical approach to the problem is under discussion which may more realistically take cognizance of the facts that fuel fabrication mixtures are not truly composed of spherical particles nor are the sizes or size ratios actually determined to fine degrees of accuracy.

6000 Program

Biology

A four compartment, three parameter model was applied to the problem of

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predicting thyroid uptake in man. Data were supplied by the Biology Operation and the rate parameters were estimated by means of the analog computer. These parameters were then applied to an analytical solution, and solutions were found for ten different sets of boundary conditions. A member of the Biology Operation has obtained solutions by means of an empirical formula found in the literature, and a cursory comparison of results indicates reasonable agreement. Further comparisons will be made.

Work continues on the multicompartment model in an attempt to show the usefulness of the model in predicting experimental results.

Work continued on the problem of expressing the multicompartment model in terms of a multivariate diffusion equation.

General

Instrumentation

Statistical analysis was continued of data from a reference system calibration study being conducted by the Instrument Research and Development Operation. The reference system will be used to calibrate linear variable differential transducers in connection with in-reactor creep testing of zircaloy.

Division of Research Programs

Work continued jointly with Chemical Instrumentation and Data Processing in the setting up of a magnetic tape master file of program sample data. Several least squares procedures for estimating total count at time zero and half-life from correlated counting data were devised and flow charted for IBM coding. The analysis of mass spectrometer uranium standard data was completed, the best estimate for each of the standards was reported to interested persons, and a report is in preparation which describes the relationship between certain statistics that can be calculated from a sequence of mass ratios and quantities which describe the functioning of the mass spectrometer.

Work is continuing on the problem of determining whether reactor conditions can be determined by a knowledge of the percentages of the various Pu isotopes in the irradiated product.

MISCELLANEOUS

Methodology

A discussion was held with personnel of Nuclear Physics Research Operation concerning the use of propagation of error formulae to approximate the error in products of random factors.

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Carl A. Bennett, Manager
Operations Research & Synthesis

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PROGRAMMING OPERATION
APRIL 1961

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Computer Code Development. The PROTEUS 1 code was completely debugged and is ready for operation. PROTEUS 1 greatly extends the information available from the MELEAGER physics code by providing extra end points as well as non-interacted graded data; but it is unable to generalize the specific power; and it is also restricted to one type of input format. PROTEUS 2 was written (and is presently being debugged) to contain these features. In addition, the code is being made more efficient to reduce the computing time required per case. When it is finished, PROTEUS 2 will replace PROTEUS 1.

The QUICK fuel cost code was modified to increase its utility. The PUVE plutonium value code was made into a subroutine and the printout arranged so that all of the output will be on a separate output tape. This will make it convenient to have the results bound into a book and be available to make additional copies, as was done for the Russian Reactor and the Price Schedule studies.

PUCK II Economics was completely debugged and results now agree with those previously obtained with PUCK I. Further work on PUCK II continues: formats are being standardized throughout all subroutines, shipping cost equations are being added to economics, and a new subroutine SCHEME, is being written to produce a table of plutonium values as a function of delta fabrication costs for nonoptimized zoned operation. The main program for testing the plutonium composition equations is now working and results have been plotted. This routine will be used to determine near equilibrium plutonium batch compositions for study in PUCK. Work on the first cladding study report continues. It is planned to extend this work in another study to demonstrate the impact of plutonium fuels on the interchange of cladding materials in nuclear reactors.

A study of burn-up calculations as a function of flux-volume weighting has also been started.

PRP Planning and Analyses Activities. The study of the fuel cycle conditions which show the most favorable economics by which the "Salt Cycle" partial-decontamination type processes may be applied was continued during the month. Efforts are being directed primarily at situations involving near-future (5-to 10-year) reactor applications. An attractive application may also exist in the use of this process as a step in plutonium oxide-uranium oxide fuel preparation rather than as a separation process. In reactor cycles discharging plutonium as well as valuable enriched uranium, it is probable that salt cycle in combination with a more conventional process for uranium recovery will be needed. For cases where the uranium is sufficiently depleted to be essentially of no value a salt cycle process should be most attractive. Work is continuing to establish these conditions, and to assess the economic results.

During the month, one member of Programming participated in visits to several NRTS hot laboratory sites (ANP-Arco, EBR-II, CPP, and MTR) for discussions of hot laboratory technology which might be desirable for inclusion in the Fuels Recycle Pilot Plant.

2. SPECIFIC CYCLE ANALYSES

Special Studies. A computer print-out "book" of enriched uranium costs was prepared for the Division of Reactor Development of the AEC at their request. This "book" contains all combinations of 16 different separative duty costs and 16 different natural uranium costs; 256 schedules in all. The cost of separative duty and the natural uranium costs were varied from 50 through 125 percent of the present values in five percent increments. The computer print-outs were bound into two volumes; each including a brief computer print-out describing the calculation procedure and the contents.

Supercritical Reactor. A number of fuel element cases have been evaluated for the supercritical reactor using available machine codes to obtain total fuel costs, which have been in the range of 3 mills per kwh. One difficulty that has been encountered is that lower fuel costs are associated with undermoderated lattices in this system. The physics models available for survey work are being operated in a region for which they were not originally designed when used with these lattices. Therefore work is in process to bracket the credibility of the results attained to date.

The codes being utilized in these studies are: IDIOT for lattice parameters, MELEAGER for reactivity and isotopic compositions as a function of exposure, and PROTEUS to generalize and interpret the exposure and isotopic composition data and prepare input cards for the economics codes. These cards are utilized by QUICK to obtain the fuel costs for batch discharge operation and by QUICK G to obtain the costs for fully graded operation.

The Graded Economics Code, QUICK G, has been extensively modified and expanded. The isotopic concentration and exposures are printed out at the beginning and end of each recycle step or at each enrichment for uranium cases. The PUCK code utilizes a minimizing routine to yield minimum fuel cost for any reactor being studied. This subroutine was modified and added to the QUICK G code so that MELEAGER or PROTEUS output may be minimized. This minimizer will calculate minimum fuel cost for each set of economic parameters used in the normal QUICK calculations.

Graded calculations were made for the supercritical reactor, but without startup and shutdown charges. These charges are added to the graded fuel cycle cost to account for the extra cost of achieving equilibrium graded operation and shutting down the reactor with only slightly burned up elements as part of the fuel charge. The addition of these charges to the supercritical reactor fuel costs amounted to less than 0.1 mill/kwh.

The supercritical reactor economic calculations have to be made using a special set of AEC economic rules. QUICK G has been altered to allow these calculations to be made.

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Advanced Pressurized Water Reactor. A portion of the final physics calculations for the revised study of the APWR have been completed using the MELEAGER code. Changes in the resultant physics calculations from those previously reported result from improved methods of calculating the effective resonance integral and from small changes in cross sections.

A study to determine the effect of adding a boron poison to the fuel in the APWR showed almost no effect on reactivity lifetime and associated fuel cost if reactor control system costs are ignored. Four sets of reactor cases were studied. In the first set, no boron was added; in the second, enough boron was added to lower the initial value of k_∞ to 1.15; in the third, to 1.10; and in the fourth, to 1.047. In all four sets, the initial conditions were for a three percent U-235 enriched fuel system, followed by nine recycle cases which used three percent U-235 plus ninety-seven percent of the plutonium from the previous case as enrichment. In all four sets of data, the reactivity limited exposure for the first case was about 13,500 mwd/t; for the second case, about 17,500; and for the third through the tenth cases, about 19,000. Gains are made, however, when using boron poisoned fuel in terms of a decreased requirement for control rods which would lower the capital costs of the reactor. In set No. 1 (no boron added), the Δk (difference between initial and final values of k_∞ for a given run) amounts to 153 milli-k; in set No. 2, to 113 mk; in No. 3, to 88 mk; and in No. 4, to 70 mk.

B. OTHER ACTIVITIES

The potential hazards involved in shipment of thousands of curies of long-lived radionuclides, particularly cesium and strontium, were studied extensively during the month. Primary attention was devoted to shipment of cesium as the adsorbed cation on Decalso inorganic ion-exchange medium. The primary hazard here is clearly the release of cesium to the atmosphere either by volatilization or by an explosion of other materials in connection with the postulated accident. On the basis of new cesium volatility data and the above study the potential hazard is less serious than previously believed. A report on this subject will be issued in the near future.

Planning was also completed on the type of studies needed for estimating the hazards of shipping Ce-144 sulfate, $Sr^{90}CO_3$, and strontium adsorbed on Decalso. Details of the above type of estimates were reviewed with Company specialists in radiological hazards analyses.

Analytical work was completed on a series of uranium ore samples comprising the total feed to a typical domestic uranium mill. The results showed a thorium-232 content ranging from 3.3 to 60 ppm. The low Th-232 specimens correspondingly showed high Th-230 ratios (up to 3.7% Th-230 in the total thorium content). In general, a mixture of selected feeds to this mill could assure Th-232 compositions containing more than 2% Th-230 in over 40% of the total ore supplied. Concurrently with these results, additional analyses were obtained in streams from a large mill in Colorado not investigated earlier. These streams also showed thorium compositions in the range of 2.1 to 2.4% Th-230 in the total thorium content. These results confirm earlier indications and firmly

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establish substantial sources of thorium of relatively high Th-230 content from existing mills.

Dr. Gerald W. Johnson, Associate Director of the Lawrence Radiation Laboratory of the University of California, was the speaker at the Hanford Science Colloquium on April 18. His topic was "Project Plowshare - Status and Problems".

Assistance was provided in arranging for visits and tours by 292 visitors during the month. This number included 35 visitors on 21 official visits, 251 high school and college students and teachers on 7 separate tours, and 6 members of the Press on two separate visits. It also included a one-day visit and tour by Dr. W. B. Lewis, Vice President Research and Development, Atomic Energy of Canada Limited, Chalk River.

F. W. Woodfield
Acting Manager,
Programming

FW Woodfield:rd

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF APRIL, 1961

A. ORGANIZATION AND PERSONNEL

R. F. Ballard was reactivated on April 12, 1961, and W. H. Bischoff was deactivated on April 13, 1961 due to extended illness.

B. ACTIVITIES

Two cases of plutonium deposition were confirmed during the month. Each employee was involved in a known incident, a contaminated minor injury and the spread of plutonium contamination in the 305-B Building. Initial bioassay measurements indicate a body deposition of less than 5% and less than 0.5%, respectively. The total number of plutonium deposition cases that have occurred at Hanford is 267, of which 194 are currently employed.

Two minor injuries were examined for plutonium contamination in the Whole Body Counter. Each case showed detectable, but minor, plutonium contamination which did not warrant medical action.

Antimony-125 was identified in a regular examination of a Radiometallurgy employee at the Whole Body Counter during the month. The body burden was estimated as 0.02 μc, an insignificant fraction of the maximum permissible burden of 40 μc. Subsequent examinations of all other Radiometallurgy personnel were negative.

Prompt action by a Radiation Monitor prevented significant exposure to an IPD employee from highly contaminated gauntlet gloves and other protective clothing. While working at a rupture tube in the discharge area of the 105-KE Reactor, the monitor observed the employee grasp the contaminated end of a rupture tool. Immediate removal of the protective clothing limited the dose to the hand to an insignificant amount. A dose rate of 200 rads/hour was measured on the gauntlet gloves.

Contamination was largely confined to the fenced burial ground area in 200 East Area following the rupture of a burial box containing equipment jumpers from Purex. Particulate contamination from 15,000 c/m to 500 mrads/hour was detected northwest of the trench, but surveys revealed negligible contamination outside the fenced area. The contamination was fixed to prevent further spread. Movement of several railroad cars from Purex to the burial ground caused extensive contamination to the track way in the 200 East Area. The cars had been used to accomplish a tunnel burial at Purex, and were moved before being surveyed. General contamination to 80,000 c/m was confined to the track and immediate area. The rails were decontaminated and the ground contamination fixed to prevent contamination of other railroad equipment. No significant personnel exposure occurred in either incident.

A strontium spill resulted in floor contamination up to 300 rads/hour at the rear face of the multi-curie cell in the 325-A Building. Decontamination was accomplished with nominal personnel dose rates, but residual low level contamination required temporary use of shoe covers for entry into the area. The recent false alarms of a criticality meter in the 325 Building were traced to a faulty photomultiplier tube. Procedures were improved to assure adequate, periodic inspection and maintenance of all criticality alarms in the 300 Area.

Investigation of film dosimeter usage during three badge exchange periods revealed that for the first quarter of 1961, an average of 3.2 film badges were issued per employee. More than 100 individuals were issued 6 or more film dosimeters for this period; twice the required number. Appropriate action through management was planned to reduce the number of film dosimeters issued.

Stack sample results at the Hot Semiworks indicated that 15 μc/day of strontium was discharged to the atmosphere during the processing of the first spike run. Air samples collected inside the facility also provided evidence that control of airborne contamination is not yet satisfactory. No significant personnel exposure occurred.

Background surveys of the plant and surrounding environs were continued with the aerial monitoring equipment for a total of 20 manhours of flying time.

Difficulties were experienced with the Redox stack 50' level sampling equipment when cell block removal caused variable stack flows. Additional equipment design work is planned to obtain a sample flow proportional to the stack flow at the higher flow rates encountered.

The solid state amplifiers for the Automatic River Monitoring Station were received and installed. Performance of the new amplifiers has been entirely satisfactory. Specifications and purchase orders were prepared to obtain sensitive, self-contained temperature recording instruments to monitor Columbia River temperatures at the 300 Area and Pasco.

Field tests of the charcoal adsorber cartridges for I-131 monitoring neared completion. The data show that the diameter of the cartridge must be increased to gain a constant air flow at the ideal linear velocity.

Efforts were continued to place the extended program for bovine thyroid monitoring into operation. Drafts of instruction sheets for the veterinarians and special agreements between the General Electric Company and the veterinarians were prepared and submitted to the concerned parties for comment.

The Annual Summary Report for 1960 on the Radiological Conditions in the Hanford Environs was completed. One hundred copies were transmitted to HOO-AEC for distribution to government agencies and interested public officials.

A comprehensive hazards analysis for shipment of Cs-137 in 10^5 curie quantities was completed. The results of the study were issued for comment with J. J. Fuquay, R. L. Junkins, and E. C. Watson as co-authors.

Radiological Design Criteria for the Fuel Recycle Pilot Plant (FRPP) were discussed with design engineers and operational personnel. Release limits for effluents were reviewed and new stack limits derived, based on an average wind velocity vector. Studies to determine the requirements for radiation monitoring and stack monitoring equipment, including cost estimates, were initiated.

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Preliminary studies indicate that density measurements with existing equipment permit evaluation of duPont 1290 film to a dose of 2000 r. This is similar to the capability of spectrographic measurements for this film. It is also comparable to the upper limit of duPont 510 film, achieved only by the X-ray spectrometer method. The 1290 film has recently replaced the 510 film as the insensitive emulsion in the Hanford film dosimeter.

The use of tungsten as a filter in prototype personnel film dosimeters has resulted in a nearly linear film density response for gamma energies between 0.05 and 1 Mev. Studies are being conducted to reduce a slight density peak at 0.062 Mev. Additional experiments with the proposed dosimeter filter system have demonstrated the capability of estimating beta dose in the presence of plutonium low energy X-ray and gamma ray exposures.

About 100 ionization chamber finger rings of Hanford design were received from Landsverk Electrometer Company. Performance tests were initiated. The manufacturer requested information regarding authorization to produce the rings for other customers. The request was referred to Purchasing and the HLO Patent Attorney.

Engineering drawings were prepared for components of the double moderator criticality dosimeter. Equations for the evaluation of the neutron energy spectrum were derived from foil activation measurements. System performance details indicate that the double moderator criticality dosimeter offers performance equal to the present threshold detector system for estimating total neutron dose and only a slight compromise in neutron energy spectrum analysis. Significant savings from lower fabrication costs plus elimination of the plutonium and other radioactive foils of the present detectors are accomplished with the double moderator system.

The characteristic parameters of silicon diodes fabricated to Hanford specifications are being investigated. Measurements of the forward current, forward resistance and pulse lifetime have been made. Studies are in progress to determine the reproducibility of these measurements before any neutron exposures are made.

The 400 channel pulse height analyzer was received and installed in the bioassay laboratory. The equipment extends the capability of the laboratory by permitting rapid measurement and identification of gamma emitters that may be encountered in biological samples.

A continuous air monitor for measuring beta emitters was installed at the Radiometallurgy Building, and field performance tests were initiated. Plans call for installation of several units. Because of frequent false alarms, the continuous alpha air monitors in the 231-Z Building were temporarily removed from service. Continued use of the instrumentation is dependent upon improved reliability.

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The prototype Scintran instrument was returned to the supplier with instructions for corrective action to meet acceptance tests. A purchase order to provide a plastic probe housing for the gamma insensitive, scintillation poppy probes was cancelled when the vendor failed to deliver satisfactory items.

Personnel from RPO components participated in the National Civil Defense Exercise, OPAL 61. The exercise for Hanford was conducted at the Mobile Emergency Relocation Center. Based on fragmentary information received intermittently through normal communications channels, fallout patterns and dose rates were calculated and plotted for simulated nuclear weapon bursts throughout the Northwest. From these predictions, radiological recommendations were made to the Hanford Civil Defense staff and other participating localities.

C. TRIPS AND VISITORS

Radiation protection consultation was provided on April 18 through April 20 for Dr. J. A. Norcross, Dr. T. S. Ely, Dr. J. V. Nehemias, and Mr. J. P. H. Kelly who were at Hanford on a periodic visit for the Office of Health and Safety, AEC Headquarters, Washington D. C.

Dr. M. Eisenbud and Mr. E. R. Thomas from the Consolidated Edison Company discussed sampling of the Columbia River and biota on April 24 and 25.

Mr. J. W. Healy from General Electric at Schenectady and Mr. J. M. Smith from APED consulted on the assessment of hazards from fission product release.

On April 3, 48 students from Chief Joseph Junior High School visited the Calibrations Building.

D. EMPLOYEE RELATIONS

Seven suggestions were submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to fifteen. No suggestions were adopted and none rejected. Ten suggestions submitted by RPO personnel are pending evaluation.

There was one medical treatment injury during the month for a frequency of 0.47. No security violations occurred during April.

Radiation Protection training included: a seminar on Internal Dosimetry was presented on three occasions to IPD processing exempt employees and IPD radiation protection personnel; radiological orientation talks were presented to four groups of new employees; and three 2-hour discussions on radiation protection were presented to Hanford patrolmen.

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E. SIGNIFICANT REPORTS

HW-69278 "Analysis of Radiological Data For The Month Of March, 1961" by R. F. Foster

HW-69464 "Monthly Report - April, 1961, Radiation Monitoring Operation" by A. J. Stevens

"Precision Instrumentation for an Electron Accelerator" co-authored by H. V. Larson and I. T. Myers was accepted for publication in "Nuclear Instruments and Methods".

"A Method of Linearizing Thermistor Thermometer Data in Calorimetry" co-authored by H. V. Larson and I. T. Myers was submitted for publication in the "Journal of Scientific Instruments".

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ENVIRONMENTAL MONITORING - RESULTS - (Mid-March 1961 - Mid April 1961)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.6	% MPC_w-GI*
Separations Areas	Gross Beta	1.7×10^{-7}	μc/cc
Pasco	Isotopic	6.3	% MPC_w-GI**
Kennewick	Isotopic	< 1.2	% MPC_w-GI**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	μc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	1.7×10^{-8}***	μc/cc
100-F Area	Isotopic	2.8	% MPC_w-GI*
Hanford	Isotopic	2.6	% MPC_w-GI*
Pasco	Isotopic	16	% MPC_w-GI**
McNary Dam	Gross Beta	No Sample	
Vancouver, Washington	Isotopic	0.8	% MPC_w-GI**
Atmosphere			
I^{131} Separations Areas	I^{131}	4.1×10^{-13}	μc/cc
I^{131} Separations Stacks	I^{131}	0.6	Combined curies/
Active Particles - Project	--	1.1	ptle/100 m^3
Active Particles - Environs	--	0.04	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} μc I^{131}/g)			
Separations Areas	I^{131}	3.9×10^{-6}	μc/g
Residential	I^{131}	$< 1.5 \times 10^{-6}$	μc/g
Eastern Washington and Oregon	I^{131}	No Samples	

* The % MPC_w is the percent of the maximum permissible limit for occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

** The % MPC_w-GI is the percent of the maximum permissible concentrations for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

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

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EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
April	0	0
1961 to Date	1	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
April	4,046	35	0	0
1961 to Date	18,788	248	13	0

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	mr(s)
April	9,931	1,055	142	29	22	10.12	24.30
1961 to Date	40,434	3,695	408	107	100	9.29	21.34

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
April	1,351	0	0	0	2
1961 to Date	6,583	0	0	0	27
Fast Neutron					
April	163	46	5	0	2
1961 to Date	1,759	264	58	0	27

Whole Body Counter

	Male	Female	April	1961 to Date
GE Employees				
Routine	78	2	80	228
Special	4	0	4	31
Terminal	0	0	0	1
Non-employees	2	0	2	11
Pre-employment	0	0	0	0
Total	84	2	86	271

Bioassay

	April	1961 to Date
Confirmed Plutonium Deposition Cases	2	4*
Plutonium: Samples Assayed	465	2,398
Results above 2.2×10^{-8} µc Pu/sample	10	63
Fission Product: Samples Assayed	568	2,630
Results above 3.1×10^{-5} µc FP/sample	0	2
Uranium: Samples Assayed	281	1,143

*The total number of plutonium deposition cases which have occurred at Hanford has increased to 267, of which 194 are currently employed on plant.

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	41.5	5.3	61	28.7	3.5	62
Fuels Preparation*	3.1	3.1	1	0	0	0
Hanford Laboratories	14.8	4.2	26	23.3	2.7	29
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	602.3	21.7	38	21.9	4.6	38
Chemical Processing*	5.2	5.2	1	0	0	0
Special Incidents	678.7	62.7	19	0	0	0
Random	1.3	0.9	6	0	0	0

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

Thyroid Checks	April	1961 to Date
Checks Taken	0	0
Checks Above Detection Limit	0	0

Hand Checks		
Checks Taken - Alpha	34,377	121,716
- Beta-gamma	48,159	188,157

Skin Contamination		
Plutonium	22	85
Fission Products	61	190
Uranium	1	25

CALIBRATIONS	Number of Units Calibrated April	1961 to Date
Portable Instruments		
CP Meter	916	3,626
Juno	230	933
GM	475	2,257
Other	194	691
Audits	102	414
Total	1,917	7,921
Personnel Meters		
Badge Film	1,536	5,799
Pencils	-	-
Other	326	1,524
Total	1,862	7,323
Miscellaneous Special Services	1,363	3,505
Total Number of Calibrations	5,142	18,749

A R Keene
Manager
Radiation Protection

1251368

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - APRIL, 1961

GENERAL

There were no security violations charged to the Operation.

There were no major injuries; the minor injury frequency rate was 5.52 for the month and 3.19 for the year to date.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 20,153 hours. This includes 14,087 hours performed in the Technical Shops, 3,661 hours assigned to Minor Construction, 67 hours assigned to other project shops and 2,338 hours assigned to off-site vendors. Total shop backlog is 19,301 hours, of which 60% is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 5.2% (933.9 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	5,195	25.8%
Irradiation Processing Department	857	4.2%
Chemical Processing Department	665	3.3%
Hanford Laboratories Operation	13,415	66.6%
Construction Engineering & Utilities	21	0.1%

Requests for emergency service decreased sharply, requiring an overtime rate of 5.2%, compared to 8.3% the previous period.

At the close of the reporting period, there were two open requisitions for Machinists. Candidates for these positions have been processed and final call-in issued. One Machinist and one Instrument Technician were added to the roll during the reporting period.

Security performance was considered satisfactory with no violations. There were 15 medical treatment injuries, which is considered higher than normal for this type of operation.

CONSTRUCTION OPERATION

There were 70 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $74,616. One hundred and four new orders, 3 supplements and adjustments for underruns amounted to $68,904. Expenditures during the month on HLO work were $72,016. Total J. A. Jones backlog at month's end was $71,504.

Summary

	HL		CE&UO	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	69	$ 73,162	1	$ 1,454
Issued during the mo. (Inc.Sup.&Adj.)	107	68,778		126
J.A. Jones Expenditures during month (Inc. C.O. Costs)		72,016		
Balance at month's end	50	69,924	1	1,580
Orders closed during month	135	89,051	0	0

FACILITIES ENGINEERING OPERATION

Projects

The following is a brief summary of project work in Facilities Engineering Operation:

There were 15 authorized projects at month's end with total authorized funds of $2,424,000. The total estimated cost of these projects is $8,734,000. The expenditures on these projects through March 31, 1961, were $1,286,000.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end 15

Number of new projects authorized during the month: 3
- CGH-902 Uranium Scrap Burning Facility
- CGH-919 314 Building Air Conditioning
- CGH-924 200 KW Induction Heating System - 306 Bldg.

Projects completed during the month: 0

New project proposals submitted to AEC during month: 0

New projects awaiting AEC approval:
- CAH-917 Field Service Center
- CGH-918 Second Whole Body Counter Cell Addition - 747 Bldg.
- CGH-922 Burst Test Facility for Irradiated Zr Tubes
- CGH-927 Additions to 271-CR Building Waste Treatment Demonstration Facility

Note - Proposals complete or nearing completion are as follows:

Coolant Systems Development Laboratory
Laboratory Waste Retention Facilities Expansion
Safety and Operating Improvements - 231-Z Building

1251370

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals.

Title	Status
Pressure Vessel and Piping Systems Engineering & Inspection Service	This is a continuing work program on HLO vessels, pressure systems and related safety devices. The work includes not only periodic inspection and engineering evaluations of plant pressure systems but engineering service during design, fabrication, installation, and operation to R&D components having process devices subjected to high pressures and temperatures. Code compliance engineering service work is being performed on 1) PRTR Systems: 2) Irradiation Studies Loop; 3) Breakaway Corrosion Loop; and, 4) Equipment Projects.
"Split-half" Machine For Critical Mass Studies	Mechanical design of machine is essentially complete. Electrical design work remains. Components have been purchased and are being assembled. The special drive for remote control with instrumentation remains to be designed and applied.
Control and Safety Rods for Tamper Tank (Critical Mass)	Development work is performed prior to completion of design.
Electrical Modifications - 3702 Building	Field work is delayed pending availability of craftsmen.
Special Filter Changer - CWS	Material is on order for testing a proposed design using plastic bags and shielded cart.
Material Handling System and Other Shop Improvements - 328 Building a) Material Handling System b) Coating Process Improvements c) Chuck Handling Procedure	Engineering work is in progress. Material is being ordered for installation.

1251371

Title	Status
Engineering Studies - 100-F	A survey tour was made during March. Recommendations of maintenance of main air supply units in 108-F Building were made.
Electrical Load Improvements - 329 Building	Load studies are complete. Engineering design complete. Installation work will be performed by Plant Forces.
Motorized Door Opening Device - 327 Building	Installation work complete except for adjustments.
Modifications to H-1 Loop - 105-H Building, for Corrosion Studies	Scope design work is in progress. This will be used in preparation of a project proposal.
Arrange space and install utilities for business machines - 3760 Building.	Design work in progress.
Source Positioner - 3745 Building	Design complete. Material on hand. Installation has started.
Zone Modifications - 325 Bldg. Air Conditioning System	Cost estimates are being prepared based on completed detail design.

Drafting and Design Services

Work load in 3706 Building drafting room is constant with some overtime work required. Branch offices in 306 and 308 Buildings have work loads without backlog. The 308 Building drafting room was reduced by one man to better equalize work load. The equivalent of 150 design drawings were completed this month.

Major design and drafting work in progress includes the following:

1. Structural Materials Irradiation Test Facility - design - 43 drawings completed.

2. Thermal Precipitator - 5 drawings required - 40% complete.

3. Critical Facility - approx. 20 drawings required - work complete.

4. Process Calciner - 25 drawings estimated - complete.

5. Rupture Loop Mock-up Facility - 15 drawings required - work temporarily stopped.

6. Process Tube Monitor Mark III - 6 drawings required - 50% complete.

1251372

7. Spectroscopy Laboratory - 6 drawings required - 25% complete.

8. Shroud Replacement Tools - 20 drawings estimated - work started.

9. Waste Sludge Sluice System - work started.

10. Flux Measuring Device - work started.

11. Arc Melt Hood - 6 drawings required - 70% complete.

12. Conductivity Insert Model II - work started.

Plant Maintenance and Operation

March costs were $156,819 which is 98.9% of forecast to date.

Analysis of Costs

The cumulative expenditure has risen to 98.9% of the forecast which was made last December when the budget was reduced. This increase in activity arises from accelerated improvement maintenance. Our efforts to obtain our share of the maintenance manpower has also produced favorable results.

Improvement Maintenance

Item	
Relocation and alteration	$ 6,136
Repainting	5,077
Reroofing	98
Electrical Modifications	410
Piping Modifications	7,813
H&Vent Modifications	2,815
Crane	2,665
	$ 25,014

Plant Engineering and Miscellaneous

Approximately 28,000 square feet of prints were reproduced during the month.

The total estimated value of the 10 requisitions issued during the month was $260,000. The majority of this procurement activity is for approved HLO projects. New signs are being procured using standard terminology for use in areas requiring special radiological protective apparel.

Painting is being continued in 325 Building.

Painting of certain rooms in 231-Z Building continued.

The rerouting of the crib waste line in 327 Building was completed by J. A. Jones Construction forces.

Electrical Load Studies are being made in 325 and 3760 Buildings. New lighting panels are being installed in 325 Building.

The crane in 314 Building has been repaired and is in service.

Improvements to fail-safe features of 325-A Building ventilation system are being installed.

The crane in 321 Building was inspected during the month.

Crane rails in 327 Building are being leveled.

Criticality alarm systems installed in the Hot Semi-Works and Critical Mass Laboratory are being interconnected.

Minor electrical modifications are being made in 3702 Building.

TECHNICAL INFORMATION OPERATION

Preparations for the interviewers from Saul Herner and Company, who are surveying Commission sites to test the effectiveness of AEC's technical information program, are proceeding smoothly. The survey was announced in Management Newsletters to all Departments. A listing of all scientific and technical personnel at HAPO is being run from the Personnel Source File in Data Processing and the ordered sample will be selected from it.

Two classification memos were distributed to the field. They are:

HW-69021 "Classification: Plutonium"
HW-69218 "Excerpts from Minutes of the Sixth AEC Classification Officers Meeting, Germantown"

All formal R & D reports will be reviewed by the Patent Attorney to ascertain whether patentable material and/or legal objections exist to prevent a document being sent off-site. A corollary problem involving the release to the AEC and its contractors of non-formal reports with patentable material has been resolved with the use of a new sticker. The sticker serves to explain the Official Use Only category under which such reports are released.

The annual listings of non-classified and Confidential-Undocumented documents charged out from Files were mailed to the field in conjunction with the periodic inventory of classified documents. The listing has resulted in an increase in the number of documents returned to Files.

1251374

Representatives of IBM met with personnel from Technical Information and C & A's Office Procedures Operation to review the detailed programming of the Files' Card-a-type installation. Necessary forms have been ordered, necessary furniture has been ordered, and the Card-a-type operator has been selected. Keypunching of off-site addresses has begun. Stores has been asked to obtain a supply of a small one-drawer file box which plant secretaries can use to keep their copies of the new IBM route forms to be used in the new system. Installation is expected about June 1.

Work Volume Statistics

	March	April
Document Distribution and Files		
Documents routed and discharged (copies)	19,763	29,057
Documents issued (copies)	11,466	14,206
Documents sent off-site (copies)	5,700	6,630
Document reserves filled (copies)	671	698
Documents picked up and delivered	19,114	18,889
Document Accountability		
Holders of classified documents whose files were inventoried	411	638
Documents inventoried in Files (copies)	--	--
Documents destroyed or retired (copies)	13,475	16,601
Documents revised (copies)	1,181	1,701
Documents pulled and documents filed (copies)	18,391	22,654
Documents reclassified	602	781
Documents microfilmed	4,220	3,772
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	204,941	199,886
Reference and Publication		
Books cataloged (new titles)	88	152
Books added to the collection (volumes)	302	374
Ready reference questions answered by professional staff	223	145
Literature searches by professional staff	71	90
Reports abstracted (titles)	287	296
Formal reports prepared (titles)	9	12
Off-site requests for HAPO reports (copies)	181	306
Reports released to CAP (titles)	17	24

1251375

	March	April
Library Acquisitions and Circulation		
Books ordered (volumes)	377	318
Periodicals ordered	208	174
Books circulated (volumes)	2,519	1,647
Periodicals circulated (issues)	4,144	3,412
Inter-Library loans	81	58
Films borrowed or rented	10	18
Industrial film showings	53	106
Bound periodicals added to the collection	172	5
Bound periodicals discarded	1	0

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	31,338	8,619	1,769	2,051	43,777
No. of bound periodicals	14,422	14	1,892	6	16,299
	45,760	8,633	3,661	2,057	60,076

Classification and Declassification	March	April
Documents, including drawings and photographs reviewed for downgrading or declassification	351	45
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	26	29
Documents submitted to Declassification Branch, Oak Ridge	64	3

J L Boyd
Manager,
LABORATORY AUXILIARIES

JL Boyd:jw

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CAH-822	Pressurized Gas Cooled Facility	4141-Operating

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	ESTIMATED TOTAL COST
$995,000	40,000	995,000		995,000	4-16-61	$ 819,466 / $ 1,120,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	8-19-59	10-17-60		6-30-61		4-29-60	9-30-61

ENGINEER

REDO - DP Schievely

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100	92	73
PF			
CPFF	17	88	70
FP	7	95	90
	76	91	71

SCOPE, PURPOSE, STATUS & PROGRESS

Struther-Wells has completed steel shielding design. Plans are being formulated to mock-up in-reactor test section in "B" cell.

PROJ. NO.	TITLE	FUNDING
CGH-834	Modifications & Additions to High Pressure Heat Transfer Apparatus - 189-D Building	0290

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	ESTIMATED TOTAL COST
$700,000	66,000	634,000		700,000	4-16-61	$ 697,658 / $ 745,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	4-20-59	4-22-59	4-8-59	4-1-61		2-15-61	7-1-61

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	10	3700
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION	0	960
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100	100	95*
PF			
CPFF	100	100	95*
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides necessary modifications to existing equipment to simulate more severe in-reactor operating conditions in out-of-reactor facilities for research and development studies.

The remaining signatures are being obtained for revised project proposal requesting additional funds and extension of the completion date. Construction has been stopped pending authorization of this revision.

* Based on the revised estimate cost of $745,000.

1251377

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CAH-842	Critical Reactivity Measuring Facility	58-e-15

AUTHORIZED FUNDS				
$ 360,000	DESIGN $ 45,000	AEC $ 148,000	COST & COMM. TO 4-16-61	$ 115,421
	CONST. $ 315,000	GE $ 212,000	ESTIMATED TOTAL COST	$ 360,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	11-17-59	DATE AUTHORIZED	DESIGN	2-1-61
CONST.	10-3-60	DIR. COMP. DATE 4-30-61	CONST.	8-15-61

ENGINEER

REDO - WS Kelly

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	NS	37
PF			
CPFF	60	NS	0
FP	40	100	93*

SCOPE, PURPOSE, STATUS & PROGRESS

The lock installation has been completed. Preliminary testing revealed certain deficiencies in the operating mechanism. The vendor has been informed and is providing the parts necessary to correct the deficiencies.

George Grant Co., the fixed price building contractor, is estimated to be complete May 15 rather than May 1, previously scheduled.

* Does not reflect the progress made on G. E. procured items until such items are installed.

PROJ. NO.	TITLE	FUNDING
CGH-857	Physical & Mechanical Properties Testing Cell-327 Bldg.	0290

AUTHORIZED FUNDS				
$ 75,000	DESIGN $ 75,000	AEC $	COST & COMM. TO 4-16-61	$ 74,941
	CONST. $	GE $ 75,000	ESTIMATED TOTAL COST	$ 430,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	11-2-59	DATE AUTHORIZED 10-1-59	DESIGN	3-1-61
CONST.		DIR. COMP. DATE	CONST.	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION	1	540
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in the 327 Building.

A project proposal revision requesting the total construction funds is in preparation.

1251378

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CGH-858	High Level Utility Cell - 327 Building	0290

AUTHORIZED FUNDS				
$70,000	DESIGN $ 70,000 / CONST. $	AEC $ / GE $ 70,000	COST & COMM. TO 4-16/61 / ESTIMATED TOTAL COST	$ 70,000 / $ 400,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 11-2-59	DATE AUTHORIZED 10-1-59		DESIGN 3-1-61	
CONST. 8-6-61	DIR. COMP. DATE 2-6-62		CONST. 2-6-62*	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		35
DESIGN ENGINEERING OPERATION	1	624
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	95	100	100
AE-TIT. II			
Vendor	5	100	100
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to prepare specimens from irradiated materials for use in determining their physical and mechanical properties and involves the installation of a cell in 327 Building.

Procurement is progressing satisfactorily. The Bid on the cell procurement order is due for opening on 5-8-61.

PROJ. NO.	TITLE	FUNDING
CAH-866	Shielded Analytical Laboratory - 325-B Building	61-a-1

AUTHORIZED FUNDS				
$ 60,000	DESIGN $ 60,000 / CONST. $	AEC $ 45,000 / GE $ 15,000	COST & COMM. TO 4-16-61 / ESTIMATED TOTAL COST	$ 15,000(GE) / $ 700,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 9-5-59	DATE AUTHORIZED 5-31-60		DESIGN 11-14-60	
CONST. 4-20-61	DIR. COMP. DATE 6-30-62		CONST. 3-1-62	

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	10	100	100
AE-TIT. II	90	100	100
CONST.	100	NS	
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow greater capacity for analytical work involving today's more highly radioactive solutions and consists of adding a shielded laboratory to the 325 Building.

HOO-AEC Directive HW-495, dated April 20, 1961, approved the project and authorized the incurrence of costs in the amount of $700,000. The directive completion date is June 30, 1962.

The advance construction notice has been issued and the bid package will be issued on April 27, with the bid opening on June 1, 1961.

125379

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ.NO.	TITLE	FUNDING
CAH-867	Fuel Element Rupture Test Loop	58-e-15

AUTHORIZED FUNDS				
$1,500,000	DESIGN $ 130,000	AEC $ 770,000	COST & COMM. TO 4-16/61	$ 385,828
	CONST. $ 1,370,000	GE $ 730,000	ESTIMATED TOTAL COST	$ 1,500,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 8-1-60*			DESIGN 2-15-61
	CONST. 11-2-60	DIR. COMP. DATE 10-31-61		CONST. 10-31-61

ENGINEER

REDO - PC Walkup

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	91	100	100
AE-TIT. II	9	100	100
CONST.	100	18**	9.8**
PF	2	--	--
CPFF	24		
FP (1)	10	97	98
(2)	33		
(3)	31		

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G.A. Grant Company.
All design drawings and construction specifications have been approved.

* Detail Design. Scope design started 11/2/59 and completed 3/15/60.
** Water plant construction was scheduled for starting 3/1/61. Design drawings and specs for water plant and holdup tank forwarded to AEC-HOO early in February. These have not been released for bidding as yet. The project is approximately 3 months behind schedule as a result.

PROJ. NO.	TITLE	FUNDING
CAH-870	Facility for Recovery of Radioactive Materials-325 Bldg.	60-a-1

AUTHORIZED FUNDS				
$ 486,000	DESIGN $ 46,000	AEC $ 446,000	COST & COMM. TO 4-16-61	$ 40,407 (GE)
	CONST. $ 440,000	GE $ 40,000	ESTIMATED TOTAL COST	$ 486,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 11-20-59	3-22-60		DESIGN 3-1-60
	CONST. 5-6-60	DIR. COMP. DATE 6-1-61		CONST. 6-1-61

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	14	2938
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	10	100	100
AE-TIT. II	90	100	100
CONST.	100	99	99
PF	1	100	100
CPFF			
FP	100	100	99

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for recovery of specific radioisotopes from wastes, and involves an addition to the 325 Building.

The Labor Service Contractor is scaling the vault cover slabs and cleaning out the vault exhaust ducts. One of the government furnished agitator motors is being replaced with an explosion-proof motor to make it compatible with the rest of the vault.

1251300

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-h-1

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	$	ESTIMATED TOTAL COST	$
$420,000	44,000	376,000	400,000	20,000	4-16-61	9,998		420,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	8-8-60	6-15-61	9-2-60			3-31-61	3-31-62

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	100
TITLE I			
GE-TIT. II	17	NS	100
AE-TIT. II	83	NS	100
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides additional space for biological research supporting services, and involves an addition to the 108-F Building.
Miscellaneous additions and changes were made by G.E. Co. to the tracings and specs. which were made at the request of B.D. Bohna and concurrence of AEC. The tracings and specs. were presented to the AEC on 4/18/61. Two sets of drawings and a rough draft of the special conditions were handed to the AEC on 4/7/61. Bid package preparation by AEC was held up pending receipt of their work authority dated 4/18/61, which was being processed. G.E. advised the AEC it considered the radiation handling facilities was insufficiently detailed (Title I only) to be included as part of the lump sum general contract. The special conditions were prepared by G. E. accordingly and presented to AEC on 4/19/61. The HLO Technical Shops is preparing an estimate of the handling facilities.

PROJ. NO.	TITLE	FUNDING
CAH-896	Stress Rupture Test Facility	60-1

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	$	ESTIMATED TOTAL COST	$
$ 90,000	7,500	82,500	78,500	11,500	4-16-61	9,271 (GE)		90,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	7-29-60	3-20-61	3-6-61	10-15-61		12-1-60	10-15-61

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	5	70
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100	14	12
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

The foundations have been poured and piping is being placed prior to pouring the walls and floor slab. The door to the 314 Building has been cut and framed. Sub-Vendor procurement is progressing favorably.

1251381

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CAH-901	Structural Material Irradiation Test Equipment - ETR	0290

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	$	ESTIMATED TOTAL COST	$
$ 125,000	12,000	113,000		125,000	4-16-61	58,308		125,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	9-15-60	6-1-61	9-2-60	10-15-61		3-31-61	10-15-61

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	1	165
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100	NS	NS
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides for the installation of equipment at the ETR for which changes in the physical properties of reactor structural materials subjected to in-reactor conditions can be determined.

Planned installation start date of 4/17/61 has been postponed for at least six weeks because of higher priority work by the Phillips Petroleum Co.

The HOO-AEC has been requested to confirm the schedule change and furnish information concerning the project status.

PROJ. NO.	TITLE	FUNDING
CGH-902	Uranium Scrap Burning Facility	61-1

AUTHORIZED FUNDS	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO	$	ESTIMATED TOTAL COST	$
$ 36,000	5,000	31,000	27,500	7,500				36,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	5-1-61	7-1-61	12-14-60*	10-15-61		7-1-61	10-15-61

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	0	0
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a means of making uranium scrap material safer for storage and off-plant shipment by converting this scrap to a stable uranium oxide. The facility will be adjacent to the 333 Building.

Directive and work authority have been received changing the Methods of Performing Work. An extension of completion date may be required because of the delay in accepting the work authority. The Work Authority and Directive Completion Date were accepted as stated.

Design will start May 1, 1961.

* Accepted by the General Electric Company 4/17/61.

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CAH-914	Rattlesnake Springs Radioecology Facility	61-j

AUTHORIZED FUNDS				
$ 72,000	DESIGN $ 3,400*	AEC $ 53,700	COST & COMM. TO 4-16-61	$ 6,075
	CONST. $ 68,600	GE $ 18,300	ESTIMATED TOTAL COST	$ 72,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	3-1-61	DATE AUTHORIZED 12-22-60	DESIGN	6-1-61
CONST.	7-15-61	DIR. COMP. DATE 10-31-61	CONST.	12-1-61

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	8
TITLE I			
GE-TIT. II	100	NS	0
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow performance of radioecological studies under local environmental conditions. It consists of constructing field facilities for this purpose.

The field survey work is complete. Scope design by the A. E. has not been received to date. After comments, detail design will be completed by Bovay.

Requisitions have been issued for equipment being purchased by G. E. Bids on the first items are being reviewed at present.

* Bovay Engineers.

PROJ. NO.	TITLE	FUNDING
CAH-916	Fuels Recycle Pilot Plant	Funds Avail. to Comm.

AUTHORIZED FUNDS				
$ 50,000	DESIGN $	AEC $	COST & COMM. TO 4-16-61	$ 43,000
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 5,000,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	3-1-61	DATE AUTHORIZED 2-9-61	DESIGN	3-1-62
CONST	5-1-62	DIR. COMP. DATE	CONST.	11-1-63

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	< 1
TITLE I		NS	< 1
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

A Design Council Meeting was held on April 21, 1961. As a design basis, it was decided to locate this facility east of the 308 Building; to use 4-foot thick high density concrete walls in routinely occupied areas; to limit stack height to 50 meters and to establish a control estimate.

1251383

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CAH-917	Field Service Center - Atmospheric Physics	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 154,000

STARTING DATES	DESIGN 6-15-61*	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN 10-1-61*
	CONST. 11-15-61*	DIR. COMP. DATE		CONST. 3-1-62*

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities necessary to conduct atmospheric physics research and development programs.

The revised plot plan and sheet 7, of the proposal was transmitted to the AEC on 4/14. The proposal has not been reviewed by the Commission for local approval.

* Based on AEC authorization by 5/15/61.

PROJ. NO.	TITLE	FUNDING
CGH-918	Second Whole Body Counter-Cell Addition - 747 Building	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 110,000

STARTING DATES	DESIGN 8-1-61*	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN 11-1-61*
	CONST. 3-1-62*	DIR. COMP. DATE		CONST. 11-1-62*

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a second whole body monitoring cell in the 747-A Building to increase the capacity of the Whole Body Counter Facility to meet projected needs.

The project proposal was submitted to the Commission on 12/9/60, and has been sent to Washington for review by the Division of Biology & Medicine. There has been no further action since the last report.

* Assuming AEC authorization by 7-1-61.

1251364

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CAH-919	Air Conditioning - 314 Building	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 35,000

STARTING DATES	DESIGN 5-2-61	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN 7-5-61
	CONST 6-15-61	DIR. COMP. DATE 9-15-61		CONST. 9-15-61

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will supplement existing cooling units, thus providing cooling air supply commensurate with heat load and outdoor temperatures.

Directive AEC-188 dated March 8, 1961, authorized the project and assigned management to the Atomic Energy Commission. Work Authority was issued 4/18/61, to the G. E. Company. Design will start immediately.

PROJ. NO.	TITLE	FUNDING
CAH-921	Geological & Hydrological Wells - FY-61	61-j

AUTHORIZED FUNDS	DESIGN $ 1,000	AEC $ 69,500	COST & COMM. TO	$
$ 79,000	CONST. $ 62,000	GE $ 9,500	ESTIMATED TOTAL COST	$ 79,000

STARTING DATES	DESIGN 4-15-61	DATE AUTHORIZED 3-21-61	EST'D. COMPL. DATES	DESIGN 5-15-61
	CONST. 5-2-61	DIR. COMP. DATE 12-31-61		CONST. 12-31-61

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I	100	0	0
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF	0		
CPFF	3	0	0
FP	97	0	0

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

On April 19, a contract orientation meeting was held by the AEC for the A. M. Jannsen Drilling Co. No work will be started on our portion of this contract until May 2, or when second drilling rig arrives on site.

1251385

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CGH-922	Burst Test Facility for Zirconium Tubes	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 228,000

STARTING DATES	DESIGN	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN
	CONST.	DIR. COMP. DATE		CONST.

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to permit deliberate destructive testing of irradiated zirconium tubing. This will provide operating and tube life data not now available because of the limited operating history of Zircaloy-2 pressure tubing in reactors.

The project proposal, which was returned by the Commission without action, has been revised to include supplemental data requested by the Commission and is being routed for G. E. Company approval.

PROJ. NO.	TITLE	FUNDING
CGH-923	Spectroscopy Laboratory	0290

AUTHORIZED FUNDS	DESIGN $ 4,500	AEC $	COST & COMM. TO 4-16-61	$ 6,300
$ 95,000	CONST. $ 90,500	GE $ 95,000	ESTIMATED TOTAL COST	$ 95,000

STARTING DATES	DESIGN 3-21-61	DATE AUTHORIZED 3-9-61	EST'D. COMPL. DATES	DESIGN 6-1-61
	CONST. 6-1-61	DIR. COMP. DATE 11-15-61		CONST. 11-15-61

ENGINEER

FEO - RC Ingersoll

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	30
TITLE I			
GE-TIT. II		NS	30
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for specialized spectroscopy work.

Purchase specification for procurement of the NMR Spectrometer has been prepared. Field Work Release #67 has been issued to J. A. Jones for procurement of air conditioning equipment.

Bid opening on the NMR Spectrometer equipment is scheduled for 4-27-61.
Bid opening on the air conditioner is scheduled for 4-28-61.

1251366

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69408

DATE 4/30/61

PROJ. NO.	TITLE	FUNDING
CGH-924	200 KW Induction Heating System - 306 Building	0290

AUTHORIZED FUNDS				
$ 31,000	DESIGN $ 3,200	AEC $ 24,650	COST & COMM. TO	$
	CONST. $ 27,800	GE $ 6,350	ESTIMATED TOTAL COST	$ 31,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	5-1-61	DATE AUTHORIZED 3-27-61	DESIGN	7-1-61
CONST.	6-1-61	DIR. COMP. DATE 2-28-62	CONST.	9-1-61

ENGINEER

FEO - RC Ingersoll

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	0	0
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100	0	0
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a source of power for induction heating for R & D work in the 306 Building.

The directive and AEC Work Authority has been received.

A work release authorization dated April 26, 1961, has been issued by G. E. Co.

PROJ. NO.	TITLE	FUNDING
CGH-927	Additions to the 271-CR Building Waste Treatment Demonstration Facility	61-j

AUTHORIZED FUNDS				
$	DESIGN $	AEC $	COST & COMM. TO	$
	CONST. $	GE $	ESTIMATED TOTAL COST	$

STARTING DATES			EST'D. COMPL. DATES	
DESIGN	7-1-61*	DATE AUTHORIZED	DESIGN	11-1-61*
CONST.	10-1-61*	DIR. COMP. DATE	CONST.	4-1-62*

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides facilities for pilot plant development of decontamination processes for intermediate level chemical processing plant waste for safe discharge to the plant environs.

The project proposal was submitted to HOO-AEC on 3-23-61, and was approved by the Project Review Board on 4-13-61. No directive has been issued to date.

* Based on authorization by 6-1-61.

1251307

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

COMMUNICATIONS

Prepared script and directed filming of televised news feature on Operation Plowshare and Project Chariot. Presentation date for the film has been set for May 14 at 4:00 P.M..

Prepared press releases on: (1) E. J. Seppi's fellowship, (2) V. G. Aquino's fellowship, (3) E. A. Evans' trip to Brussels. In addition, participated with Relations Operation in the preparation of releases on: (1) magnetic force resistance welding (2) E. D. Clayton's trip to Germany.

EMPLOYMENT (Professional)

Advanced Degree - Twelve Ph.D. candidates visited HAPO for professional employment interviews. Eighteen offers were extended; three acceptances (all HL) and one rejection were received. Current open offers total 17. Recruiting trips to three universities occurred.

BS/MS - Offer acceptances rose sharply during April as did rejections. Year-to-date progress in campus recruiting has resulted in 152 offers, 48 acceptances and 42 rejections. We currently have 62 offers open.

Technical Graduate Program - Six Technical Graduates were placed on permanent assignment during the month. Three new members were added to program rolls. Current program members total 48.

EMPLOYMENT (Non-professional)

Ten requisitions were filled during the month with a total of 25 active requisitions remaining to be filled.

for

O. E. Boston, Manager
Professional Placement
and Relations Practices

OEB:lmh

1251300

UNCLASSIFIED

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1960 to date

		Visits to Richland			Offers			
	Cases Considered	Invited	Visited	To Visit	Offered	Accepted	Open	On the Roll
PhD	515	150	59	31	40	9	17	3
Exp. BS/MS	363	66	53	2	61	40	1	26
Prog. BS/MS	345	-	-	-	152	48	62	8

B. Technical Recruiting Activity - HL - September 1, 1960 to date

		Visits to Richland			Offers			
	Cases Considered	Invited	Visited	To Visit	Offered	Accepted	Open	On the Roll
PhD	515	150	59	31	33	7	16	2
Exp. BS/MS	190	32	22	1	18	11	1	4

In addition to the above activity, 8 exempt employees have transferred into HL from other HAPO departments and 10 technical graduates have accepted off-program placement in HL to date.

UNCLASSIFIED

1251389

C - Technical Graduate Program
Month ending April 30, 1961

Number Personnel on Assignment		48
(HAPO Tech Grad Program	44	
(Engineering & Science Program	4	

Distribution of Assignments by Departments

IPD	16
HL	19
FPD	5
CPD	5
C&AO	3
CE&UO	0

Distribution of Assignments by Function

Research & Development or Engineering	30
Other	18

FINANCIAL OPERATION MONTHLY REPORT
APRIL 1961

Personnel

There were no personnel changes during the month of April.

Activities

GENERAL ACCOUNTING OPERATION

A report which has been issued by General Accounting for some time was discontinued following receipt of information that information contained was not of great value to Hanford Laboratories. This report was entitled "Visitors to HLO and Travel Planned by HLO Personnel".

Following is a schedule of approval letters in the hands of the Commission or which have been submitted to them and the current status of each letter.

Number	Title	Status
AT- 97	Cooperative Program for Evaluation of Decontamination Agents.	Submitted to AEC in April. Not yet approved.
AT-104	Fission Products Dispersal Handbook	Submitted to AEC in March. Not yet approved.
AT-105	Symposium on the Biology of the Transuranic Elements	Submitted to AEC in February. Not yet approved.
AT-140	National Academy of Sciences - National Research Council - Advisory Committee on Civil Defense	Approved April 13, 1961.
AT-149	Recruiting Practices	Submitted to AEC in early May.

Travel activity in April was considerably below the year earlier level. The total year-to-date level at the end of April was essentially the same as for the first ten months of FY 1960.

Project unitization reports were issued during the month on the following projects:

CAH-864	Shielded Animal Monitoring Station, 100-F Area	$45,244
CGH-877	Pyrochemical Test Facility, 321A Building	68,584
CAH-878	Additional Facilities for Isotope Study on Animals - 141C Building	

During the month preliminary unitization work was performed on the following projects and equipment tagged:

AEC-167	Plutonium Recycle Test Reactor
CGH-785	In-Reactor Studies Equipment - 105 KW
CGH-805	High Temperature Tensile Testing Cell - 325 Building
CAH-822	Pressurized Gas Cooled Loop Facility - PRTR Site
CAH-842	Critical Facility - PRTR Site

The physical inventory of movable cataloged equipment in the custody of Reactor and Fuels R&D Operation which began March 13, 1961, is still in progress. The field count is proceeding on schedule.

Reconciliation of physical inventory of fixed property in connection with the Cold Semi-Works - 321 Facility by C&AO is still in progress.

The quarterly inventory of Special Materials in the custody of 93 HLO holders was conducted as of March 31, 1961. The new verification type inventory introduced this quarter was well accepted by holders of special materials and expedited the inventory reconciliation. The new HLO verification type inventory procedure has been put into effect plant wide and incorporated in HAPO OPG 8.14.

Heavy Water expenditures through April were $74,659. Heavy Water accumulated for return to SROO for rework at April 30, 1961, amounted to 4,223.540 kgs. During April, 14,485.850 kgs. D_2O were received from SROO valued at $446,465 Fund and $309,779 Non-Fund.

Thirty-nine new items valued at $22,565 were received at the Laboratory Equipment Pool during the month. Four items valued at $900 were withdrawn by custodians and 19 items valued at $5,008 were disbursed in lieu of placement of requisitions. One item valued at $101 was retired from record on a Property Disposal Request. There are currently 657 items valued at $243,135 located in the Equipment Pool. Included in this total are 100 uncataloged type items valued at $15,519 available for loan or transfer and 44 items valued at $1,800 which are being held for the convenience of others.

Reactor and Other Special Materials on hand at month end consisted of the following:

Beryllium	1,211 gr.	$ 696
Gold	2,258 gr.	3,027
Palladium	2,219 gr.	2,530
Platinum	5 896 gr.	17,158
Silver	2 433 gr.	97
Zirconium		
Inventory Stock	3,075 lb.	67,490
R&D Stock	607	9,114
Scrap	9,643	-0-
		$100,112

Action as indicated occurred on the following projects during the month:

New Funds Authorized HLO

CAH-866	Shielded Analytical Laboratory	$138,500
CAH-888	Biology Laboratory Improvements	10,000
CAH-902	Uranium Scrap Burning Facility	7,500
CAH-919	Air Conditioning - 314 Building	6,350
CAH-924	200 KW Induction Heating, 306 Building	6,350

Construction Completion and Cost Closing Statements

CAH-864 Shielded Animal Monitoring Station - 100-F
CAH-878 Additional Facilities for Isotope Study on Animals 141-C Building
(4-C reports for AEM Services on these projects were issued several months ago)

Concurrent with the authorization of Project CAH-924, 200 KW Induction Heating 306 Building, the AEC will retain management of equipment projects when work is to be performed under lump sum contract. General Electric will record and report all costs (GE and AEC) in Equipment Work in Progress and apply these costs against GE equipment fund allocations.

A complete analysis of equipment fund expenditures fiscal year to date and forecasted expenditures for balance of this fiscal year was prepared for Cost Accounting.

COST ACCOUNTING OPERATION

As a result of a meeting held on April 27, 1961 between Cost Accounting personnel and the Specialists - Technical Administration to discuss the budget status of Hanford Laboratories and subsequent discussions between the Specialists - Technical Administration and the Section Managers, the HLO control budget was adjusted to reflect a more appropriate balance between anticipated fiscal year costs and program authorizations. Adjustments were as follow:

Program (Amounts in Thousands)	Change	New Authorization
04 Program		
Swelling Studies	$ - 21	$ 169
In-Reactor Measurements of Mechanical Properties	- 30	395
UO_2 Fuels Research	+ 51	761
Plutonium Recycle Program		
Plutonium Fuels Development	+ 25	1 425
Uranium Fuels Development	- 63	602
Fuels Reprocessing Development	+ 25	875
Physics and Instrumentation	- 10	565
Design Development	- 30	128
Reactor Engineering Development	--	612
Materials Development	--	450
Test Reactor Operation	+325	1 625
Cycle Analysis	--	200
Procurement of HX Plutonium	- 44	56
Total Plutonium Recycle Program	+228	6 538
Project Gas Loop	- 35	385
Equipment	-193	789
Total 04 Program	--	10 601
05 Program		
Radiochemical Analysis	+ 10	250
Equipment	- 10	43

In addition to the adjustments listed above, the April control budget reflects the following authorization changes.

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Decrease of $10,000 in CPD Sponsored Process Technology.
Increase of $20,000 in service for CPD to provide a budget for a work order associated with their Weapons Research and Development program.

The Budget for FY 1963 and Revision of Budget for FY 1962 is complete. The Research and Development Proposals have been distributed to all interested personnel. Work will now begin on a book for presentation of the budget to HLO management.

Special request activity during the month was as follows:

1 - Costs for Project Chariot for the summer of 1961 were estimated at $32,800 (incremental). Authorization of $30,000 is expected in the FY 1962 Financial Plan.

2 - S. H. Bush participation in the APED review of practices with respect to reactor and power plant structural materials. Authorization was for salary, IME and travel.

3 - A transmittal letter was received from HOO-AEC to proceed with fabrication of 48 aluminum alloy clusters for Bettis - Westinghouse. A total of $30,000 will be authorized for this work.

4 - Cancellation has been received on the Air Force purchase order PR J572. This authorization was in the amount of $55,000 and was for experimental investigation at Edwards Air Force Base, California. This is the result of the discontinuance of the overall aircraft nuclear propulsion program.

Cancellation has been received on a $3,600 purchase order from GE ANPD for X-ray Diffraction Analyses. The reason is the same as above.

A new data processing report has been prepared for submission to the cost center managers. It will detail the charges for Buildings and Utilities by building, percent of space occupied and monthly charge by building. This report is a by-product of information already on the machine.

The quarterly report listing Hanford Laboratories planned expenditures of $5,000 or more for each item of material and off-site contract procured for research and development programs during the balance of FY 1961 was prepared and transmitted to Contract Accounting.

The quarterly report on Hanford Laboratories' Training Program costs was submitted to Financial Consolidations.

Unit Cost Reports for Radiation Protection, as prepared for the old organizations, were temporarily discontinued; two meetings have been held with the new Subsection Managers to discuss the continuation of these reports. As a result, A. J. Scott, Specialist - Measurements and Procedures, was requested to investigate the situation and provide recommendations in accordance with their current requirements.

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Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 361	641	720
Additions and Transfers In	14	4	10
Removals and Transfers Out	14	6	8
Employees on Payroll at End of Month	1 361	639	722

Overtime Payments During Month	April	March
Exempt	$ 6 988	$ 4 622
Non-Exempt	18 673	22 004
Total	$25 661	$26 626

Gross Payroll Paid During Month		
Exempt	$572 243	$ 576 812
Non-Exempt	371 529	466 797
Total	$943 772	$1 043 609

Participation in Employee Benefits	April		March	
Plans At Month End	Number	Percent	Number	Percent
Pension Plan	1 213	99.3	1 215	99.3
Insurance Plan				
Personal Coverage	371	99.9	371	99.9
Dependent Coverage	981		982	
U.S. Savings Bonds				
Stock Bonus Plan	64	32.2	65	32.7
Savings Plan	83	6.1	84	6.2
Savings and Security Plan	1 046	90.0	1 049	90.3

	April		March	
Insurance Claims	Number	Amount	Number	Amount
Employee Benefits				
Life Insurance	1	$21 514	0	$ 0
Weekly Sickness and Accident	16	939	7	581
Comprehensive Medical	62	6 071	95	7 087
Dependent Benefits				
Comprehensive Medical	129	12 185	240	14 910
Total	208	$40 709	342	$22 578

Good Neighbor Fund	April	March
Number Participating	930	929
Percent Participating	68.3	68.3

W. Sale:bk
May 12, 1961

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
H. L. Libby	An Eddy Current Device for Detecting Anisotropic Conditions
R. T. Allemann R. L. Moore	Cataphoretic Bubble Scrubber for Radioactive Off-Gas Decontamination
G. B. Barton W. H. Swift	High Strontium Glasses for Heat Source Application
H. L. Brandt	A Device for Transporting Solid Particulate Resin in a Liquid Medium
R. F. Maness	Preparation of Strontium Titanate
R. F. Maness	Preparation of SrO via SrO_2
P. W. Smith	The High Temperature, Chemical Reprocessing of Power Reactor Fuels Clad with Oxide Coated Zircaloy-2
D. W. Pearce	The Use of Ultramarines, Natural or Synthetic, in the Removal of Radioactive Ions from Radioactive Wastes; In Particular the Use of Ultramarines or Modified Ultramarines in the Removal of Sulfate, Phosphate, Arsenate, Arsenite, and Ruthenate from Solution
D. W. Pearce	The Use of Ferro-Magnesian Minerals in the Treatment of Radioactive Wastes with Particular Respect to the Use of Olivine-Containing Rocks for the Removal of Radioruthenium from such Wastes
J. F. Jarosch	Rubber Hose Air Chuck

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