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HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

MARCH, 1961

APRIL 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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HANFORD 78409

HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
MARCH, 1961

DECLASSIFIED
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Compiled by
Operation Managers

April 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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TABLE OF CONTENTS

TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE March 31, 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	126	117	243	127	119	246	1	2	2	4
Reactor & Fuels Research & Development	193	181	374	197	182	379	1	1	5	2
Physics & Instrument Research & Development	86	57	143	82	40	122	6	17	2	0
Biology Operation	33	47	80	34	48	82	0	0	1	1
Operation Res. & Syn.	16	4	20	16	4	20	1	0	1	0
Radiation Protection	39	98	137	38	98	136	3	3	2	3
Laboratory Auxiliaries	49	184	233	52	198	250	2	2	5	16
Financial	20	14	34	13	15	28	7	0	0	1
Prof. Placement & R. P.	62	10	72	72	11	83	0	0	10	1
Programming	15	4	19	15	4	19	0	0	0	0
General	2	4	6	2	4	6	0	0	0	0
Totals	641	720	1361	648	723	1371	21	25	28	28
Totals excluding internal transfers.	641	720	1361	648	723	1371	6	7	12	11

BUDGETS AND COSTS

March operating costs totaled $2,250,000; fiscal year-to-date costs are $18,966,000 or 72% of the $26,279,000 budget.

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

(Dollars in Thousands)	Cost				
	Current Month	Last Month	FY To Date	Budget	% Spent
HLO Programs					
02 Program	$ 96	$ 50	$ 439	$ 661	66%
04 Program	841	784	7 071	9 619	74
05 Program	64	65	589	796	74
06 Program	198	159	1 694	2 402	71
	1 199	1 058	9 793	13 478	74
IPD Sponsored	260	268	2 399	3 170	76
CPD Sponsored	144	168	1 483	1 954	76
Total	$1 603	$1 494	$13 675	$18 602	74%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

Startup of PRTR proceeded. The helium system was placed in operation, initial operating problems were determined, repairs effected, and the system returned to service. The secondary coolant system was operated, modified, operated again, and tested during the first week of the month. Design testing of the primary coolant system began on March 21, and continued intermittently with progress limited by the helium system problems associated with loop pressurization.

The contract for paving and landscaping the PRTR and PFPP site was awarded March 23, 1961, and is to be completed within 120 days. Construction of the Maintenance and Mockup Facility (including the PRTR Rupture Loop Annex and PRP Critical Facility Buildings) is estimated at 68.5% completed versus 76% scheduled predicted to April 1, 1961.

Bristol-Siddeley, Ltd., reports successful operation of one Gas Loop blower at reduced conditions of 3000 pounds per hour and 450 F for several hundred hours and approximately one hundred starts and stops. Delivery of one such blower by May 15, 1961, was verified. The heater for the PRTR Gas Loop in-reactor test section testing was repaired, bench tested, and installed in the mockup.

The conceptual design and economic evaluation of a 300 MWe Supercritical Pressure Power Reactor continued with studies directed toward defining the more detailed aspects of the power cycle, fuel element design, reactor control, and plant layout.

A review of the ORNL Pebble Bed Reactor design was completed and submitted to the AEC, Advance Evaluation Branch. The concept was found to be technically feasible. It was recommended that a more detailed study of the concept be performed in order to better predict the power cost.

Studies are in progress on the distribution of micron size particles of simulated PuO_2 in relatively coarse particles of arc-fused UO_2 for application in swage compaction and high energy vibrational compaction processes. Two loading techniques were developed which control the axial distribution of fines in half-inch diameter by eight-foot long fuel rods to a variation of plus or minus five percent. Mixtures of PuO_2 and UO_2 fines and coarse UO_2 are also under study.

Volatility and flow of PuO_2 previously observed in a hydrogen atmosphere was not seen with samples heated in helium for 72 hours. This supports the speculation that the volatility in hydrogen is due to the high vapor pressure of the reduced species, PuO_{2-x}.

Radiometallurgical examination revealed no changes in a seven-rod, Zircaloy-2 clad, aluminum-plutonium alloy cluster thermal cycled 72 times in a high temperature ETR loop.

Fabrication of aluminum-plutonium spike elements needed for replacement of depleted first PRTR loading elements is about 60% complete. Autoclave malfunctions and availability of Zircaloy are current problems.

Power generation calculations indicate an acceptable self-shielded plutonium fuel element can be designed using a small diameter PuC core surrounded by graphite and clad in Zircaloy.

End caps have been successfully welded into type 406 thin wall stainless steel tubing using the fillet head weld. No failure of the weld or weld zone occurred in hydrostatic burst testing.

Although a swaged UO_2, 19-rod cluster fuel element was irradiated for 13 hours after sustaining a failure, there was little evidence of washout of the fuel. The cause of the cracked fuel cladding has not been determined.

Investigations of the compatibility of UC and UO_2 with several refractory metals show that in general UC is by far the more reactive. Tantalum proved to be the most compatible with UC and was able to contain molten material for three minutes at 2350 C.

An NPR inner tube, designed to check the hypothesis that an unbonded flat-bottomed end cap could be used satisfactorily, failed by shearing the jacket at the base of the cap with subsequent cracking of the weld after an exposure of 1700 MWD/T.

An eight-piece production test with closure of the tubular elements produced by hot heading and projection welding operated satisfactorily to an exposure of 2000 MWD/T.

Four KSE-3 single tube elements operated satisfactorily to 2000 MWD/T under conditions closely approximating those in NPR. Basin examination disclosed white areas on the Be-Zr closure and a gray appearance replaced the usual lustrous autoclave film.

The maximum radiation-induced expansion transverse to the long dimensions of the NPR graphite bars is expected to be 0.02%, occurring at an NPR exposure of about 400 MWD/AT. An additional 0.01% expansion is expected from the thermal annealing of stresses in the graphite.

To limit the corrosion rate of carbon steel in the NPR emergency cooling system, it will be necessary to reduce the concentration of dissolved oxygen. Tests with flowing river water indicate that the addition of sodium sulfite and cobalt ion catalyst is a promising means of reducing the oxygen concentration to an acceptable level.

Earlier indications that sections of a locally hydrided KER-1 zirconium process tube had transformed to the beta phase in-reactor are now attributed to overheating during sectioning. However, evidence of partial recrystallization found throughout the tube is still valid.

Microsectioning of very thin oxide films on aluminum and zirconium alloys has been accomplished by ion bombardment. This technique will be useful in studies of the structure and properties of corrosion films.

Hydraulics laboratory experiments indicate that flow reductions caused by partial blockage of the front nozzle coolant inlet port during operational charging operations at the B, D, F and K reactors are not serious enough to cause excessive fuel temperatures.

2. Chemical Research and Development

Better characterization of the foaming problem with batch waste calcination was obtained. A tangential air sparge into the top of the boiling pot seemed effective in controlling the amount of foam over simulated foaming wastes.

The radiant heat spray calciner is being modified by insertion of an insulated inner sleeve at the top of the vertical column. This feature was designed to cause channeled recycle of hot gas up the outer annulus and into the spray region where partial evaporation will occur as the gas and droplets move

down through the center of the sleeve insert. This feature should reduce scaling of the hot outside walls of the column.

Low concentrations of ammonia in Purex waste tank condensates were detected and believed responsible for poor results on recent tests of ion exchange purification of these wastes.

Repairs were completed to A-cell equipment in the High Level Radiochemistry Facility and a third purification run recovered about 8,000 curies of strontium-90. This product was added to 13,500 curies previously recovered and loaded into the HAPO-1A shipping cask on a Decalso bed (inorganic ion exchange media). Twenty thousand curies were retained in the cask for shipment to the Oak Ridge National Laboratory.

Laboratory scale testing of the Hot Semiworks flowsheet for solvent extraction recovery of strontium-90 showed excellent strontium recovery from a feed of 10% full level activity. Other features of the flowsheet were within expected behavior. The Hot Semiworks began shift operation during the month to check out the process system. A review of safety and radiological hazards of Hot Semiworks operation was completed.

A systematic study of electrodeposition of UO_2 from NaCl-KCl melts showed the atmosphere over the melt had a profound effect on the nature of the cathodic UO_2 deposit. Dense, polycrystalline deposits with 98% of theoretical UO_2 crystal density were observed with O/U ratios as low as 2.0015. Under alternate conditions large single UO_2 crystals as much as 8 mm long were formed.

Electrodeposition of UO_2 from $PbCl_2$-KCl salt mixtures were studied at temperatures from 500 C to 750 C with potassium to lead ratios from 1.0 to 2.5. Well-formed UO_2 of good quality is deposited over this wide range of conditions and the electrochemical behavior of this system gives promise of a better theoretical insight to Salt Cycle technology.

A simple device was developed to assure one-way flow of resin in a continuous ion exchange contactor. The device acts as a "resin pump" and involves two plastic sphere check valves operating in conjunction with a pulser.

Comparison of U. S. Geological Survey aerial magnetometer data taken in 1959 to ground level magnetic field measurements made locally showed reasonable agreement on site geological features. These extended data identify a basalt anti-cline passing beneath 100-F and 100-N Areas in an orientation south of 100-D area. The significance of this newly identified sub-surface basalt mass is being evaluated.

Mineral bed experiments indicated that pyrite (FeS_2) will be replaced by sphalerite (ZnS) in aqueous solutions where zinc ion concentrations are as

low as 10^{-3} or 10^{-4} molar. The reaction is independent of the oxygen content of the system, indicating that the mechanism does not involve oxidation of the mineral pyrite. This work may have significance to the problem of removing radiozinc (Zn-65) from surface waters or low level aqueous wastes.

3. Physics and Instrument Research and Development

A simple system for automatic control of existing production reactors is being studied jointly with IPD. This system uses on-off rod motion actuated by limits on outlet tube temperatures. Satisfactory performance was obtained in four tests on an operating reactor in which an operator simulated the proposed controller action. Effects of wider variations in parameters of the controller operation are being investigated by analog simulation.

Knowledge of the neutron economy of the NPR was aided by exponential pile measurements intended to throw light on neutron streaming in the many void channels of the graphite stack. Hazards analyses will be assisted by reduction to useful, accurate formulas of the data recently obtained on reactivity effects of fuel temperatures. These formulas now include the effects of phase transformations in the fuel. Control rod strengths were also studied further.

In the Plutonium Recycle Program a reassessment of the state of knowledge of basic nuclear data was made possible by recently available results on U-235 and U-233 obtained elsewhere. The conclusions are that the thermal neutron data on U-235 and U-233 are good to one percent but that the data for Pu^{239} are good to only four percent accuracy. Further measurements will be required to improve the reliability of nuclear data of Pu^{239}.

Nuclear safety analyses will be aided by improvements in two methods of criticality prediction. In one, a computation method for predicting interactions between neighboring accumulations of fissionable material in complex geometries has given good agreement with more exact methods when applied to geometrically simple test cases. In the other, methods developed for predicting critical masses of plutonium oxide-water slurries were found to be consistent with existing experimental data on dilute plutonium solutions.

The inexpensive radiation detector newly developed for installation at locations where nuclear incidents might conceivably occur has been successfully tested for gamma dose rates from 5 r/hr to one million r/hr and for total doses up to one hundred million r.

The accuracy of field radiation instruments will be improved through use of a new portable scaler which requires about one-tenth the power of the best available commercial scaler.

The range of available data on diffusion of atmospheric contaminants was

extended substantially by completion of the reduction of all data taken during the 1960 field test series. Data now available include those taken under moderately unstable conditions as well as under a range of stable situations.

A pebble bed reactor design, evaluated jointly with Reactor and Fuels at AEC request, would be improved by better matching of coolant flow distribution to heat generation distribution. With this exception, completion of the physics portion of this study has indicated generally attractive nuclear properties for the design and has also pointed up the need for improved nuclear data on thorium.

Utilization of available physics computer codes should be improved as a result of the current effort to issue documents describing the codes. Two such documents were issued during the month: HW-68858, describing "A Computer Solution to the Generalized Least Squares Problem"; and HW-68100 RD, describing "Meleager--A Burnup Code for Fuel Cycle Analysis."

Our knowledge of the behavior of P-32 in humans will be augmented by a cooperative study begun with the University of Oregon Medical School, using the whole body counter to determine the distribution of that isotope in some of their patients.

The direct thermal testing of the heat transfer properties of fuel element bonds was assisted by the development of an alternate method for making such measurements using a plasma jet heat source and an inductive (eddy current) thermometer. The new method may be advantageous with ribbed fuel, for example, and on smooth fuel gave results comparable with those obtained using an induction heater and infrared detector.

4. Biology

C columnaris is showing a wide variation in virulence, making it extremely difficult to associate virulence with environmental factors.

It was previously shown that absorption of strontium and calcium from the lumen of the small intestine of the rat into the blood showed discrimination and a changing discrimination factor with change in calcium concentration. For the reverse process, where strontium and calcium is introduced into the blood and the amount that appears in the lumen is measured, there was found to be no discrimination and no change in discrimination factor with calcium concentration. This important finding shows there is a one-way active transport process operating in the small intestine for the absorption of these two ions.

By using dinitrophenyl (a specific plant poison), it was shown that water movement (transpiration) and calcium uptake in plants do not parallel each

other. This may prove an important step in elucidating basic mechanisms in plant physiology.

Rats can apparently take bi-weekly doses of 500 r without protection up to a total of 10,000 r. At this dose, animals seem to die of starvation. Cysteine prevents the weight loss and mortality.

5. Programming

Substantial progress is being achieved in the development, simplification, and improvement of computer codes for performing a variety of fuel cycle and fuel value calculations. This includes routines for calculating exposure vs. enrichment, isotopic composition vs. burnout, plutonium "value" for a wide range of uses, and minimized fuel costs and conditions as a function of variables such as reactor constants, fueling mode, uranium price schedule, and fuel element fabricating and jacketing costs.

An economic study has been initiated to evaluate the potential of partial-decontamination separations processes, including the "Salt-Cycle" process, for recovering plutonium for recycle to power reactors. An important factor included is an estimate of the cost of remote, shielded refabrication of the partially-decontaminated plutonium.

TECHNICAL AND OTHER SERVICES

There are 16 currently active projects having combined authorized funds in the amount of $18,388,000. The total estimated cost of these projects is $25,383,000. Total expenditure through February was $14,654,000. In addition, project proposals have been submitted to the Commission requesting authorization for eight new projects with an estimated cost of $753,000.

A major bibliography "Review of Power and Heat Reactor Designs -- Domestic and Foreign" was completed during the month. Fifteen copies were prepared for internal HAPO use. The multilith masters are being forwarded to the Office of Technical Information Extension, Oak Ridge, from which they will be able to reproduce additional copies as off-site demand warrants.

The Classified Files microfilming program is proceeding steadily, with 22,800 documents microfilmed to date.

Project CG-785 - In-Reactor Studies Equipment - 105-KW, Project CGH-805 - High Temperature Tensile Testing Cell - 327 Building, and Project CGH-907 - Strontium-90 Interim Program, were completed during the month.

An HLO employeed assigned to the 325-A High Level Facility received an exposure of 6.5 rads, including .19 r, as a result of handling a contaminated piece of equipment. The dose to the skin slightly exceeded the permissible dose of 6 rads recommended by the NCRP for a 13-week period.

There were no new cases of plutonium deposition confirmed during the month. The total number of plutonium cases that have occurred is 265, of which 193 are currently employed.

A faulty seal on a tank containing plutonium nitrate solution resulted in contamination of equipment, floor areas, and three employees at the Physical Constants Test Reactor in the 305 Building. Decontamination and resurfacing proceeded throughout the month. Preliminary bioassay samples of involved employees indicated minor, if any, deposition of plutonium.

Data from the complete file of fuel elements thus far irradiated and measured under the Quality Certification Program are being used to obtain revised estimates for the coefficients of various models of fuel element performance.

Initial steps are being taken to use evolutionary operation techniques in connection with certain production problems in the Finished Products Operation of CPD.

Consultation was continued in connection with instrument calibration for the proposed pulse column test facility experiments.

The statistical analysis of data from the work sampling study recently conducted by the Analytical Laboratories Operation has been completed.

Nondestructive testing at field locations with radiography and other test methods will be expedited and performed more efficiently through use of a new mobile laboratory.

SUPPORTING FUNCTIONS

Special requests were received from the U. S. Air Force during the month to perform atmospheric studies at Cape Canaveral, Florida ($190,000) and Edwards AFB, California ($55,000). Due to the cancellation of U. S. Government contracts in the nuclear aircraft field some of this work may be cancelled.

The budget for attendance at professional societies was 39% spent at the end of the month.

Sections have been requested to estimate their expenditures for Equipment Not Included in Construction Projects for the balance of this fiscal year. Information gained will be used to effect any necessary budget reallocation.

Fourteen Ph.D. candidates visited HAPO for professional employment interviews. Three offers were extended; one acceptance and two rejections were received. Current open offers total three. Recruiting trips were made to four universities.

Eighty-eight BS/MS applicants were considered, 51 offers were extended, 8 acceptances and 16 rejections were received. Current open offers total 98.

Six Technical Graduates were placed on permanent assignment during the month; four others terminated from HAPO rolls. Current program members total 51.

Nine requisitions for weekly salaried personnel were filled during the month with a total of 11 active requisitions remaining to be filled.

Information meetings were held in each department at HAPO concerning the Advanced Engineering "A" Course to be held this fall.

Two consultations were held with legal counsel regarding the acceptance and use of proprietary information on trade name chemicals of other companies.

The incidence of medical treatment injuries (49 for the month) and security violations (5) continued at the increased levels established in February with a strong decline in the injury rate beginning in the middle of the month.

Ten participants completed the Creative Approach Seminar. Arrangements were essentially completed to offer "Principles and Applications of Transistors" beginning early in September.

Carl C. Gamertsfelder

for Manager
Hanford Laboratories

HM Parker:CAB:mlk

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Erosion - Corrosion of Aluminum Alloys. The impingement apparatus has been modified by increasing the size of the small groove between intake and exhaust holes from 15 to 25 mils to allow more water to flow past the sample with less friction. Samples of X-8001 and 1245 aluminum alloys were exposed to 300 Area tap water at 110 C in the modified system. The corrosion of 1245 was about half that of X-8001 in five-hour tests. However, the difference was not as pronounced after 16 hours. A 300 psi back-pressure caused approximately an 8% decrease in the amount of corrosion at several water velocities. Experiments were also run with deionized water at 110 C for 24 hours. The velocity of flow was varied from 60 ft/sec to 120 ft/sec, but very little increase in the amount of corrosion was measured. The corrosion was negligible when compared with samples exposed to tap water.

Chromic Acid Protective Film on Aluminum. Autoclaving aluminum in one percent chromic acid at 170 C for 40 hours produces a thin film which has been previously demonstrated to offer a high degree of corrosion resistance in a reactor environment. However, this treatment also produces a localized attack resulting in dark elongated pits, which have been termed "worm tracks".

The nature of the worm track attack is quite similar to "Filiform corrosion" which is observed on steels and other metals which have protective oxide or lacquer films. Several approaches being studied to eliminate worm track attack include: (a) increased pH and chromic acid concentration, (b) initial treatment at high pH, followed by low pH treatment, and (c) initial treatment at 100 C followed by treatment at 170 C.

Hydriding of Zircaloy-2. The effect of several gas mixtures on the corrosion rate and hydrogen pickup in Zircaloy-2 foils of five mils thickness has been measured at 400 C. The foils were exposed in a glass vacuum system to the following atmospheres: 23 mm water vapor; 23 mm water plus 25 mm oxygen; 23 mm water plus 400 mm hydrogen.

The corrosion rates in oxygen-water vapor were similar to those in water vapor alone. The corrosion rates in hydrogen-water vapor were high, particularly when the hydrogen content of the metal exceeded 300 ppm (the solubility limit at 400 C).

The hydrogen pickups in water vapor alone were low, averaging 7 to 10% of the corrosion hydrogen, whereas 15 to 40% is normal for 400 C, 1500 psi steam. Hydrogen pickups in oxygen-water vapor were still lower, averaging 5 to 8%. Hydrogen pickups in hydrogen-water vapor were higher than for water vapor alone, averaging 18 to 380%. Hydrogen pickups in excess of 100% of the corrosion hydrogen indicate hydriding from the hydrogen overpressure. In contrast to the above results, 400 mm hydrogen overpressure in 1500 psi steam has no effect. Further tests are planned to determine if the increased corrosion rates and hydriding observed when the hydrogen content exceeds the solubility limit are real and reproducible effects.

Corrosion Evaluation of the Irradiated KER-1 Zircaloy Process Tube. Preliminary corrosion data have been obtained from a sample cut from the irradiated high corrosion portion of the KER-1 process tube. The sample was cleaned of all oxide, etched, and exposed to 300 C, pH 10 water. Sections cut from the cold end of the KER-1 tube and 30-mil Zircaloy strip were also tested.

After approximately ten days of exposure, the irradiated sample appears to be corrosion-prone. The oxide surfaces of the irradiated sample are beginning to show visible cracks and the weight gain for the sample is almost twice the value obtained for the 30-mil strip comparison pieces. The sample sections cut from the cold end of the KER-1 tube show black oxide films and weight gains only slightly higher than the 30-mil strip comparison pieces.

The corrosion test of the irradiated sample is being examined for any information it may reveal on the solubility of ZrO_2 in high temperature deionized water. Some radioactive deposition has been found on the cold pieces which does not appear to be zirconium. A radioassay of the water discharged from the autoclave shows virtually no activity.

Radiometallurgy Laboratory Studies

An inner and outer tube from the hot head closure Zr-2 clad tube-in-tube elements were sectioned and are being examined metallographically. Considerable cracking of the uranium cores was found, but no serious defects in the cladding have yet been seen (RM-706).

Three KER single-tube Zr-2 clad enriched elements with Zr-Be brazed end caps were measured for diameter, length and warp. One of the elements showed a maximum double throw warp of 30 mils. The irradiation had caused a slight shortening of the elements (RM-577).

Examination of the element and basket from the fifth defect test has been completed. An estimated 250 ppm H_2 in the Zr-2 basket opposite the rupture was found from the metallographic examination. This will be checked by hydrogen analysis (RM-574).

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. In order to augment limited data on changes in mechanical properties of structural materials resulting from radiation damage, tensile specimens of aluminum alloys M-388 and M-257 were irradiated in the 105-KE magazine facility. Three charges accumulated exposures of 7×10^{19} nvt, 3.19×10^{20} nvt, and 6.25×10^{20} nvt (thermal), respectively. The aluminum powder metallurgy alloy (M-257) is of interest because of its superior high temperature strength; however, it does not have corrosion resistance in high temperature water comparable to the nickel aluminum alloy M-388. A comparison of the mechanical properties of the irradiated alloys demonstrates the persistance of strength differences. Their ductility was not markedly affected by the irradiation. Test results are given in the following table:

Alloy	Irradiation Exposure nvt thermal	Strength 1000 psi .2% Yield	Ultimate	Young's Modulus	% Total Elongation
M-257	Unirradiated	28.3	36.2	10	8
"	7×10^{19}	28.8	35.3	11.7	10
"	3.19×10^{20}	34.7	38.6	11.4	6
"	6.25×10^{20}	35.5	40.2	11.3	6
M-388	Unirradiated	9.2	16.1	11	29
"	7×10^{19}	6.8	15.3	--	29
"	3.19×10^{20}	8	17.1	9.4	23
"	6.25×10^{20}	10.2	19.1	13.5	15.6

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material before and after irradiation is a direct way of detecting radiation induced damage in these materials. Thin films and foils suitable for electron microscopy offer advantages, since radioactivity hazards are minimized. High purity annealed aluminum foils, 0.003" thick, have been irradiated to 1×10^{20} nvt (thermal) and thinned for transmission electron microscopy. Prismatic dislocation loops similar to those observed in foils which received one tenth of this dose were again detected. Normal dislocation lines appeared jagged and frequently were clustered into tangles.

An aluminum rod with a polished, transverse face was coated with a thin layer of collodion and then UO_2. After irradiation the collodion with adherent UO_2 was stripped in acetone and the original polished surface of the aluminum was replicated. This experiment, similar to a previous one, indicates that fission fragments which enter a solid do, indeed, damage the surface of a solid metal. It is impossible to directly determine the extent of damage as a function of distance below the specimen surface by chemical or electrolytic removal of surface layers and subsequent replication. However, it is possible to study fission fragment damage as a function of depth in sandwich foils containing a constant thickness of UO_2 and various increasing thicknesses of metal. This type of study has begun.

A series of specimens containing approximately 60 A thick UO_2 films were prepared by a single evaporation. These films were then arranged at appropriate distances from a Pd evaporation source to provide a series of sandwich films each differing by a geometric factor in thickness of the palladium metallic layer. Subsequent irradiation and direct transmission examination of the films disclosed that (1) damage regions or track geometry is definitely a function of metallic film thickness; (2) in very thin layers, $\lesssim \sim 10$ A, the tracks appear to be independent of the metallic layer and characteristic only of the UO_2 layer; (3) in films approximately 40 A in thickness, the projected damage track consists of discrete high density damage spots (maximum electron transmittancy) and superimposed regions of broad irregular regions of damage about the main track. These tracks are characterized by heterogeneous patches of condensed or piled up material adjacent to the broad damage regions; (4) in films approximately 54 A thick, the tracks become narrower and their length and number per unit area appear to decrease. Since loss in contrast is a function of effective electron scattering power of the material being studied, the conclusion that damage in thick films is less than in thin films may be erroneous. The effect is now being studied by a modified technique.

X-Ray Diffraction Studies. The crystalline perfection of large metal single crystals before and after neutron irradiation is being studied through measurements of x-ray extinction. The magnitude of the extinction can be interpreted in terms of the sizes of the "blocks", or coherently diffracting domains, and the degree of angular misorientation between blocks. A single crystal of molybdenum, grown by the strain-anneal method has been cut into seven individual specimens. Only the central one-third of the rod was used. The individuals were oriented by x-ray methods, and faces were ground parallel to selected crystal planes. Three were ground with 110 faces, two with 211 faces, and two with 100 faces. Grinding was followed by finish polishing and heavy electropolishing. Precise measurements of x-ray intensity diffracted from these faces are being performed. The extinction, as indicated by incomplete data, is that expected from a crystal containing domains about one micron in size. Assuming these domains are bounded by dislocations, a dislocation density of about $10^8/cm^2$ is indicated. Several samples of aluminum single crystals of high purity (99.996%) and with varying degrees of physical perfection have also been obtained and will be included in this study.

Tantalum Fabrication. Work is currently under way to attempt the recovery of about 35 pounds of tantalum scrap in the form of turnings. It is anticipated that this material can be made into usable metal by consumable vacuum arc melting. Four octagonal electrode bars have been compacted into bars weighing 8.5-lb each. Density of the compacted bars is 70-75%. Preliminary welding tests indicate that these bars can be welded together with the electron beam welder to make the finished electrode.

Zirconium Alloy Fabrication. Forging of the 13 zirconium base alloys (Nov. '60 and Feb. '61 monthly reports) has been completed. Forging was performed on the 700-Ton Bliss Press. Preheat temperature was either 850 C or 875 C depending on the alloy being forged. Three of the alloys showed a slight amount of center cracking. Two of these required cropping before forging could be completed.

Metallic Fuels Development

Fuel Irradiations. Radiometallurgical examination was continued on the KER tube/tube elements irradiated to an average 3200 MWD/T exposure in KER Loop 2. The following density measurements were made on specimens cut from the center of a uranium core element and a U-2 w/o Zr core element.

		Density	% Density Decrease
U Core	Inner Tube	17.92	5.28
	Outer Tube	18.36	2.96
U-2 w/o Zr Core	Inner Tube	17.42	4.65
	Outer Tube	17.15	6.14

The outer tubes both increased in OD and decreased in ID. However, the uranium inner tube increased in ID and the U-2 percent Zr inner tube decreased only slightly in ID.

An NPR-size inner tube fuel element (KSN-1) ruptured in a KER loop after 1700 MWD/T. The end caps of this element were flush-fitted to the uranium and welded in place. An axial section was made through the failed end cap. In addition to a crack through the weld, there is a crack on the inner clad of the fuel element next to the cap-uranium interface. The outer clad next to the cap-uranium interface is deeply grooved as a result of thermally-induced shear strain in the clad. At one point this groove has cracked open. It is probable that this failure initiated at the cap-uranium interface as a result of shear failure in the clad.

The post-irradiation examination of PT-IP-300A is complete. This PT consisted of eight, 20-inch long, natural uranium, Zr-2 clad, KER tube-tube elements irradiated in KER at 280 C outlet to 2000 MWD/T, at an average specific power of 70 kw/ft. The inner tubes feature the hot-headed and projection welded closure; the outers were closed by TIG welding. Dimensional measurements, including double throw warp were taken on all elements. No defects, other than cracking of the uranium, were found in the one inner and one outer tube sectioned for metallography.

Ten 15-inch elements of NPR inner tube stock, processed with variable beta heat treatment, are being irradiated in KER Loop 1. The approximate exposure of the elements on March 23, 1961, was 890 MWD/T. The average and maximum element power was 48 and 54 kw/ft, respectively. The charge is operating normally and is due for scheduled discharge during the first

week of April at an exposure somewhat in excess of 1000 MWD/T. Two elements of the same group have been approved for irradiation in the 3x3 loop in the ETR during Cycle 36.

The second KER loading of enriched single tubes (KSE-3) was discharged from KER Loop 2 late in February after attaining an exposure of 2000 MWD/T. Operating conditions of these coextruded elements with Zr-Be eutectic brazed closures simulated those expected in NPR outer fuel tubes. Examination of the elements in the K basin revealed some white areas on the Zr-Be eutectic braze closures and the absence of the usual black, lustrous appearance of KER irradiated Zr-2 clad material. In other respects, there appeared to be no changes produced by the irradiation. The fuel elements were weighed in water against an unirradiated standard piece for the direct determination of swelling behavior. Calculations of the irradiation-induced volume increases from the weight change data for the four elements were in good agreement and indicate a 3.0 percent increase in fuel volume. This compares with a 1.3 percent volume increase determined at 1200 MWD/T.

Radiometallurgical examination of the 18-inch long KSE-3 fuel elements discharged during January at 1200 MWD/T shows a length decrease of about 0.070-inch, warp changes of -0.002 to +0.008 inch, and outside diameter changes of +0.003 to +0.005 inch.

Heat Treatment Studies. X-ray data have been received on the preferred orientation of the samples of NPR inner and outer tubes which underwent various heat treatments involving varying hold temperatures and nitrate quenching temperatures. All heat treatments showed an effective randomization of the grain structure, but further analysis will be required to determine if any one of the heat treatments offers a better randomization than the others.

All grain sizes of samples studied in these heat treatment studies have been remeasured using the uranium grain size standards kit adopted by the Fuel Element Development Committee with an attendant increase in the accuracy of measurement and consistency of results. Previous conclusions are more strongly supported and show that the nitrate quench definitely gives the finest grain sizes of any of the quench media studied. The normal grain size obtained on NPR inner tube 59 (30-mil inner clad, 38-mil outer clad, 1.263 OD, 0.431 ID) using a nitrate quench was A3 (A1 being the large end of the range) while the same treatment on samples of NPR outer tube 74 (25-mil inner and outer clad, 2.401 OD, 1.740 ID) resulted in a finer grain size of A5 to A6.

Warp Studies. Twenty-four NPR inner tube elements, 24-inch length were salt bath beta heat treated for warp studies. These elements were obtained from six coextrusions made on the 700-ton vertical press in an effort to evaluate the warp problems arising from the horizontal orientation of the production press, such as billet chilling and cooling bed handling. The extrusions were cooled by hanging vertically from the die.

The warp data for the as-recevied and beta heat treated conditions are shown in Table I. All orientation of the elements has been kept with the top of the die of the primary extrusion from which the coextrusion billets were machined as the reference point. Wall thickness variation and shift of the coextrusion were also related to this reference point. There is no apparent correlation of the warp direction with wall thickness, shift, or direction of the primary billet. The elements were sealed by welding unbonded end plugs for hot straightening and autoclaving tests.

TABLE I

Warp Data for NPR Inner Tube Vertical Extrusions

Element No.	As-Received		Beta Heat Treated		Warp Vector	
	Warp Mils	Orientation Degrees	Warp Mils	Orientation Degrees	Warp Mils	Orientation Degrees
1-11	80	300	156	90	230	100
1-35	50	270	61	90	111	90
1-59	30	170	48	175	16	182
1-83	24	90	31	170	36	211
2-11	32	90	57	100	28	114
2-35	45	240	62	245	18	259
2-59	22	190	16	195	6	353
2-83	19	170	13	150	9	20
3-11	40	180	37	170	7	58
3-35	55	185	53	190	6	300
3-59	12	180	25	170	14	161
3-83	40	270	20	270	20	90
4-10	115	195	87	270	126	333
4-34	31	198	28	230	8	313
4-58	10	50	27	265	36	256
4-82	47	100	33	100	14	280
5-11	56	190	110	260	106	290
5-35	43	270	92	275	49	280
5-59	14	190	29	260	28	288
5-83	21	90	40	110	22	128
6-11	111	270	93	270	18	90
6-35	22	170	34	165	12	156
6-59	15	270	11	270	4	90
6-83	23	180	28	250	30	297

The Effects of Cladding Thickness Uniformity on Zircaloy-2 Clad Coextruded Rods. Failures of Zircaloy-2 clad uranium rods and tubes as a result of localized clad straining have occurred in NaK capsules and high temperatures recirculating water loop irradiations. Radiometallurgy examination of the Zircaloy-2 clad uranium rods irradiated in NaK capsules has been completed. Measurements of cladding thickness variations from photographs of the rod cross-sections are planned. With these measurements it is hoped to verify the conclusion made from previous observations that an appreciable percentage thickness change over a short gage length may be necessary to initiate local instability.

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. Two 0.600-inch diameter Zircaloy-2 clad rods of U-2 w/o Zr have been coextruded. These rods have been bond tested, measured, and machined to length for the irradiation specimens and control samples. Cladding thickness on the first extrusion varies from 0.029 to 0.034 inch and on the second extrusion it varies from 0.028 to 0.033 inch. When the cladding on the irradiation and control specimens is machined concentric with the uranium to a thickness of 0.025 inch, the variation will be decreased by the amount of the surface irregularities. Heat treatment and primary extrusion of an unalloyed uranium billet preparatory to making coextrusion billets is complete.

Fuel Component Development. The NPR fuel element self-supports, as now designed, have a negative temperature coefficient for the support circle diameter. This is caused by the increased separation of the support tabs as the fuel element expands thermally. Separation of support tabs because of heating lowers the support height more than thermal expansion increases the fuel diameter. This condition is greatest for the inside support where the diameter clearance between the supports and the outer tube will be 15 mils greater when the fuel is operating than when it is cold. A support designed to have a zero or positive circle diameter coefficient is being developed for testing.

Closure and Joining. In order to enhance the investigation of the metallic inert gas filler metal process as a method of making the final closure on the NPR fuel element, several changes in the equipment were made and several are planned for the future.

The turntable drive was changed from belt to chain with a change in the diameter of the sprocket and driven gear. This change will give a positive drive to the turntable, which had a tendency to slip, and increase the speed with which the turntable can be driven, thus allowing a weld on the ID of the fuel element to be made under the same conditions as the OD weld. Instrumentation was added to the system which will allow more precise settings of the welding machine and also act as a check on the accuracy of the machine dial settings. In addition to this, a record of the welding voltage of each specimen will be made.

Before the equipment changes mentioned above were made, a group of welds were made on specimens with varying step dimensions. The start and the arc (or running) voltage was also varied in a range just above the lower limit of the welding machine. Several of these welds showed very little or no beryllium in the weld metal when they were polished and viewed on the metallograph. The majority of the samples showed at least one small spike of braze material in the weld. In some instances, however, the spikes were small and did not appear to go through the weld to the outside. Other specimens are to be welded in the near future in an attempt to duplicate these welds.

Attempts to resistance braze a Zircaloy-2 cap to the uranium surface in the projection-welded resistance-brazed closure have been encouraging. Approximately 80% of the surface was bonded by using the existing 100 KVA welding machine at full capacity. The braze material used was a copper immersion plate on the face of the Zircaloy-2 cap.

The initial projection weld between the cap and the element cladding has been improved to the point where the weld is adequate for the succeeding brazing step; however, results indicate that additional power and pressure will be necessary to produce a weld satisfactory for the closure.

Fuel Deformation Studies. A model for tubular fuel elements has been formulated which accounts for the cyclic nature of straining within the cladding but neglects the resistance to shear stresses of the fuel material. Assuming cyclic strain data can be represented by a power function and data obtained from relatively rapid rates of strain cycling can be used to evaluate the cladding material model, the resulting equations for the fuel element model have been solved and evaluated. These analyses predicted that the ratio of exterior cladding strain to specific volume dilatation should be 0.181 for an NPR outer tube, 0.385 for an NPR inner tube, and 0.258 for the KSE-3 tubes presently being irradiated. The rough draft report describing these analyses is written. Testing apparatus needed to evaluate the effect of realistic rates of strain cycling and the effect of incremental straining is designed. Parts for the apparatus are on order and the extensiometer is fabricated.

Increased Creep Rates Due to Large Temperature Changes. Temperature cycled constant load tests on uranium are being conducted. In order to evaluate the deformations of tubular fuel elements, the flow resistance of the uranium during temperature decrease and increase must be determined. Previous measurements have only detected the net strain per temperature cycle. Two weeks of temperature cycling tests of a specimen without any loading were run in order to establish the thermal expansion. The variations in lengths during thermal cycling were so erratic that a mean thermal expansion could not be established. Hence, separation of the strains occurring during heating and cooling will not be possible with the existing equipment.

Extrusion Lubricants. It has been known for some time that vanadium pentoxide above its melting point is a slightly viscous liquid with extremely oily characteristics when in contact with other metals. Unfortunately, the melting point of vanadium pentoxide is approximately 690 C, which happens to be above the alpha phase of uranium. A search was made for a method of depressing the temperature of this liquid phase; two means of doing so were found. The addition of 9 w/o calcium oxide to vanadium pentoxide forms a eutectic with a melting point of 618 C. It has also been found that the addition of lead oxide (PbO) to vanadium pentoxide in a 50-50 mol percent produces a eutectic with a melting point of approximately 490 C. A small amount of the $PbO-V_2O_5$ eutectic has been made and will be ground to a powder for subsequent use as a billet lubricant in the extrusion press. Similar experiments will be made with the $CaO-V_2O_5$ in the near future.

2. REACTOR PROGRAM

Coolant Systems Development

Cyclic Testing of APACE Decontamination Procedure. Two cycles have been completed in ELMO-14 in the past month, making a total of seven completed cycles in the inhibited APACE study. Isolated permanganate stains have been noted on several stellite coupons. Sectioning in the stain area revealed dendritic attack to a depth of about 75 mils. Since the stains are seen on both sides of the coupons, it is possible that some continuous channels run completely through the 100-mil thick coupons. It is postulated that this attack resulted from casting defects in the test coupons and that exposure to the alkaline permanganate solution opened channels through these casting defects. Although coupons from the same lot have been used in cyclic tests of other decontamination processes, this attack has not been observed previously.

Oxygen Scavenging Studies. It will be necessary to reduce the concentration of dissolved oxygen in the NPR emergency cooling water to keep the corrosion rate to an acceptable level. A dynamic test has been completed at 10 C to determine the corrosion rate of polished carbon steel coupons in water that has been filtered and treated with sodium sulfite to remove dissolved oxygen. Cobalt ion was used as a catalyst for the scavenging reaction. The coupons were mounted on a stainless steel ladder which gave an effective area ratio of carbon to stainless of approximately 0.9. The operating conditions were similar to those specified for NPR emergency cooling operations. During this test 98 to 100 percent of the dissolved oxygen was scavenged. The residual dissolved oxygen concentration averaged over the total period of operation was 50 to 75 parts per billion. This level is considered acceptable. The addition of sulfite appeared to reduce the corrosion rate of the carbon steel. Quantitative data to show the exact amount of reduction will be obtained.

During the corrosion test it was necessary to increase the sulfite concentration to 1.5 times the concentration normally required to obtain complete scavenging. This result has been tentatively attributed to

adsorption of a fraction of the cobalt ions on the metal surfaces, resulting in a decrease in catalytic activity. However, this hypothesis has not yet been verified experimentally.

Tests are planned to determine the effectiveness of hydrogen gas and hydrazine as an oxygen scavenger in the normal NPR coolant water. A production test is being written to authorize the use of one or more of the KER loops for tests with or without a charge in the active zone.

Crud Studies. A program is now in progress to evaluate the concentration of particulate solids in coolant streams by filtration through 4-micron plastic paper. Although the present tests are intended to establish the feasibility of this method and are, therefore, not yet capable of accurately determining the concentration of crud, the method appears promising. It is much simpler and less expensive than the carbon filters (hot crud probes) currently being used, although the hot crud probes are capable of retaining finer suspended solids than is the 4-micron paper.

Samples from ELMO-5 and KER-1 were viewed at 600X magnification to examine the crud and to determine whether or not a particle count would be feasible. A heavy background of rust particles was present in the KER-1 sample but not in the ELMO-5 sample. Photographic techniques are now being evaluated as a means of determining the size and concentration of crud particles.

Corrosion in High Temperature Water. Corrosion tests of stainless steels, Monel, super alloys, and Zircaloy in 300 C water are continuing. The corrosion rates of all alloys are low, ranging from 0.02 to 0.04 mils/yr.

The KSE-3 elements discharged recently from the KER-2 loop had a very light colored oxide film after discharge. An unirradiated element from the same lot is being exposed to pH 10, 300 C recirculating water to determine if the light colored film can be duplicated out-of-reactor.

ELMO-15 Supercritical Loop. The construction of ELMO-15 has been delayed to permit further pressure testing of the components. The heater vessel was again tested with a stress coating at 12,600 psi. The results of the test were all satisfactory, except for the heater head which was inconclusive; this part will be retested. Another review of the pump was made and a delay in shipment was requested until specific answers could be obtained to questions on design, testing, and certification. This will result in considerable delay of the program, since the loop fabrication cannot be started until the pump is on site. The pump will be securely anchored, with other pieces of equipment free to move relative to the pump.

Structural Materials Development

Burst Testing of Pressure Tubes. A revision to the project for the construction of an unirradiated burst test facility has been approved. The project was discussed with the contractor but construction has not started. Construction is scheduled for completion in early August 1961.

A technique for measuring localized deformation occurring during the burst test was developed. Heat resistant paint is used to print a grid on the tube prior to testing. Initial results reveal a marked variation in both axial and circumferential strain throughout the specimen.

The design of a prototype chamber for burst testing irradiated pressure tubing at elevated temperature is nearing completion. When fabricated, the chamber will be placed in the basin of the 327 Building to test the adequacy of the design.

Zircaloy Retubing Program. With the advent of the overbore concept for retubing the production reactors, about 200 Zircaloy tubes fabricated during early development work will no longer be suitable for C Reactor. Adaptation of a special fabricating technique was undertaken to convert these 43-foot C Reactor tubes to larger diameter 48-foot K Reactor tubes. Initial trials with short sections of tubing were successful. Close control of the increase in the inner and outer diameters, the decrease in wall thickness, and the increase in length was demonstrated. Tubes with fabrication histories varying from annealed, 30 percent and 60 percent cold work were successfully resized. To assure that the minimum length requirements are met, some of the tubes will require a short length of tubing to be butt welded on the end. Techniques for butt welding were successfully developed, and the welds underwent resizing without apparent damage. Prior to attempting the resizing of full length tubes, minor regrinding of the tools will be required to eliminate the light die pickup encountered during resizing.

NPR Process Tubes. To develop an ultrasonic test for small transverse tears in NPR process tubes it was necessary to produce a standard against which the material under test could be compared. Transverse notches of known dimensions were produced on the inner and outer surfaces of a section of tubing using the Electrojet machine. This machine cuts by action of a carefully controlled spark discharge between the work piece and a tool of the desired geometry. The machine had not previously been used at Hanford for this purpose so it was necessary to develop the tooling and machine settings required to produce notches 1/8" long, 3 mils wide and from one to five mils deep. A replication technique was adapted for measuring the actual depths of the grooves cut in the inner and outer surfaces of the tube.

For the ultrasonic tests a focusing crystal was employed to determine the correct angular relationships and machine settings to provide a balanced response from the grooves on the inner and outer surfaces. Tests proved that scanning rates which are impractically slow are required to assure detection of defects. Application of a flat crystal allowed greatly increased scanning rates with only a small loss in precision. The tests successfully detected a small pit and crack present on the inner surface of a production tube. Additional refinements will be needed, but ultimate success of the technique is now assured.

KER-1 Process Tube. Previously it was reported that the grain structure of samples from two sections of the KER-1 tube indicated beta transformation had taken place. Subsequently it has been determined that this was caused by sample preparation. It has been demonstrated with unirradiated samples that insufficient cooling water while sectioning allowed the specimen to heat into the beta phase. Most of the samples from KER-1 were submerged under water during sectioning which reduces the amount of heat-affected material to a region less than one mil from the cut surface. This material is easily removed during the grinding and polishing. Thus, evidence of partial recrystallization found throughout the tube is still valid.

Wet chemistry completed on a portion of the tube that was beneath the heavy oxide layer gave the results: nickel, 0.073 ± 0.004%; iron, 0.030 ± 0.002%; copper, 10 ppm. No tin was detected by wet chemistry, but the spectrochemical analysis indicated one percent or greater. Tin is very difficult to keep in solution, and it is possible that the tin precipitated out prior to the chemical analysis.

Nonmetallic Materials Development

Graphite Burnout Rates at C Reactor. Burnout samples were discharged from 1889-C, 1960-C and 2780-C after 115 operating days. The average burnout rates (percent weight loss per 1000 operating days) are shown below:

	Distance from Front Van Stone Flange				
	10-ft, 8-in.	15-ft, 6-in.	20-ft, 4-in.	25-ft, 2-in.	30-ft
1889-C	2.12	2.35	0.29	0.23	0.11(gain)
1960-C	2.71	2.94	0.65	0.20	0.11(gain)
2780-C	0.12	0.60	0.36	0.18	0.03

The rates in the front zone of the reactor in the first two channels are greater than the established limit of 2% per 1000 operating days. However, they are lower than a year ago when a high rate of 35% per 1000 operating days was measured in 1960-C. The rates from the same relative position in channels 1889 and 1960 are nearly the same, while those from 2780 are considerably lower. Hence, it might be concluded on the basis of these data that the oxidizing condition extended across the stack in the areas of these two channels but did not reach as high as the 27th row.

Physical Properties of NPR Core Graphite. The tensile strength of NPR core graphite has been measured parallel and transverse to the direction of extrusion. The average high and low values of sixteen parallel samples were 1668, 1909, and 1242 psi. In the transverse direction these values were 957, 1421, and 545 psi.

Defects in NPR Tube Blocks. NPR tube blocks which have been rejected for visually observed cracks were examined. Flow lines as well as cracks were noted. The flow lines reduce the tensile strength of 1/4-inch and

1/2-inch sections. The compressive strength of large sections is apparently not reduced by the flow lines. Cracks were also observed between the bore and outer surface of the bar. This type of defect will probably become apparent when the keying notches are machined and may result in further rejection of bars.

Initial Radiation-Induced Expansion of NPR Core Graphite. On the basis of available data it appears that the maximum radiation-induced expansion transverse to the long dimension of the NPR graphite bars will be 0.02%. This maximum will occur at an NPR exposure of approximately 400 MWD/AT. An additional expansion of about 0.01% resulting from the thermal annealing of stresses in the graphite will be superimposed on the radiation-induced expansion.

Thermal Properties of Irradiated NPR Core Graphite. Room temperature thermal conductivities after irradiation at 500 to 600 C, 1257 MWD/AT in KW Reactor (an equivalent exposure of 600 MWD/AT in the NPR) were 0.19 cal/cm-sec-C parallel to the extrusion axis and 0.09 cal/cm-sec-C transverse to the extrusion axis. The thermal expansion coefficients between 25 and 425 C decreased slightly upon irradiation to about 500 MWD/AT but returned to the unirradiated value upon continued exposure to 1257 MWD/AT. These results have been reported in more detail in HW-68762, "Irradiation Effects on NPR Core Graphite - Initial Short Term Irradiation Results."

Irradiations of NPR Graphite in the ETR. The GEH-13-5 graphite irradiation capsule was discharged from the ETR on March 5. The NPR reflector graphite contained in the capsule was irradiated at 700 C to a maximum exposure of approximately 1.4×10^{21} nvt, E > 0.18 Mev. The capsule was successfully disassembled in the hot cell and all four sample cups, containing three samples each, were recovered intact and are being shipped to HAPO for post-irradiation measurements. Twenty-two of the 24 iron, nickel, and cobalt flux monitors were recovered.

Fabrication has begun on a capsule, GEH-13-7, to be irradiated in the F-6 position of the ETR. The purpose of this irradiation is to obtain qualitative comparisons of NPR core, NPR reflector, and CSF graphites. The capsule will contain 24 quarter-round samples in groups of four. The sample temperatures, which are expected to be in the range 400 to 800 C, will be monitored by nine thermocouples.

Thermal Hydraulics Studies

Heat Transfer Experiments Pertaining to NPR. The studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel element were continued. Experimental data were obtained in the heat transfer laboratory to complete the scheduled program for a test section of the outer flow annulus of the fuel element.

The test section consisted of a 24-inch long Hastelloy tube having an OD of 2.390 inches placed inside a 2.70-inch ID process tube. The Hastelloy

tube was electrically heated and the heat was transferred to water flowing through the annulus. Thermocouples attached to the inside wall of the Hastelloy tube allowed the detection of temperature excursions associated with boiling burnout conditions.

A series of burnout points were recorded at 1000 psig with inlet temperatures of 530 F and mass flow rates over the range from 0.5×10^6 to 5×10^6 lb/hr-ft^2. Additional points were obtained at 1500 psig with inlet temperatures of 510 to 550 F. Burnout indications were always given by thermocouples in the bottom 90° quadrant of the annulus. The data from these experiments are presently being prepared for 7090 computer analysis.

Preliminary analysis of the test results obtained previously for the inner annulus of the tube-in-tube fuel element indicate that the burnout heat flux will correlate well with mass velocity and outlet enthalpy at mass velocities above 1×10^6 lb/hr-ft^2. Difficulty has been encountered in obtaining a satisfactory correlation at lower mass velocities.

Special test sections are presently being fabricated to study the effect on boiling burnout at high pressure of having the inner tube of the tube-in-tube fuel assembly placed in a non-coaxial position within the outer tube.

Fuel Element Temperatures Following A Front Header Pressure Loss At K Reactors. A study was concluded to determine the fuel element temperature rise which would be associated with various degrees of coolant supply pressure decrease at a K Reactor. Such pressure losses could result from loss of electrical power to the process pumps, or rupture of coolant supply piping between the pumps and the front headers. The pressure reduction events were simulated on the single tube prototype K Reactor assembly while using d-c electrical resistance heating to simulate the nuclear heating of a 38-piece charge of I&E fuel elements. Power input to the test section was reduced systematically to simulate a 500 ih reactor scram. The results of the experimental study will be useful in evaluation of the reactor hazards which involve the coolant supply systems. The results are reported in HW-68273.

While it was not the purpose of the study to make specific recommendations, the experimental data allow one to make conclusions such as the following sample conclusions: (1) With five-pump operation a sudden pressure reduction event as severe as rupture of a supply line to a front riser could result in fuel jacket melting during the reactor scram and subsequent power decay at tube powers of about 1500 KW. (2) With six-pump operation fuel jacket melting would not occur even with failure of a front riser at tube powers up to about 1900 KW. (3) Coolant boiling following a complete electrical power loss should be avoided to prevent fuel jacket melting.

The appendix of the report includes a comparison between the heat output from the 189-D experimental equipment following a simulated reactor scram and the recommended curve of reactor heat output which is based on a number of reactor experiments.

Silicon Rectifier Control System Modification. The control system of the silicon rectifier direct current power supply has been modified to prevent progressive damage of multiple rod heating element test sections during boiling burnout experiments. The control system was originally designed and installed with a power feedback control such that the rectifier output control was based on test section power. During experiments with electrical heating in several parallel electrical paths, the inadvertent failure of one element would not change the total power supplied to the test section and thus would result in increased power generation in the remaining elements and progressive burnout failures.

A voltage feedback control circuit has been added to permit the rectifier output control to be based on test section voltage. Thus, failure of one element will not affect the power generation in the remaining elements. Since power feedback is desirable for single element "fuel" assemblies to overcome changes in test section resistance due to temperature change, the power feedback control circuit is being retained on a selector switch basis with the voltage feedback control circuit.

Low Pressure Boiling Burnout Conditions for Eccentric Annuli. The program was continued to investigate the effect on heat transfer conditions of the non-coaxial positioning of fuel elements within a coolant tube. During this month the effort has been directed toward the collection of data applicable to I&E fuel elements in a K Reactor process tube for the case of 0% eccentricity (i.e., concentric annulus).

In these experiments thermocouple trouble was encountered, and it was found quite difficult to detect boiling burnout and manually reduce power before test section damage occurs. One fairly conclusive burnout point was determined for K Reactor central zone flow conditions (40 gpm annulus flow) and 107 psig at a heat flux of 1.87×10^6 Btu/hr-ft^2 at 3 F subcooling. A one by 1/2-inch hole was melted in the test section as a result of this burnout point. This burnout heat flux is about seven times the burnout fluxes which were determined with 90% eccentricity and 40 gpm annulus flow.

Flow Reduction During Operational Charging. Hydraulics laboratory experiments indicate that flow reductions caused by blockage of the front nozzle coolant inlet port during operational charging operations will not exceed 10 percent of normal central zone flow rates. Part of the experiments were conducted by recording transient flow rates during use of a Mark II Operational Charging Machine (designed by IPD personnel) on a K Reactor single tube mockup. The remaining experiments were conducted on a BDF single tube mockup under steady state flow conditions while purposely restraining a fuel element over the nozzle inlet port. In neither case was the flow reduction caused by the charging machine action or the "stuck" fuel element greater than 10 percent of a normal central zone flow. Since a flow reduction of about 30 percent is necessary to cause flow instability, excessive fuel temperatures as caused by insufficient flow should not be a problem during changing operations with the geometries investigated.

Project CGH-834. Installation of equipment in the 189-D heat transfer laboratory was resumed on Project CGH-834 which will allow investigation of fuel temperatures following a simulated rupture of reactor coolant piping at pressures up to 2000 psig. Equipment installed during the report period included two heat exchangers, two pressurized air tanks, and a 1000-gallon water storage tank. The tanks will supply water at constant pressure during the simulated piping rupture. The completion of this project awaits the receipt and installation of some quick acting valves designed to simulate the piping rupture.

A new injection pump was installed in place of one of the large injection pumps used previously in the high pressure experimental apparatus. The new pump uses three cylinders instead of one to deliver the required injection rate and thus should reduce the magnitude of the system pressure fluctuations.

Shielding Studies. The IBM-7090 computer program to calculate neutron and gamma attenuation for shielding design studies is in the debugging stage.

The electronic components of the fast neutron spectrometer are being overhauled in preparation for future neutron spectrum measurements in shield materials.

B. WEAPONS - 3000 PROGRAM

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

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

PRTR Fuel Fabrication. The fabrication of replacement Pu-Al elements for PRTR use has been delayed by uncertainties in sheath tubing quality. Of 487 tubes received in 1961 for this loading, 97 are being held for corrosion testing as all tubes using K and L billet material are questionable, and samples from each tube are being autoclaved. All the other tubes on hand have been made into fuel element rods and await etching and autoclaving. Autoclaving will continue as soon as the new racks, holding 57 rods compared to the 36 in the previous racks, are conditioned.

Fabrication Development. The development of economical fabrication techniques for uniformly enriched UO_2-PuO_2 fuel clusters has been accelerated during the past month and is essentially on schedule. Swage compaction fabrication will be utilized in fabricating the first portion of the 81-cluster PRTR load, followed by high energy vibration compaction of the remainder. This will allow direct comparison of these processes for UO_2-PuO_2 with UO_2 experience obtained during the fabrication of the first PRTR loading. Incremental process differences due only to the plutonium enrichment can then be evaluated.

Distribution of plutonium oxide in uranium oxide is one of the major problems involved in the development. Although the utilization of high density UO_2-PuO_2 solid solution feed material would completely eliminate the problem, considerable fabrication economies will result if small particle size PuO_2 can be uniformly distributed in arc-fused UO_2 having the wide range of particle sizes needed to achieve high fuel densities by both swage and vibrational compaction techniques. The complexity of this problem is demonstrated by dispersion results obtained on a twenty kilogram blend of 0.446 w/o PuO_2 high surface area powder in arc-fused UO_2 directly after removal from the twin shell blender. Since this is the most favorable process point at which to expect homogeneity, subsequent pouring, vibrating and swaging operations will aggravate rather than relieve the problem. Distribution results by chemical analysis were as follows:

1. For 15 samples taken throughout the blend,
   a. Two-thirds of the samples were within ± 5% of the nominal value.
   b. Over-all variance within the group of samples was approximately 19%.
2. For the sample taken from the blender wall,

   The sample showed a retention of PuO_2 in the blender. The magnitude of the retention was four times the nominal blend value.

3. For 10% cut sample from the blend,

   The sample analyzed 12% below the nominal blend value. This analysis was below any of the 15 individual samples mentioned above. As a cut 10% sample of a blend should be more representative of the blend than an individual "grab" sample, a repeat analysis will be made.

Since the PuO_2 powder used in this study was low temperature calcined plutonium oxalate of very high surface area, some improvement should result from the use of lower surface area powder formed by a higher temperature calcination or by calcination of plutonium nitrate. Therefore, this experiment has been repeated using oxide calcined at 1000 C for four hours, but analytical results have not yet been obtained.

Two methods were developed to control the macro-distribution of plutonium oxide along the length of a tube loaded with mechanically mixed UO_2-PuO_2 powders. One method consisted of preparing and mixing "one-tube batches" of oxides and controlling the 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. Both methods have general application to other systems of mixed powders. The advantages of the first method are simplicity and initial cost, while the advantages of the incremental method are flexibility, accuracy, and amenability to mechanization. Since both of the methods were developed with UO_2 fines, determination of variations with mixed UO_2-PuO_2 fines will be made. Since the calcined PuO_2 particle size is very small (entirely -325 mesh), it is assumed that PuO_2 will follow the general distribution of -325 mesh UO_2. Therefore, a less time-consuming and more basic understanding of the distribution problem is obtained by studying the distribution of particle sizes of UO_2 along the length of a tube than by obtaining spot analyses of plutonium throughout the fabrication process. The experimental method consists of loading a tube with UO_2, shaking on a 60-cycle vibrating table to obtain the desired tap density, cutting the tube into segments, and obtaining the particle size distribution in the segments through screen analysis. Based on the results of the experiments the following conclusions are drawn:

1. The mixing, blending, and pouring methods and the container materials all affect the distribution of particles in the tube.

2. A process of blending in large batches and splitting into "one tube load" batches is not sufficiently under control to assure (a) obtaining the proper amount of fines (-325 mesh particles, e.g., PuO_2) in a given tube, and (b) obtaining uniform distribution of the fines in the tube.

3. A process of blending "one tube batches" affords better control for both obtaining desired plutonium content and distribution in a tube.

4. The variation of fines along the length of the tube (4% to 20% fines) may be expressed by the empirical formula:

$$V_T = \frac{180}{F}$$

where: V_T = total variation of fines expressed as a percent of the percentage of fines

F = percentage of fines (-325 mesh particles).

Thus, for a mixture containing 4% fines total variation of fines along the tube will be 45% or approximately 4% ± 1/2(0.450)(4%) = 4% ± 0.9%, or total variation from 3.1% to 4.9%. Similarly, with 20% fines the total variation is approximately 9% or 19.1% to 20.9%. Increasing the percentage of fines decreases the relative variation, so that if it were desired to keep plutonium distribution within a 10% variation (± 5%), as is the case for Al-Pu spike elements, approximately 18% fines would be required in the charge. Since greater amounts of fines decrease final density in the cold swaging process, no determinations beyond 20% fines were made.

A more accurate and flexible method of obtaining uniform distribution is by incremental loading. The technique was developed when particles in a glass tube were not observed to preferentially settle or migrate when being vibrated on a 60-cycle table. This led to the conclusion that the longitudinal distribution would be uniform if the PuO_2 could be loaded uniformly. Several tubes were incrementally loaded with UO_2 using the -325 mesh UO_2 to follow the distribution of fines which would include the PuO_2 enrichment. The tubes were manually loaded in one-quarter inch increments. In each increment fixed quantities of coarse particles were mixed with fixed quantities of -325 mesh particles. Screen analyses were made of segments cut along the length of the tube. Less than 10% variation of -325 mesh particles was readily obtained, and it appears that much smaller variations will result from refined loading techniques. Hand loading tubes in increments is relatively slow (approximately 30 minutes per tube), but the process is readily adaptable to automation.

In addition to the distribution of the PuO_2 in UO_2, a number of other problems peculiar to the swaging process are under investigation. Seven additional UO_2-PuO_2 fuel rods have been swaged with an over-all length variation after four swaging passes of approximately 1-3/8 inches. Tube wall thickness variations as well as die heating due to friction and mechanical work are the main contributing factors in length variation. It now appears practical to control length with a total variation of one inch and rods will be segregated so that within any one cluster total length variation will be within one-half inch. Fluorescent penetrant examination of these rods after they had been given a brief cleaning etch revealed numerous pit type defects. Surface examination showed that the cleaning etch had not been of long enough druation to attack the cladding surface completely. The rods were given a standard etch, (0.004 - 0.005-inch on the diameter), and on re-examination all rods passed the fluorescent penetrant test. Ultrasonic testing of the rods indicated defects ranging

from 0.003-inch to 0.005-inch in the preswaged ends. Traces along the rest of each rod were uniform, and no defects were recorded. Improvements are needed in the quality of the preswaged ends; however, this problem does not exist with the alternate process using swagable end caps.

A study was made of the relative movement of various sized particles in a vibrating column using the high energy vibratory compactor. A one-inch ID lucite tube was filled with alternate layers of fused UO_2: (1) coarse (-6 +10 mesh), (2) medium (-35 +60), (3) fine (-200), and (4) coarse from bottom to top. This was shaken and the movement of the interfaces was observed with a stroboscope.

Confirming the results found on the Syntron shaker, no interfacial movement was noted at 60 cps when the acceleration level was one gram or less. At two grams acceleration the medium particles began to move through the coarse fraction. The experiment was repeated varying the frequency. It was found that movement of the medium particles through the coarse layer took place readily at a one-gram acceleration level when the frequency was in the 30-40 cps or the 450-480 cps region. At acceleration levels of two grams or less no movement was detected of the fine particles through the medium ones. When the acceleration was increased to 20 grams and the rod was cycled for ten minutes between 30 and 2000 cps, some disruption of the fine-medium interface was noted, but the mixing was not extensive. As is to be expected, no penetration of the fine layer was made by the top coarse particles. It is concluded from these experiments that there is a threshold acceleration below which relative particle motion does not occur. This threshold is considerably lower at natural resonance frequencies than at 60 cps.

Development has continued on a nondestructive technique for determination of longitudinal segregation after swage compaction or vibration compaction of UO_2-PuO_2 fuel rods. Gamma spectrometer studies were made on the two five-inch capsules previously reported but measurements did not reveal the one w/o defect present in one of these capsules. Three additional capsules were fabricated in the same manner, containing 10 w/o, 3 w/o, and 2 w/o defects along with a fourth capsule repeating the one w/o defect. On initial examination all of the defects with the exception of the one w/o defect were readily detected. Further examination of the capsules is continuing.

Samples from sections of three zirconium rods extruded from scrap and sponge were studied metallographically. The samples were then subjected to a steam autoclave corrosion test. The sample made from sponge showed considerable impurity in the form of hydrides at the grain boundaries and unrecognizable inclusions. The grain size varied from fine at the outside to large at the center. Corrosion resistance was very poor with a weight increase of 234 mg/dm^2. Heavy white oxide prevailed. The samples made from scrap were in each case a good clean specimen. There were some light oxide stringers. One sample showed mixed alpha and transformed beta zirconium while the other sample was all alpha with very fine grain. The

difference would have to be due to temperature at the die during extrusion. Each of these samples showed good corrosion resistance, 18.1 mg/dm^2 for the fine grain alpha and 23.3 mg/dm^2 for the alpha and mixed beta. Tools for the extrusion of a one inch diameter tube have been fabricated. It is planned to direct extrude a tube from loose particles of scrap, using only a copper can to contain the particles.

Weld quality tests have been made on 0.565-inch diameter, 0.010-inch wall, type 406 stainless steel using the fillet head weld. The welds have been subjected to hydrostatic burst tests and autoclaved at 350 C and 2400 psi with no detectable change, further studies are being made on the weldability of 406 stainless steel for fuel element end closures. It is felt that fusion welding of 406 stainless steel will not be a problem.

Ten injection-cast cluster rods were drilled and counterbored preparatory to making end closures. The machining was done without coolant to avoid introduction of volatile hydrocarbons into the closures. The counterbore diameters were within dimensional specifications with good surface finish. Two rods which were transferred to an open front hood and measured with calipers were within the ± 0.005-inch tolerance for machined length and the others as measured against a standard with shim stock were also within specifications.

During the autoclave testing of Zircaloy-4 clad fuel elements it was noticed that some rods exhibited a uniform grayish coloration rather than the usual black color. Upon further examination it was noted that the autoclaved surface had small flecks of white oxide uniformly dispersed with the black oxide. This oxide coating is harder to remove by grit blasting than a uniform black oxide coating.

Fuel Evaluation. The four-foot long Zircaloy-clad UO_2-PuO_2 seven-rod cluster containing sintered and ground pellets has been irradiated 71 full power days in the ETR 3x3 loop. Corrected exposure calculations indicate the element has received a maximum of 2500 MWD/T and an average of 1400 MWD/T. The calculated core temperature during this irradiation was 1850 C with an associated maximum heat flux of 346,000 Btu/hr-ft^2. After an appropriate cooling period, the element will be returned to Hanford for examination.

The radiometallurgical examination of the in-pile thermal cycling element has been completed. No changes in the seven-rod cluster were observed as a result of receiving 72 thermal cycles in the 3x3 loop. Metallography showed some intermittent bonding between the plutonium-aluminum alloy cores and the Zircaloy-4 cladding. This has been observed in other high temperature cluster irradiations.

Some out-of-pile thermal cycling tests are being run on dummy elements in an effort to determine the pressure dependence of cycling effects on PRTR prototype fuel rods. The cycling apparatus has been changed so that constant pressure is maintained regardless of temperature and, as expected, cycling effects are dependent upon the test pressure. Even though some

of the rods are badly distorted, no cladding failures have been experienced with the improved quality tubing now being used for fuel fabrication.

Radiometallurgy results have been obtained on a Zircaloy-clad three-rod cluster. This 11-inch long cluster was fabricated by inserting Al - 3 w/o Pu alloy cores into Zircaloy tubing with an average diametral gap of four to five mils between the core and cladding. In this respect it is similar to the PRTR Al-Pu spike power elements. The element was exposed for 34 effective full power days and initially operated at an average power generation of 66.5 kw/ft with an associated maximum heat flux of about 677,000 Btu/hr-ft^2. The external surface of the irradiated element had a mottled appearance similar to what has been observed previously. All the fuel cores were loose in the cladding. The cladding ends have been removed and core length measurements are being made.

More power generation calculations for the self-shielded fuel concept have been received. The physical makeup of the fuel concept presently under consideration is a small diameter PuC core surrounded by graphite which is clad with one-half inch diameter, 0.030-inch thick Zircaloy. Results of the calculations are as follows:

Self-Shielded Power Generation Calculations
PuC Core Material

Core Diameter (inch)	Core Density (% Theoretical)	Power Generation in Thermal Flux of 2×10^{14} nv (kw/ft)
1/16	90	19.10
3/32	90	31.97
1/8	90	46.56
1/16	100	19.81
3/32	100	33.26
1/8	100	48.60

These calculations indicate that the self-shielding factor is greater and the power generation is consequently lower than previously thought and, hence, lower temperatures will be encountered. Heat transfer calculations will now be made.

Corrected power generation values for the PuO_2-UO_2 experiments in the Hydraulic Rabbit Facility (VH-4) at the MTR were received. Some typical values, calculated by computer, were as follows:

UO_2-PuO_2, (a/o PuO_2)	Density, (% of theo)	Specific Power (kw/ft)
0	65	12.36
0.187	65	16.47
15	65	78.36
40	65	82.80
0	90	16.12
0.0259	90	55.49
15	90	80.24

The PuO_2-UO_2 test element for the reactivity measurements in the SNOUT Facility mockup in the 305 Reactor has been designed and preparation of the components has been initiated.

UO_2 Fuels Development

Irradiation of 19-Rod Assembly. The failed rod in the prototypic PRTR 19-rod cluster (GEH-12-4) was metallographically examined. The failed cladding shows no evidence of strain or necking, indicating that the fracture was not ductile. The internal surface of the cladding is penetrated by many small cracks in the area near the failure. It has not yet been determined whether the failure was associated with an internal crack in the cladding. Localized concentrations of hydrogen ($\sim$100 ppm) were observed near the outer cladding surface and in the immediate vicinity of the failure. Surprisingly little evidence of wash-out of the UO_2 is evident, although the fuel element was operated a total of 13 hours after the rupture occurred.

Magnetic Force Closures. The electrical conductivity and hardness of electrode materials for resistance welding have a dramatic effect on the quality of the resulting weld and on the electrode life. There are at least twenty-two alloys which may be obtained as "standard" materials. Four of these alloys have been evaluated as inserts for the non-segmented cylindrical electrode on the magnetic-force welder. Long electrode life was obtained with 10w3 (Tungsten Carbide-Copper), 20w3 (Tungsten Copper), and TC-53 (Tungsten-Carbide-Copper). The low electrical conductivity of TC-53 improved the heat balance when making closures on thin stainless steel clad fuel rods. TC-53 is recommended for welding stainless steel and 20w3 for welding Zircaloy-2.

Vibrational Compaction. Two vibrationally compacted, fused UO_2, thermal conductivity specimens were prepared. The specimens, three inches in diameter and one inch thick, were compacted to 86.4 and 84.2% of theoretical density in thin-wall stainless steel containers. The procedure involved vibration of the coarse (+4 mesh) fraction to minimum volume, followed by addition and compaction of a sized and blended mixture, using a floating restraint on the mixture to minimize segregation of fines.

Particle size effects were investigated. Widely varying particle size distributions have been reported as optimum by various sites on the basis of theoretical and empirical results. Four promising mixtures of UO_2 particles were selected and compacted at low accelerations and with carefully controlled times and frequency cycling rates. The difference in bulk density between each of the duplicate samples of the four mixtures was less than 0.3%. The highest density was obtained using the mixture empirically derived at Hanford for PRTR fuel rods. Particle size distribution of this mixture is 55 w/o -6+10 mesh, 12.5 w/o -10+20 mesh, 12.5 w/o -35+65 mesh, and 20 w/o -200 mesh.

Combined low-frequency mechanical vibration and ultrasonic vibration may provide a method for fabricating large, complex fuel assemblies, using relatively inexpensive equipment. An electromechanical, 60 cps vibrator was used in combination with air-jet generators; the frequency ranges employed were 7-15 kcps and 26-32 kcps. In ten mixtures of fused UO_2 grain, the bulk densities obtained by low-frequency vibration were increased by superposed or successive vibration in the high sonic or ultrasonic frequency ranges.

Hot Swaging. Reduction in the amount of hydrogen added to Zircaloy cladding during hot swaging of UO_2 fuel rods is being investigated. Fused UO_2 (-60 mesh) was vacuum out-gassed at 900 C for 18 hours, and loaded into 12-inch long sections of Zircaloy-4 tubes within a helium filled dry box. End caps were welded into the filled tubes by the T.I.G. process. The swage was modified to permit flooding of the heated fuel rods with helium during the heating and swaging process. One fuel rod hot swaged in a helium atmosphere and one hot swaged in air are being metallographically and chemically analyzed for hydrogen. A Zircaloy-4 clad, hot swaged, four-rod cluster fuel element was fabricated for irradiation in the MTR. The UO_2 density is 92% of the theoretical. This test will determine the extent to which hydrogen picked up during hot swaging precipitates as embrittling hydride in the Zr-4 cladding during irradiation.

The density of hot swaged fuel rods was increased by rapid cooling of the cladding just before the fuel rod entered the swaging dies. This presumably was the direct result of higher cladding strength at lower temperatures. With helium as the cooling medium, a density increase of $\sim$ 2% T.D. (to $\sim$ 94% T.D.) was observed. In one test thus far conducted using water, the fuel rod density was 86% T.D., indicating that the UO_2 had cooled too much before swaging. The water cooled fuel rod did exhibit an excellent surface finish, however. Other tests are in progress.

Hydride In As-Received Zr-2 Tubing. Samples from fifty Zr-2 tubes (0.505 ID) were examined metallographically for zirconium hydride. Forty-three of the tubes contained less than 20 ppm hydride; seven tubes had 25-75 ppm hydride.

Irradiation of Defected Fuel Elements. Post-irradiation examination of the purposely defected pellet-containing (95% T.D.) fuel element HD-1 (irradiated in a Hanford reactor) was completed. No significant increase of hydride content was found in either the Zr-2 or Zr-4 cladding. The element was irradiated at a low heat generation rate and with a low coolant temperature.

The irradiation of HD-2, a cluster containing swaged, $\sim$ 90% T.D. UO_2, is continuing successfully. The test, to date, has included three power cycles. The first power cycle occurred during initial startup when the reactor was scrammed after reaching about 1/4 full power. The second cycle included a normal shutdown (from full power), and normal startup. The third cycle resulted when the reactor was scrammed from full power. Fission gas release, as determined by a gross gamma monitor on the

effluent system, apparently was not affected by the power cycles. Analyses of samples of the effluent coolant are incomplete, but it appears that the quantity of fission products released to the coolant is about ten times greater in this test than it was during irradiation of HD-1. This is still many orders of magnitude less than the "allowable" fission product release. The two elements were operated at about the same power generation rate.

Recycled UO_2, Post-Irradiation Study. The "recycle" fuel element was returned to HAPO after irradiation in the MTR and is undergoing post-irradiation examination. Warp measurements and fission gas analyses are complete. There was a maximum warp of 74 mils over the length of the pellet-containing rod which forced the rods to twist slightly and caused a slight ovality of the rods in the bundle before it was disassembled. The pellet-containing rod was the only one with any measurable warp or other dimensional change.

Corrosion and Materials Studies

Fretting Corrosion. Zircaloy-2 fretting specimens have been examined after 605 hours of testing in 316 C, pH 10 water. The specimens consisted of ribbed Zr-2 cylinders fastened on carbon steel rods and suspended vertically in a housing lined with Zr-2. The tests were conducted in a coolant flow of 30 fps with both natural loop vibration and an imposed vibration of three cps. The contact area between the ribs of the samples and the liner was double that of previous tests. Fretting was observed, although the penetration was somewhat reduced. A penetration of one to two mils was measured on samples exposed only to the natural loop vibration; this increased to two to four mils when an additional three cps was imposed. These penetrations are one-half those obtained with one-half the contact area.

Aluminum Corrosion. Certain portions of the 6061 aluminum alloy shroud tubes and shim rods in the PRTR are estimated to operate at 450 to 600 F in a heavy water-helium atmosphere containing small amounts of deuterium and oxygen. A test to investigate the corrosion of 6061 aluminum under these conditions has been operating for 3000 hours. The first 500 hours of exposure was at 450 F and the balance at 600 F. The corrosion medium is 40% H_2O, 58% A, 1% H_2, and 0.5% O_2, flowing over the coupons at 100 ml/hr (STP). No weight gains were found for the coupons until 2800 hours. At this time, three of the coupons increased about 20 mg/dm^2; the other two coupons, of a slightly different alloy, had only a very small increase in weight. The test is continuing.

Microsectioning of Thin Films by Ion Bombardment. Microsectioning by ion bombardment of very thin oxide films on aluminum and zirconium alloys has been developed. The usual bombardment arrangement locates the sample on the cathode where it is in line with the accelerated ions of inert gas. This arrangement produces intense arcing through the insulating oxide film and consequent sample damage due to charge accumulation. This difficulty has been overcome by rearranging the electrodes so that the sample

is exposed to the bombarding ions without being placed at the cathode.

Hydriding of Zircaloy-2. Low-temperature hydriding techniques for the formation of ZrH_2 surface layers without dissolving considerable H_2 in the bulk metal are being investigated. Electrolytic hydriding at 80 C in 0.05 M H_2SO_4 at a current density of 46 ma/cm^2 resulted in a uniform hydride layer 0.014 mm thick. Gas-phase hydriding at 250 C proceeded fairly rapidly, but hydriding occurred only in discrete areas on the specimen surface.

Oxygen Additions to Zircaloy-2. Controlled additions of oxygen to Zircaloy-2 coupons may be accomplished by controlled oxidation followed by high-temperature homogenization in vacuum. It has been found that the oxidation step must be carried out at comparatively low temperatures (i.e., about 600 C) to insure a uniform oxidation for a given limited amount of reacting oxygen gas. Oxidation at 900 C led to non-reproducible weight gains.

The dissociation of HgO was investigated as a possible source of pure oxygen for oxidation studies requiring a constant oxygen pressure. The O_2 pressure is theoretically infinitely variable, depending on the temperature of the HgO bed. It was found that the rate of approach to the equilibrium oxygen pressure for any given HgO temperature is slow, and for all practical purposes the dissociation is irreversible. Reagent grade HgO gave off impurity gases that reacted with metallic mercury elsewhere in the system. The gas obtained from the HgO decomposition analyzed 97% O_2, an unacceptable impurity.

Corrosion of Zr-4 Sheath Tubes. Questionable corrosion results on Zr-4 sheath tubes fabricated from Wah Chang Ingot K have been reported by Wolverine Tube Co. The weight gain of three lots of this material tested at Nuclear Materials (NUMEC) was about 26 mg/dm^2 after a three-day, 750 F steam test; the specified maximum is 22 mg/dm^2. Samples from the same three lots were then autoclaved for 14 days. The weight gains of two of the lots were normal and the third lot had a weight gain of 40 mg/dm^2. The surface appearance to all samples was reported to be a mottled gray. These lots represent some 154 sheath tubes.

Babcock and Wilcox Company is fabricating the fuel elements for Heavy Water Components Test Reactor and Wolverine Tube Company is fabricating the sheath tubes. Samples from B&W tubes fabricated from this same ingot have had weight gains as high as 108 mg/dm^2 after a 14-day steam test. B&W also report that Wah Chang Ingot M tubes are failing to pass the corrosion test.

At HAPO corrosion coupons were cut from every other tube of K ingot material. Fifteen of the 77 coupons were prepared for weight gain measurement and the remainder for surface appearance only. After 14 days in steam approximately 50% of the coupons exhibited light to moderate stringering and one sample (K-51) was heavily corroded. The weight gains of all fifteen samples were normal after three- and fourteen-day tests;

however, once again approximately 50% had light to moderate stringering. Duplicate coupons were then prepared for all samples which showed stringering. These samples now have nine days of steam exposure and all have excellent surface appearance including sample K-51 which was heavily corroded on the previous test. Quadruplicate samples from lots KA and KB with over 30 days of exposure have normal weight gains and excellent surface appearance.

Because of the wide variance in results from the different testing laboratories, Wolverine Tube Company has initiated a round robin test on material from Ingots K and M. The sites cooperating in this test are Nuclear Materials and Equipment Corp., duPont Savannah River Lab., Babcock and Wilcox, and HAPO. Samples have arrived and are scheduled to begin testing 4-3-61.

PRTR Process Tubes. Twenty-seven spare PRTR process tubes have arrived on site and the final six tubes are in transit. A non-destructive testing program at Hanford has been proposed for these tubes. It will provide the best assurance that only tubes of sound structural integrity and good corrosion resistance are used in the reactor and conversely that tubes of questionable quality are not used in the reactor.

A wide angle borescope (180° field of view) was borrowed from Lerma Engineering Corporation for further tests to establish the feasibility of coupling a TV camera to this borescope for the purpose of examining process tubes in the PRTR. These tests showed conclusively that the TV camera and borescope can be matched provided the surface of the process tube under view is properly illuminated and the TV camera is equipped with a very sensitive vidicon. Light transmission through the borescope must be 0.2 foot candles or more. A tubular frosted lamp placed about 3/8 inch in front of the objective lens and a ring of lamps positioned to shine down the tube past the borescope objective lens provide the best illumination of surface films and surface scratches.

Effects of Irradiation on Tensile Properties of Iron- and Nickel-Base Alloys. Possible fuel cladding and process tube metals were machined into duplicate sets of tensile test specimens and irradiated to a thermal neutron flux of 2.53×10^{20} nvt in dry graphite-helium environment at about 650 C. The unirradiated control specimens were heat treated on graphite supports in helium at 650 C (1200 F) for 500 hours to simulate reactor environment conditions.

The effects of irradiation on the room temperature tensile properties are indicated below, each value representing the average of two tensile tests.

Alloy		Tensile Properties					
		Unirradiated			Irradiated (2.53×10^{20} nvt thermal)		
No.	Type	Yield Strength 1000 psi	Ultimate Strength psi	Elongation* %	Yield Strength 1000 psi	Ultimate Strength psi	Elong.* %
14	Ferral(modified)	73.6	97.5	15.5	76	76	3
15	AISI 406 SS	67	88.6	23	70	91	25
22	Hastelloy X	51.7	116	30	37.7	108	34
24	Hastelloy R-235	91	157.5	16.5	97	158.5	19
26	Inconel	35.6	94	42	35.5	95	42.5
28	Inconel 702	97	155	27	97	154	31
33	AISI 316 SS	29.5	81	62	27	78	56
34	AISI 347 SS	52.8	100	43.5	52	95	39

*Crosshead motion of tensile testing machine.

Alloy 14, Ferral modified, an Fe - 7.6 Al - 5 Cr - 2 Cb - 0.7 Zr experimental alloy suffered the most pronounced property changes from irradiation by losing close to 25% of its strength and 80% of its ductility. The remaining materials tested sustained only minor changes in strength or elongation. It is intended to further investigate the effects of irradiation upon the properties of these alloys at lower temperature and different environmental conditions.

PRTR Project Management and Design

PRTR Construction. A contract in the amount of $73,664 was awarded March 23, 1961, to L. W. Vail Company for paving and landscaping the PRTR and PFPP site and for related 300 Area parking lot work. Contract costs have been split as follows: CA-747 - $40,546, AEC-167 - $16,450, and FPD - $16,650. The contractor has done layout work and started excavation.

Construction of the Maintenance and Mockup Facility (including the PRTR Rupture Loop Annex and PRP Critical Facility Buildings) is estimated at 68.5% completed versus 76% scheduled predicted to April 1, 1961. The M&M Building portion is estimated to be approximately 60% completed versus 71% scheduled. Forming and placing embedded items in the 0'-0" slab of the M&M Building constituted the major effort during the month. The contractor poured the 0'-0" floor slab, which completed the last major concrete pour for the building.

The inflatable seals for the PRTR exhaust stack filter are scheduled to be shipped at the end of March.

Installation of the gasoline engine driven generator unit and battery on the loadout facility shipping trailer has been completed. Initial testing has started at the Radiometallurgy Building.

New spline shafts of hardened 400 series stainless steel have been ordered for the Fuel Element Examination Facility manipulator to correct galling at this location. Delivery is predicted for the end of April pending successful completion of testing. No work on equipment installation was done during the month.

Larger oil absorber units were designed, built, and installed on all helium compressors and at other key locations in the helium system. This work was performed following a failure of a compressor diaphragm which flooded a portion of the helium system with oil.

The fuel transfer system and automatic H_2O injection system were completed.

Operating experience with the primary system has revealed a need for additions and modifications to the leakage collection system in A cell. Design of these revisions has begun.

Plutonium Recycle Critical Facility (Project CAH-842). The construction contractor is about 80% complete, on schedule after an extension of 48 days allowed because of the late delivery of the fuel transfer lock. Work remaining includes pouring the building footings, erecting the building, and installing the ventilation equipment.

The fuel transfer lock frame has been placed in the loadout basin wall and grouted in place. Some installation difficulties as a result of dimensional variances from the vendor s drawings have been encountered

and are being corrected. The compression seals have not been delivered. The vendor's representative was on site during the week of March 20, and is scheduled to return on April 4 for seal installation, painting, and testing.

The heavy aggregate shielding concrete was completed March 21, 1961, and painting of the heavy aggregate cover slabs has started. Erection of the structural steel frame was started, and the new doorway was cut into the existing 309 Building.

The bids on the Instrument Package were received and reviewed and the contract awarded to the low bidder, General Electric - APED, at a bid price of $39,250. Delivery is scheduled for June 1961. Bids have been requested on the flux chambers for the reactor. The CPFF contractor to the AEC has placed orders for the in-cell valves at a price of $6,843.67. The moderator storage tank vendor has completed fabrication and testing, and the tank was shipped by truck the week of March 20. One of the reactor pumps has been received. The other reactor pump and the thimble coolant pump are enroute from the vendor.

Fuel Element Rupture Test Facility (Project CAH-867). All except nine tracings, part of "B" cell work, have been approved. The total number of approved drawings now in process of being issued is 48. A complete package of work contained in completing "B" cell and the annex has been prepared and is pending a decision on the water plant.

The water plant, which was designed and approved to provide filtered Columbia River water to both the Rupture Loop and the PRTR heat exchangers, is being reviewed to re-establish the necessity of providing this source of water for both facilities. The water plant drawings and specifications have been approved since January, and delays at this time will extend the attainable project completion date.

Construction of the annex building is approximately 91.4% completed versus 94% scheduled. Work on the tunnel floor slab and the installation of the two-inch process drain from the building to manhole "C" progressed during the month. Remaining work includes roofing, painting, and concrete work to complete the tunnel.

Bids on instrumentation, electrical switchgear, control valves, and the makeup pumps have been received, and orders have been placed or are in process. The bids on all items were considerably below the estimated cost. A detail stress analysis of the heater (RLHX-1) revealed that excessive stresses were possible at the bottom vessel closure (flat plate design). A new design incorporating an ellipsoidal end cap has been developed and will be provided at the vendor's expense. Delivery of the vessel will be delayed approximately two months to the middle of May. The vendor who is fabricating the cooler (RLHX-2) maintains that it is not feasible to radiograph the high pressure nozzle-to-bonnet and bonnet-to-tube sheet welds. Review by qualified HAPO personnel indicates that these radiographs can be obtained with standard commercial practices. A detailed procedure for performing the required radiographs was prepared and forwarded to the vendor, Pfaudler Company.

Design and Component Testing

PR-10 - Primary Loop Mockup. The spare primary pump operated 687 hours during the month for a total 6049 hours. The leak rate increased rapidly up to a maximum of four gph and has settled back to about 3.5 gph. All pump data appear normal, pointing to possible leaking at the static neoprene seals. The new self-adjusting seal assembly to be tested on the spare primary pump was received during the month.

The prototype pump with the self-adjusting seal assembly operated 687 hours during the month for a total of 5190 hours. The present leak rate is 0.9 gph. The seal test stand operated an additional 180 hours and 24 starts for a total of 710 hours and 95 starts with the two prototype primary pump mechanical seal assemblies.

The Aldrich injection pump operated 273 hours for a total of 1115 hours, after which testing was discontinued on the present set of R/M Vee-Flex packing due to one gland leaking 5000 ml/hr with no further adjustment possible. Disogrin U-cup packing has been received and testing will begin during the week of April 3, 1961.

Flexure Loop. The 3-Clamp Grayloc transition union (SS to Zr-2) completed 450 hours and 74 cycles of operation at 2000 psig and 200-600 F.

PRTR Shroud Tube Replacement. The main efforts were directed toward the full-scale mockup of the center section of the reactor tank. Scope design is complete and detail design is 75% complete on this mockup. This mockup will represent the reactor from 0'-0" level to the -27'-0" level. It consists of the large center shroud tube and nine regular shroud tubes.

After checking dimensions on the west test pit, it was ascertained that the mockup would fit in this pit; however, there is an interference with the building crane. The crane will clear the outlet nozzles by six inches. This means that the "upper rotating shield" would have to be removed in order to use the crane. With this weight supported from the roof, each of two trusses would have to support 1000 to 1200 pounds, which is a safe limit and which seems to be the most expedient method of removing this upper section.

Tests have been started which will determine if an acceptable shrink fit joint can be made between the shroud tube and bellows.

Critical Facility Mockup. The weir for the critical facility was designed to control the level of the moderator in the reactor tank. All parts for this component have been procured, and fabrication is 25% complete.

Specifications for components of an eleven-point moderator temperature monitoring system for the critical facility are nearing completion and these items should be on order by the first week of April. Resistance

temperature detector elements have been chosen as a basis for the system. Differential temperature measurements with a resolution of 0.0025 degrees Centigrade are desired with this system. The remainder of the system consists of a scanning switch, a bridge with provisions for zero suppression, and a recorder. Bids were received for the rod magnet power supply and it was found that none conformed to the specifications. All were rejected and the specifications were to be sent out again for bid. An order has been placed and a contract fixed with the Exactel Corporation for four synchro transmitter-receiver units, very similar to those required by the original purchase specifications. Delivery is anticipated in about 60 days. Standard Fairchild Model 909, 10 turn potentiometers, have been ordered for the safety rod position indicators. Initial radiation tests with one of these potentiometers was not conclusive; however, it is anticipated that, at the worst, these potentiometers will last for some 200 to 500 hours of critical facility operation. In the meantime, further evaluation of potentiometers for radiation service can be completed.

Rupture Loop Mockup. The o-ring at the bottom of the test section seals [redacted]

present Inconel-X system. These results indicate that the strength of the PRTR shim system could be varied over a considerable range, if desired, using readily available materials.

Safeguards Analysis. A memorandum summarizing the results of PRTR fuel element testing to date and describing the planned PRTR process tube monitoring program was forwarded to the General Electric Technological Hazards Council. This was in response to a request by the Council for additional information on these programs.

The detailed study of the consequences of primary coolant leaks in the PRTR (HW-61236 SUP 2) was published as a supplement to the PRTR Final Safeguards Analysis.

PRP Reactor Physics Calculations. A more realistic set of macroscopic nuclear constants have been determined to represent the PRTR core and its detailed components during critical testing, for use in reactor calculations with the FLUX-WEIGHT multigroup code. Of particular concern were the plutonium elements. The revised constants include a more accurate treatment of actual fuel content in the core, the consistent use of Westcott cross sections, and a more detailed treatment of self-shielding.

The success of calculations of multiplication for the all-plutonium loading is not fully evaluated. Where one-dimensional reactor calculations necessarily treat the geometry of the core as a circular cylinder, the actual loading configurations were effectively elliptical cylinders of higher eccentricity. The degree of inequity in leakage due to this difference in geometry has not yet been determined. Calculations of multiplication in the two- and three-zone configurations of the critical tests do not present this geometry difficulty in such a degree. Moderator level coefficients calculated for two-zone loadings are greater than those for three-zone loadings; it is speculated that the importance of vertical non-uniformities in the side reflector is reduced as the plutonium is moved toward the center of the core.

A theoretical determination is being made of the reactivity effect of loss of coolant for various coolant and moderator degradation conditions. Light water concentrations up to 10% in both coolant and moderator are being studied.

Heat generation rates were calculated for several fuel samples which are to be tested in the MTR as part of the continuing Plutonium Metallurgy Program. These samples are four inches long and contain various fuel and cladding compositions. The radial flux traverse over the fuel sample was carried out using the S_4 and the P_3 neutron transport theory codes. Heat generation rates varying from one kw/ft to 80 kw/ft were found depending on the fuel and cladding used.

PRTR Operations

Reactor Testing and Activation. The bulk of the testing work has been completed on the following Design Tests:

DT 4	Helium Pressurization System
DT 5H	Helium Gas Balance System - Hot
DT 6	Dry Gas System
DT 11	Secondary Coolant System
DT 14	Single Pass Shield Coolant System
DT 18	Electrical System, Panel Index Verification
DT 19	Electrical System, Switchgear and Controls
DT 20	Electrical System, Motor Control Centers
DT 24	Fuel Handling Equipment
DT 31	Data Handling System
DT 34	Cranes and Hoists
DT 40	Gas Seal Leak Collection System
DT 44	Automatic Controller

Study of data collected during Design Test 55, Moderator Level Stability continued. A. L. Ruiz of Systems Research, Physics and Instrumentation Research and Development Operation, participated in the analysis.

Helium system performance was generally satisfactory, although at full operating pressure several previously undetected leaks were disclosed. These have primarily been associated with the failure of valves to be leak-tight. It is anticipated that this may be a long-range problem. Corrective steps are now being taken, including removal of valves where possible without sacrificing operating flexibility. New valves may be required in certain locations to achieve desired levels of system reliability. Pressure control of the primary system at low temperature was satisfactory. Failure of a high pressure compressor diaphragm released oil into the gas system, requiring extensive cleaning. In the course of cleaning, it was discovered that the recombiner had not been filled with catalyst by the Phase III contractor Helium compressor performance has been satisfactory since the diaphragm failure incident. Orifices were installed in the unloading valve lines of the high pressure compressors to restrict flow to approximately 75 scfm, maximum. This was required to prevent excessive loss of helium from the high pressure helium system should the compressor discharge check valves fail to hold. External leaks in the high pressure helium system were found at the piping connections to the storage tanks. These have been repaired by seal welding.

Piping connections to the reactor dry gas system compressor were revised to reduce stresses on the compressor casing. Numerous leaks have been located and repaired in this system, but gas losses have not yet been reduced to acceptable levels.

Shim rod modifications in progress include the following:

1. The 17-4 PH ball nuts that support the inconel shims on the lead screws are being replaced with 300 series stainless steel material. The nuts are being replaced because of possible failure of the 17-4 PH ball nut due to stress corrosion. As an added deterent to possible dropping of shims, two small steel pins are being welded in the inconel shim. In the event a ball nut fails, the pins will limit shim drop to 1/8 inch.

2. Shim assembly wiring is being improved by providing internal connectors in place of troublesome soldered connections. The new connectors are being potted with a waterproof compound as work progresses.

3. The electrical connector at the top of the shim rods was modified to provide a waterproof seal. The modification was tested and found satisfactory. The original compression locking device was removed to facilitate maintenance of the system. Present cable connectors will be provided with an amphenol screw connector and an O-ring seal.

4. The thermocouple attached to each shim is being replaced with new SS sheathed couples. The couples are being encased their full length in an aluminum tube that is welded to the shim web.

5. Each shim is being thoroughly inspected. Doubtful parts are being replaced or reconditioned. All maintenance efforts are being accurately recorded to aid future evaluation of shim performance.

6. A program to improve shim position readout was initiated. Present VTVM's will be replaced by bridge circuits incorporating the VTVM's 0-200/ua meter for readout. This work is not critical to completion of the startup program.

The total shim repair job is approximately 40 percent complete. All necessary material is on hand or is being fabricated locally.

Considerable difficulty has been experienced during the removal of three calandria access plugs. It has been found that approximately 200-foot pounds of torque is required to break a plug loose. This excessive tightness is due to galling at the seal and will be eliminated in the future by using new anodized plugs to replace plugs which are removed.

Plans and Procedures. Preparation, review, and approval of the Operating Standards and Procedures continued. Two Operating Procedures were approved during the month by the PRTR Startup Council, leaving eight procedures yet to be approved. Six new standards were written during the month and are currently being reviewed. Seventeen standards remain to be approved. Rough drafts of two of the three remaining power test descriptions were prepared and are being circulated for comments. Equipment procurement and installation is continuing.

The list of information required for approval of special irradiations in the PRTR was distributed to the groups expected to sponsor the majority of tests in the PRTR.

2. PLUTONIUM CERAMICS RESEARCH

Plutonium Dioxide-Uranium Dioxide. Experiments on the PuO_2-UO_2 system and on the stability of PuO_2 were curtailed due to replacement of a burned out heating element in the sintering furnace. Another "long time" sinter experiment was conducted, however, in which eight UO_2-PuO_2 pellets were held at 1550 C for 76 hours in helium. The volatility and flow of PuO_2 rich compositions previously seen in hydrogen atmospheres was not observed. This lends further support to the speculation that the volatility in hydrogen is the result of a high vapor pressure of the reduced species, i.e., PuO_{2-x}. In this experiment each pellet was enclosed in an individual molybdenum tube and on discharge from the furnace, a thin molybdenum coating was noted over the majority of the surface of each pellet. The molybdenum boat wire which was near a PuO_2 pellet was coated with fine black whiskers which is evidence of the deposition of oxide from the vapor. Examination of these pieces is currently in progress.

The resistance to indentation of a ceramic material should be a function of its total pore volume resulting in a hardness-density relation. Micro hardness data have been obtained from the center, half radius, and edge of about twenty UO_2-PuO_2 pellets ranging from 60 to 97 percent of theoretical density. A very definite relation exists between density and DPHN and should prove of assistance in evaluating in-reactor mass transfer and densification. Hardness tests will be made on the GEH-14 capsules currently in Radiometallurgy storage.

A UO_2 - 5.67 w/o PuO_2 (GEH-14-88) sample which had been irradiated to approximately 2000 MWD/T in the MTR has been subjected to x-ray diffraction analyses together with its unirradiated counterpart. A quick comparison of the two scans indicated a slight line broadening and shift had occurred as a result of irradiation. Intensities were noticeably different also, presumably due to excessive grain growth and orientation. The two samples are presently being scaled for detailed examination.

Plutonium Carbides. Experiments to determine the composition limits and gain some understanding of the defect phase PuC have continued. Back reflection x-ray data obtained from 19 plutonium-carbon alloys in both the as arc-melted and annealed condition showed the lattice parameter to vary uniformly over the range 43-49 a/o carbon. The samples which had been annealed at 1450 C in vacuum showed a slightly higher lattice parameter, presumably due to loss of plutonium. Above 49 a/o C, the lattice parameter remains constant at 4.974 A. Below 43 a/o C, the lattice parameter also remains essentially constant as a function of composition, but extrapolation indicates the composition to correspond to about 48 a/o C. Densities obtained on the arc-melted buttons gave approximately 13.35 g/cc for the PuC phase and varied uniformly with composition for carbon rich and carbon deficient PuC. The above data were fit to the

PuC phase diagram proposed by Ellinger and several modifications to the "dashed" lines are postulated. It should be pointed out that the compositions discussed above are based on the amounts of plutonium and carbon initially mixed together. All the alloys are presently being analyzed for carbon by a combustion technique.

Additional melting data fixes the peritectic decomposition of PuC at 1660 ± 15 C and that of Pu_2C_3 at 2075 ± 25 C.

Micro hardness tests on a series of arc-melted PuC-UC alloys was rather unsuccessful due to oxidation of the sample surfaces. The most reliable data were obtained from a pure PuC specimen and gave a value of 700 DPHN. These samples will be rerun next month immediately following a polishing treatment. Detailed metallographic examination was also impossible due to poor surfaces.

Plutonium Oxide-Zirconium Oxide System. Several sintered pellets ranging in composition from 77 - 95 m/o ZrO_2 were quenched in water from 600-1000 C. Points determining the phase boundary between the F.C.C. solid solution and the two-phase (F.C.C. solid solution + monoclinic ZrO_2) regions are as follows:

Composition (m/o ZrO_2)	Temperature (°C)
77.0	Approx. 20
83.6	600
89.4	800
94.9	1300

Thermal Conductivity. After familiarization with the thermal conductivity device and the concept involved in the determination of thermal conductivity by the comparative method which is the design basis of this setup, some changes were found to be required. A new set of thermocouples was attached to the conductivity insert and the head plate was machined to remove a warp that had been introduced during installation of a cooling coil. Alteration of the heater circuitry completed these changes.

The first two trial runs showed the thermocouples, vacuum system and main molybdenum heater to be functioning properly. Trial runs three and four showed that the constant voltage source used was inadequate to raise the maximum thermode temperature over 250 C with the main heater alone. Runs five and six tested out the bottom balance heater and recirculating water pump. The pump was found to leak after pressure had been built up. This was remedied. The maximum temperature obtained with the main heater and bottom balance heater was less than 300 C after five hours. Changes were made in order to put higher amperages into the main heater and the top balance heater. Trial run seven employed all three heaters. At a temperature of 480 C, the top balance heater went out. Disassembly revealed that the heater windings had shorted and also that much of the heater insulation had broken off. Three faulty water valves were also discovered and replaced. The heater was rewound and will be assembled following a few more changes.

3. UO_2 FUELS RESEARCH

Fuel - Cladding Reactions

High temperature reactions of UO_2 and UC with various cladding materials are being investigated. Small specimens (about 50 mg) of UO_2 and UC are weighed to ± 1 ug and placed on a 1/4 inch wide strip of the cladding being investigated. The strip of cladding is resistance heated in a helium atmosphere to the desired temperature (as measured with an optical pyrometer) and allowed to soak for a predetermined length of time. Specimen weight change is measured and any changes in specimen appearance is noted. The filament and specimens are then sectioned and examined metallographically. Cladding materials include tungsten, tantalum, molybdenum, Zircaloy-2, Zircaloy-4, 304L stainless steel, Hastelloy F, Inconel X, Fansteel 80 (99% Nb, 1% Zr), and Fansteel 82 (66% Nb, 33% Ta, 1% Zr). UO_2 and UC specimens were heated on each of these materials for ten minutes at 1000-1500 C (or the melting point of the cladding minus 100 C, whichever is less), the melting point of the cladding minus 100°, the melting point of UC (2350 C) and the melting point of UO_2 (2790 C).

Uranium carbide was much more reactive than UO_2 in all cases. The molten carbide reacts vigorously with tungsten, molybdenum, and Fansteel 80 and 82. Tantalum was most compatible with UC and was able to contain a molten puddle for about three minutes at 2350 C before the filament separated. All of the claddings whose melting temperature was less than that of UC reacted extensively at a temperature 100 C less than the melting point; but with the exception of Hastelloy F, all filaments remained intact for the duration of the ten-minute test. The Hastelloy filament broke after four minutes at 1200 C. Heating at temperatures greater than 1000 C produced a silvery metallic coating on the surface of the carbide in most cases. This was especially evident on the specimen heated on Zircaloy. Complete penetration of a 30-mil thick strip of Zircaloy-2 by a dull black reaction product occurred during heating at 1660 C for ten minutes. A 15-mil strip of 304L stainless steel was also penetrated, but by a shiny black product, at a temperature of 1300 C. The other claddings all reacted to form dull gray products which seem to be less refractory than the reacting metal.

Uranium dioxide appears to be compatible with tungsten at all temperatures. Molten UO_2 reacts rapidly with tantalum, but at temperatures less than 2800 C the two appear to be quite compatible. Molybdenum does not appear to react appreciably with UO_2 at temperatures to 2275 C. A UO_2 metal reaction does occur at temperatures 100° below the melting point of all the other claddings investigated, but only in the case of Fansteel 80 was it sufficiently extensive to prevent removal of the UO_2 specimen from the cladding after heating. The Fansteel 80 strip broke after three minutes, 45 seconds at 2290 C, and the UO_2 appeared to have reacted almost completely.

Metallography and analyses of observed weight changes are expected to yield more definitive information regarding these reactions.

High Temperature and Electron Microscopy

Reflection electron microscopy techniques were used to examine the cleavage surfaces of a fused UO_2 single crystal. The appearance and detail of the micrographs were comparable to those of transmission replica micrographs. The quality and information value of the reflection micrographs appear to be closely related to the nature of the surface examined and the application of careful experimental technique.

The UO_2 cleavage surface was also examined by high temperature reflection microscopy. Initial examination revealed no apparent changes after heating at 1000 C for 20 minutes. Experiments to allow more detailed examination to the present upper temperature limit of the apparatus (approximately 1200 C) are in progress.

A miniature resistance heating furnace was selected as the most direct approach for obtaining the desired 1800-2000 C in the electron microscope. The proposed design, utilizing Lucalox ceramic supporting members and tungsten grid and connecting wires, will allow removal of the specimen from the vacuum chamber without disassembling the microscope. The optical transmission characteristics of Lucalox ceramic should allow temperature measurement by optical pyrometry. Direct beam heating to achieve temperatures above 2000 C also may be possible. A design involving a grid bias control and "telefocus" grid to control the specimen heating and the image intensity independently is being considered.

A series of exposure tests was performed with the hot stage of the optical microscope using various types of black and white and colored still and motion picture films. These tests will provide calibrations for the high temperature microscopes when they are used as metallographs under various lighting conditions. Royal Pan and Ectachrome were found to be most suitable for still pictures; Kodachrome A was satisfactory for motion picture microscopy.

High Energy Impact Forming of UO_2

A series of statistically-designed experiments was performed in which the effects of temperature, pressure and O/U ratio on the UO_2 density attained by high energy impact forming were determined. Density measurements of the compacted UO_2 are in progress.

4. BASIC SWELLING PROGRAM

Irradiation Program

Constant temperature capsules No. 7 and 8, each containing three axially split, hollow, uranium cylinders, were successfully charged into a reactor and are presently operating at control temperatures of 500 C. They will be operated at this temperature for a short period of time in order to safely establish the "in-reactor" operating characteristics of the capsules and the control instrumentation. The control temperatures will be increased to 525 C and 575 C for capsules 7 and 8, respectively, and remain there for the duration of the irradiations. It is not anticipated that the small amount of burnup accumulated at the low temperatures will significantly influence the ultimate results of these irradiations.

A vacuum heat treating facility has been modified to allow annealing of laboratory capsules containing uranium specimens identical to those irradiated in swelling capsules. Five laboratory capsules have been fabricated and will be subjected to the same thermal treatment as the in-reactor capsules. Post-annealing examinations will be conducted in order to determine the changes that have occurred with respect to geometry, density, and microstructure. Comparisons will then be made between these laboratory specimens and the irradiated samples.

Pore Size and Distribution

Optical and electron microscopy are being used as a direct means of determining the size and distribution of pores in irradiated uranium. Specimens of 0.29 a/o and 0.41 a/o burnup which were annealed in an unrestrained state at 400 C and 500 C for times of one hour and 100 hours have been replicated and their microstructures have been photographed. Pore size distributions are currently being derived from the micrographs. In addition, a specimen with a burnup of 0.29 a/o was annealed for 100 hours at 700 C to provide metallographic data on pore size distributions. This latter heat treatment and metallography is a duplication of prior work, as there were reservations concerning the validity of the original observations. The swelling, $\Delta\rho/\rho$, associated with the 0.29 a/o burnup specimens (ρ as irradiated = 18.62 g/cc) was found to be 0.021 and 0.035 due tc one hour annealing at 400 and 500 C, respectively. The swelling associated with similar specimens annealed at 400, 500 and 800 C for 100 hours was found to be 0.020, 0.028, and 0.092, respectively. Specimens utilized for similar annealing treatments but representing burnups of 0.41 a/o (ρ as irradiated = 18.70) yielded the following fractional changes in volume: for one hour annealing at 400 and 500 C, $\Delta\rho/\rho$ = 0.021 and 0.047, respectively. Changes for 100-hour annealing treatment at 400 and 500 C were 0.022 and 0.057, respectively.

Statistical treatment of pore size measurements permits estimation of the fractional volume in the uranium which is occupied by pores, the pore void

fraction (V.F.), and also the number of pores per unit volume, the pore void density (V.D.). Assuming that the internal pressure of all pores is exactly balanced by surface tension forces, it is possible to calculate the number of gas atoms that are contained in observable pores from the pore distribution data. Values so calculated were compared with the theoretical number of gas atoms that should be present on the basis of reported burnup. A sample irradiated to 0.29 a/o burnup should theoretically contain 34×10^{18} gas atoms per cc of uranium which is somewhat less than the experimentally derived number, 51×10^{18} atoms/cc, for a specimen annealed at 700 C. The discrepancy is undoubtedly due to errors in surface tension and restraint values and errors in the experimentally derived pore volume fraction and pore void density values. On the assumption that all of the gas atoms are contained in observable pores after the 700 C anneal and that errors associated with measurements after various annealing treatments are alike, it can be inferred that 61% of the atoms are accounted for in the as-irradiated state, 78% after a 600 C anneal and 91% after a 650 C anneal. This information is being correlated with various hypotheses to explain the agglomeration and growth of pores in irradiated uranium and involves consideration of gas atoms in pores which are too small to be observed by the techniques employed.

Fission Product Mobility

Uranium specimens are being examined that have had inert gas introduced into the surface by "glow" discharge and U-U diffusion couples are being examined 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. Two NaK-filled capsules are at the MTR awaiting irradiation at essentially ambient water temperature. Each capsule contains a single specimen which consists of a slice from an extrusion which has a core of depleted uranium and a shell of enriched uranium. One surface of each specimen is completely precharacterized.

A uranium disk that was "glowed" in Kr and then heated in several stages in the same system to about 900 C was removed from the system, lightly electropolished, and reheated to its melting point in a new vacuum annealing system integrally connected to the mass spectrometer. A maximum in the Kr evolution rate was observed at about 400 C amounting to about 2×10^{13} atoms per second. No increase in rate was observed when the previous maximum temperature of 900 C was exceeded.

Restrained Irradiations

Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposure are being irradiated in NaK-filled temperature monitored capsules. Three swelling capsules, GEH-14-94, 14-95, 14-99, are presently being irradiated in the MTR to various goal exposures Exposures and average outer uranium temperatures for the fuel rods in these capsules are respectively 0.18, 0.27, 0.29 a/o and 575, 500, and 540 C. Seven capsules have now been discharged from the MTR and will be examined in Radiomet during the succeeding months

Radiometallurgy Laboratory Studies

The third NaK capsule containing an unrestrained uranium specimen irradiated at high burnup has been opened and is being examined. Gross swelling and distortion of the specimen had occurred (RM-284). Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

The in-reactor behavior of one second generation creep capsule showed that certain weaknesses in the capsule had to be corrected before other capsules in this series could be irradiated. Consequently, three capsules were returned to the vendor's plant for modification. Emphasis was given to the reworking of one capsule so it could be shipped ahead of the others. The modification work on one capsule was followed at the plant by a laboratory representative until the capsule was completed and packed for shipment.

Upon opening the capsule in which thermocouples had failed during thermal cycling, it was established that the failures were in a short section of swaged oxide thermocouple extension lead. All the thermocouples in the capsule have been replaced with heavy gage wire and alumina insulators identical to those used in the successful prototype capsule. Another area of concern in the modification work was the limited life imposed by using unlubricated components in the mechanical extensometer system in the capsule. It is generally known that lubricants suffer deterioration in a nuclear environment, yet all attempts to use unlubricated bearings in reactors have indicated that any lubricant, no matter how poor, is better than none at all. Therefore, when the capsules were open, the best known dry film lubricant was selected and used to lubricate the moving parts. A lubricant composed of lead oxide and graphite was selected as being the best for our capsule. A special formulation was made for this particular case which eliminated all organics that could decompose and contaminate the helium atmosphere in the capsule. The mechanical extensometer after lubrication exhibited a marked improvement in the smoothness of operation at room temperature. The lubricant becomes more effective at temperatures near 500 F, which will be the operating temperature of the extensometer in the reactor. During the modification of the capsule some material was removed from certain areas in the capsule to obtain improved thermal characteristics. Component tests during reassembly revealed a trouble spot in the variable permeance transducers. The temperature cycling had caused the cores of the transducers to become loose on the gaging support, which would cause erratic behavior of the transducer output. The cores were reaffixed to the gaging wires in a way that thermal cycling will not loosen the cores. The reworked capsule was completely checked at the vendor's plant before shipping. A further check will be made after arrival at Hanford before the capsule is charged in the reactor.

Capsule and Instrument Development

A review of the drawings, the materials and techniques of construction for six third-generation capsules has now been completed. The major difference in the third generation capsules over the others is the attention paid to simplification. Only one variable permeance transducer and one mechanical extensometer are used. The two extensometers are combined, however, so that each may be used independently and either one can be used to calibrate or check the other. The known system accuracy of the mechanical system of the second generation capsule has now permitted a ten-fold reduction in the ratio of the gear box within the new capsules. The ten-fold reduction in the gear box ratio, from 20,000:1 to 2000:1, should retain all the system accuracy but require only one-tenth the operational time for obtaining the readings. This reduction in operational time will greatly improve the life of the mechanical extensometer system. The mechanical system will be proved at the vendor's plant before installation in the capsules. Further improvements were made in the heat balance in the third generation capsules as well as improvements in the ease of fabrication and assembly.

Pre-Irradiation Material Characteristics

Measurement of the activation energies for creep of annealed and cold worked Zircaloy-2 at various temperatures and stresses has continued. Activation energies were determined in the temperature range 300 to 350 C on annealed material and 300 to 317 C on cold worked material. Values found in the temperature range studied were within the experimental scatter of the previously determined value of 61.4 K cal/mole.

An existing creep frame has been modified to allow determination of activation energies as low as 1 K cal/mole in the temperature range zero to 250 C. The modified apparatus will allow determination of the activation energy spectrum at temperatures below which only rough estimates of activation energies could be made by using conventional creep machines.

6. GAS-GRAPHITE STUDIES

EGCR Graphite Irradiation

The H-3-2 experiment continues to operate successfully in the GETR. The capsule has been in the reactor for four cycles, but due to two long shutdowns for loop installations, has received only two cycles of irradiation. All but one of the thermocouples are operating satisfactorily.

EGCR Burning Experiments

Experiments conducted in the EGCR burning rig demonstrated that silicon carbide coated fuel sleeves greatly reduce the hazard of runaway oxidation. Runaway did not occur until graphite temperatures exceeded those expected in the reactor by 100 C. All experiments were conducted with a full scale radial mockup of an EGCR fuel channel and with expected air flows.

In the cases where runaway occurred two distinct causes were observed. The more serious was a fuel sleeve failure in the vicinity of a joint resulting from poor coatings or uncoated sleeve ends. In this case a hole was opened from the fuel coolant channel to the moderator coolant annulus. Air streams through the hole impinged on the moderator and caused oxidation to proceed through the moderator block. Temperatures began to rise at approximately 10 C/min and showed no indication of stabilizing. Such a failure in the reactor would cause the fire to spread to adjacent channels.

The second type of runaway observed was caused by a coating failure near the center of an assembly in the fuel coolant channel. In this case the sleeve did not serve as a heat sink for the section of moderator opposite the burning spot. Temperatures increased at the rate of 1.5 C/min for about 100 minutes, after which the rate decreased to about one-half this value.

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

A preliminary estimate of approximately $6,500 was received from Struthers-Wells to modify the pre-heater by reducing the amount of NaK contained to a tolerable level (approximately 150 lbs). A contract was awarded to Struthers-Wells in the amount of $10,850 for the detailed design of a removable section type steel shield for the external face of the gas loop framework. It is planned to invite bids on the open market for fabrication and delivery of the shield before July.

Details of the Bristol-Siddeley blower shipment were discussed with C. E. Wurr of the vendor's engineering staff. It was agreed to eliminate the touch meter and internal thermocouples from the machine. Mr. Wurr recommended 60-cycle starting, which can be done. In the event replacement of rotor is required, the new assembly will require balancing with the impeller on an air bearing machine (Gisholt 315). This probably can be done at Boeing's in Seattle; however, Mr. Wurr foresees no difficulties in six months of operation.

Component Testing

As previously reported, testing of the in-reactor test section has been delayed due to failures of the internal electrical heater. Both heater failures have occurred in the lower portion of the test section where the clearance between the heater and test section is limited. The repaired heater, which is ready for installation, has been shortened so that the heater does not extend into the limited clearance section. The heater has been successfully bench tested at 31 KW and reinstalled in the test section mockup.

7. GRAPHITE IRRADIATION DAMAGE STUDIES

ETR Graphite Irradiations

The GEH-13-6 irradiation capsule was installed in the N-14 position of the ETR on March 14. This capsule contains seven sets of three samples each. The temperatures of four of the seven sets will be controlled by thermocouples and heaters. The remaining three sets will be operated on gamma heat alone and have neither heaters nor thermocouples. The five graphites included in the test are: CSF (Standard); "A" grade, a raw coke graphite; ZT, a hot worked graphite; ARF-3, a furfuryl alcohol bonded graphite; and 901-S, a special isotropic graphite.

Preliminary design has started on the GEH-13-8 irradiation capsule. The purpose of this experiment is to obtain irradiation data at sample temperatures of 200 to 600 C. Information in this temperature range is needed to extend the high exposure data from test reactor experiments down to exposures in Hanford test holes. The capsule will be irradiated in the E-5 position of the ETR.

Hanford Graphite Irradiations

A variety of experimental graphites is being irradiated in the Hanford reactors at about 500 C to determine the relative effects of binders and fillers on the dimensional stability. Petroleum pitch and furfuryl alcohol binders are combined with conventional fillers. Korite coke, fluid coke, coal tar pitch coke, lampblack and anthracite fillers are combined with coat tar pitch binder. Graphites proposed for sleeves in the HTGR and EGCR, as well as NPR core graphite, are being irradiated simultaneously.

Sonic Modulus Measurements of Irradiated Graphite

The dynamic modulus of TS-AGOT and TSF graphite irradiated to 3385 MWD/AT at 30 C was determined as a function of temperature to 2500 C by Armour Research Foundation. On each sample two heating and cooling cycles to 2500 C were run to determine the extent of annealing. Unirradiated control samples were measured to indicate the precision of the measurements. The room temperature moduli varied with exposures as indicated in the accompanying table. Two samples were measured at each exposure. The differences in modulus due to irradiation to different exposures is statistically significant only at the 90% confidence level.

SONIC ELASTIC MODULUS OF IRRADIATED GRAPHITE SAMPLES AT ROOM TEMPERATURE

Graphite Type	Exposure	Elastic Modulus x 10^6 psi
TS-AGOT	Unirradiated	0.678, 0.665
TSF	1189 MWD/AT	0.720, 0.720
TS-AGOT	2471 MWD/AT	0.695, 0.740
TS-AGOT	3385 MWD/AT	0.625, 0.670

The effects of annealing were small. Only the samples irradiated to 2741 and 3385 MWD/AT displayed a lower modulus at the start of the second run. However, there was a noticeable difference in the character of the modulus versus temperature curve, with the greatest differences appearing at higher temperatures.

Irradiation of Pyrolytic Graphite

An initial short irradiation (130 MWD/AT) of pyrolytic graphite at 500 to 600 C revealed a distinct difference in the behavior of as-deposited material and material annealed at temperatures ranging from 2200 to 3000 C. As-deposited material expanded about 0.2% in the direction parallel to the layer planes, whereas the annealed material did not expand. Upon continued exposure this distinction has disappeared. Both as-deposited and annealed samples expanded about 0.4% after 2100 MWD/AT. In addition, some samples were large enough to measure transverse length changes. After 1930 MWD/AT an expansion of 0.3% occurred. Thus, there is a reduction of about 1% in bulk density upon high temperature irradiation to 2000 MWD/AT.

Irradiation of Explosively Compacted Graphite

Samples of explosively compacted material made from natural flake and from ground nuclear graphite were irradiated at 500 to 600 C to 1930 MWD/AT. The original bulk density of the natural graphite compacts was 2.12 g/cm^3. After irradiation an expansion of 0.9% was noted in the transverse direction and a contraction of 0.2% in the parallel direction. In contrast, nuclear graphite compacts with an original bulk density of 1.9 g/cm^3 contracted about 0.07% in both the transverse and parallel directions.

Electron Microscopy Studies

Comparison of cathodically etched and as-polished graphite surfaces by electron microscopy has shown that, although cathodic etching reveals a network of microcracks, the surface between cracks is left smooth and more difficult to interpret than the small oriented platelets present on unetched surfaces. Oxidation will be combined with cathodic etching in an attempt to reveal the orientation of structure between microcracks.

Metallography Studies

Work on a technique to improve replica contrast of porous materials was initiated. The conventional shadowing technique obscures much detail with a material such as graphite because long shadows are cast by replica material stripped from pores. The technique under study would leave no shadows and allow observation of areas in or near pores. A thin film of liquid epoxy resin is applied to a carbon replica prepared in a conventional manner, with the exception that no heavy metal shadow deposit is applied. The liquid resin seeks a level on the contoured surface of the carbon. A variable resin thickness results which will cause a variation in electron scattering. The application of the resin to one surface of the carbon will result in a positive replica, whereas application to the opposite surface yields a negative replica. Japanese investigators have pioneered this method on other materials with some success.

8. SUPERCRITICAL PRESSURE WATER REACTOR STUDY

The conceptual design and economic evaluation of a 300 MWe Supercritical Pressure Water Reactor continued with studies directed toward defining the more detailed aspects of the power cycle, fuel element design, reactor control, and equipment layout.

Moderator Heat Utilization

Heat generated in the moderator by nuclear reaction and absorbed by the moderator through transfer from the fuel elements may be as high as 10% of the total thermal output of the reactor. Effective utilization of this heat for feedwater heating is, therefore, an important consideration. If the heat in the moderator represents no more than approximately six percent of the total power, nearly all of this heat can be recovered and used to preheat the feedwater. Any quantity of heat in excess of six percent can be used only partially, with about 1/2 percent reduction in over-all thermal efficiency for every one percent heat generation in excess of the base six percent.

The most effective method for conserving the moderator heat is to directly feed the moderator into the feedwater cycle. This method was originally incorporated into the power cycle. However, concern about severe contamination of the primary system upon fuel element failure (blowout of a pressure member) into the moderator led to separating the primary and moderator systems. In addition, the desirability of moderator poisoning for coarse control of reactivity resulting from burnup and other slow transients has been under consideration. Where boron is used, a direct moderator feed to the feedwater cycle is, of course, prohibitive. For these reasons the power cycle has been revised to regeneratively transfer some of the moderator heat to the feedwater in a heat exchanger. A second heat exchanger to lower the moderator temperature further is also required. Tentative sizing indicates both heat exchangers to require about 19,000 square feet of heat transfer area if heat in the moderator is 10% of the total reactor heat output.

Turbine Bypass System

A turbine bypass system is necessary during rapid or slow startups and shutdowns. During the operation of the bypass system, close proximity of normal temperature must be maintained throughout the cycle to prevent thermal shocks or overtemperature conditions in the reactor components. The most difficult condition appears to result from turbine stop valve trip followed by reactor scram. In such an event the bypass system must progressively reduce the pressure and temperature of the fluid leaving the last pass of the reactor to provide heat sink media in the reheat heat exchangers, and yet maintain steam at appropriate pressure and temperature for the feedwater heaters and for the turbine-driven feedpump. Simultaneously, the pressure and temperature reduction must correspond to the reactor flow reduction which must follow the reactor power decay relation.

As a result of these considerations it is proposed to utilize several bypass valves, pressure reducing devices, and desuperheaters in the turbine bypass system to regulate the pressure and temperatures. Because of the speed of response necessary, some compromise may be necessary. This area appears to be the main problem in the supercritical pressure water concept from the power cycle standpoint.

Equipment Sizing and Cost

Preliminary specifications for the reheat heat exchangers, feedwater heating system, condenser, and pumps have been submitted to various manufacturers for sizing and cost information. To date, information has been received on the condensers. Vendors' recommended sizes for the service have been essentially similar to preliminary calculations. For a maximum cooling water temperature of 75 F, the surface condenser will require 170,000 square feet of area to maintain 1.5" Hg absolute pressure. On the basis of an average cooling water temperature of 57 F, the surface area requirements will be 110,000 square feet.

Fuel Element Assembly

Work continued during the month on optimization of the fuel element design for the "inverted cluster" element. The U-tubes carrying the coolant, initially 26 in number, were decreased to 18 to provide a more favorable fuel-to-tube metal ratio and to ease fabrication problems. With the 18-tube cooling array, power densities on the order of 20 megawatts per ton of uranium appear feasible.

One of the basic quantities which must be assigned in a power reactor study is the design value of the heat flux to the coolant. For a given fuel design, this value determines the specific power (MW/T) and hence the core size. In most reactor concepts the value is assigned by determining the burnout heat flux (about 1,000,000 Btu per square foot per hour for many reactors) and taking a factor of two or three for safety and unknowns. For supercritical water technology no burnout limit has been determined, indeed if one even exists. However, there does exist a phenomenon called the "whistle effect", which, while the consequences of it appear to be an entirely different order of seriousness from burnout, does produce pressure fluctuations and vibration (about 1500 to 2500 cps). Because of the limited data on the "whistle effect", a factor of two on the estimated "whistle effect" region in the Supercritical Pressure Water Reactor has been assumed, resulting in a design heat flux of 750,000 Btu per square foot per hour. This results in a reactor average heat flux of about 200,000. Definition of the magnitude and location of the "whistle effect" represents, perhaps, the most significant barrier to fully exploiting supercritical cooling technology.

To provide a reasonable distribution of the heating load over the fuel elements, circulation of the coolant through the reactor in three passes has been selected. These passes will be:

(1) First Pass: Inlet temperature 540 F, outlet 805 F.

(2) Second Pass: Inlet 805 F, outlet 1050 F.

The exit coolant from the second pass will be led to the steam reheat exchangers returning at 805 F for the third pass.

(3) Third Pass: Inlet 805 F, outlet 1050 F.

The effluent from the third pass will be fed directly to the turbine.

The first pass will represent approximately half of the total heat load. Tubes carrying "first pass" coolant will be concentrated in the central zone of the reactor, whereas the "high temperature" passes will comprise the lower power fringe tubes. It appears that an average pressure drop of about 200 to 250 psi per pass will be encountered at projected operating levels.

Reactor Control

To realize the high exposures (approx. 20,000 MWD/T) desired from the fuel, it will undoubtedly be necessary to introduce a variable reactivity factor, either by introducing a burnable poison into the reactor loading or by utilizing a variable-density soluble poison in the moderator. One interesting possibility being considered is the division of the moderator tank into zones by partitioning and controlling the soluble poison content of each of the three temperature zones. Such an arrangement would permit tailoring of the poison content to the reactivity of the individual zone and should permit extension of fuel operating life without accentuating flattening problems.

"Gray" control rods would then be used primarily for short-term reactor control, with strong safety rods interspersed in the fuel pattern for shutdown.

Work continued on the layout of the SPWR site and reactor building. The layout of the control, office, and waste handling areas has been completed.

The waste handling system flow diagram and the first draft of the system description were completed. A cost estimate for the system is being prepared.

Work continued on the refinement of the SPWR unit cost of producing power. While the costs remain quite competitive, sufficiently detailed analyses have not been made to set a power generating cost.

9. ALUMINUM CORROSION AND ALLOY DEVELOPMENT STUDIES

Metal Growth During Corrosion

The relationship of dimensional changes and film growth is being determined for Zircaloy-2 and for the aluminum alloys X-8001 (1% Ni, 0.5% Fe), 1245 (99.45% Al), and an experimental aluminum alloy containing 1.5% Fe, 1.5% Ni. Sample thickness from two to 62.5 mils is being tested.

For the two-mil aluminum foils the dimensional increases seem to have a linear relationship to weight gain in the early part of the test, after which the growth rate decreases. The heavier aluminum foils show no discernible growth during the first part of the test, but at a given film-thickness to metal-thickness ratio growth becomes detectable. There is an indication that the corrosion rate may also increase at this point, but this is not yet conclusive. The Zircaloy foils have shown no growth up to a weight gain of 11 mg/dm^2.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals, namely, copper, nickel, titanium, zirconium, iron, and type 347 stainless steel.

Isothermal annealing of zirconium, iron, nickel, and copper was continued during the month. A series of isothermal anneals was begun to determine the kinetics of yield strength recovery in irradiated zirconium.

Analyses of tensile tests on irradiated iron have been made using two techniques: (1) increase in upper yield stress with increasing exposure, and (2) separation of radiation hardening into lattice and source hardening. The contribution of source hardening appears to decrease with exposure and increase with interstitial impurity content. The amount of radiation hardening increases with decreasing interstitial impurity content and reaches saturation at increasingly higher exposures as the impurity content is decreased. The interstitial impurity atoms are obviously acting as trapping sites for point defects. In the material of highest purity, fewer trapping sites are available and the radiation-induced defects migrate to other sinks such as grain boundaries and dislocations. Annealing at temperatures suitable for freeing trapped defects results in an increase in the source hardening. This is reasonable if one considers that only "fresh" dislocations are moving under the applied stress.

A similar treatment has been applied to tests of Type "A" nickel. After initial yielding, a specimen exposed to 3.6×10^{18} nvt was unloaded and immediately reloaded, resulting in a decrease in the amount of source hardening. After aging for one hour at 200 C, the source hardening was increased by 2000 psi; upon unloading and immediate reloading, the source hardening decreased by 1500 psi.

Strain-rate sensitivity tests are being conducted on irradiated and unirradiated titanium in an effort to determine the effect of neutron damage on dislocation velocities. An irradiated specimen with an exposure of 1.0×10^{17} nvt was strained 0.5% at a strain rate of 0.02/min. Then the rate was instantaneously changed to 0.002/min. This cycle was repeated several times. The same procedure was followed on an unirradiated specimen. The coefficient of strain-rate sensitivity was 0.024 to 0.028 for the irradiated specimen and the strain-hardening exponents were the same at both strain rates. The unirradiated specimen, however, was more sensitive to an increase in strain rate than to a decrease, due to a lower strain-hardening exponent at the lower strain rate. The coefficients of strain-rate sensitivity were 0.018 to 0.019 for a decrease in strain rate and 0.021 to 0.024 for an increase in strain rate.

E. CUSTOMER WORK

Radiometallurgy Service

Examination of the female end cap of an I&E hole failure revealed a pocket of UO_2 under the cap and a pocket of UO_2 extending one inch down the element under the outer cladding. A large void in the AlSi was found around the outside edge of the cap. From the observations it is believed that the defect was in the female weld, although the exact point of water entry was not found (RM-417).

A natural uranium, I&E production element rupture from 3781-H failed by splitting longitudinally. Examination to date has indicated that prior to splitting the cladding was penetrated at the upstream end by uniform corrosion and an oxide pocket formed in the uranium. The uranium corrosion products displaced the cladding and reduced the coolant annulus on the top side of the element. The aluminum corrosion product downstream from the blister indicates that the surface temperature was at least 350 C (RM-420).

A side failure which occurred in tube 4173-H was examined this month It appeared that melting of the cladding had occurred. A detailed examination revealed that the failure resulted from water penetration of the cladding in the maximum temperature zone of a "hot spot" Water and/or vapor undercut the cladding displacing the cladding over a large area around the entry site. The appearance of the cladding did not indicate that melting had occurred (RM-422).

Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

Metallography Service

A metallographic examination of a short section of the KER-1 carbon steel loop has revealed no cracking such as encountered recently in the stainless steel loops of KER. The same localized area where cracking occurred in the stainless steel was examined in the case of the carbon steel

The gas pressure bonding technique for NPR fuel element closures has been under study by FPD's Materials Engineering Operation. Initial work produced incomplete bonds which were found to be the result of improper cleaning before assembly. Techniques used recently require that the components be cleaned by vacuum cathodic etching. Metallographic examinations of pieces assembled after cleaning in this manner have shown that complete bonding occurs along the cap-to-uranium interface, but only partial bonding sometimes results between the cap and can wall. This partial bonding is caused by incomplete removal of what appears to be zirconium oxide from the mating surfaces.

Samples Processed During the Month:

Total Samples	624
Replicas	58

Photographs:

Micrographs	566
Macrographs	217
Electron Micrographs	195
	978

VBWR Control Rod Review

The technical review of the Vallecitos Boiling Water Reactor control rods with respect to the possibility, probability, and circumstances which could lead to nine control rod "shoot-out" incidents was completed. It was the opinion of the reviewers that a control rod shoot-out incident was credible (defined as a probability greater than 10^{-5} to 10^{-7} per reactor lifetime). Further, it was the reviewers' opinion that the present control rods could not be modified (without essentially rebuilding them) to place a shoot-out incident in the incredible range. It was their recommendation that certain interim modifications be made to the rods until new rods could be designed, fabricated, tested, and installed on the VBWR (about two to three years' time).

Pebble Bed Reactor Study

The review of the ORNL design study was completed on March 17, and sent to the AEC. A formal document will be issued in the near future. The PBR concept was found to be technically feasible. However, the optimized unit cost of producing power appeared somewhat high, 8.0 to 8.5 mills/kwhr, when compared to the competitive cost area of 7.0 mills/kwhr or below. It was recommended that a more detailed study of the concept be performed in order to better predict the power cost. The technological problem appeared to be development of a reliable fuel ball for the exposure conditions established. An R&D program to develop this reactor concept would cost approximately twenty-three million dollars and require at least eight years to complete. Included in the program would be the eventual construction and operation of small prototype pebble bed reactor.

NPR Charging Machine

Fabrication and assembly of the NPR Charging Machine is estimated to be 35% complete.

Status of individual components is as follows: rail assemblies are complete; the cross travel drive sub-assembly is complete; transfer arm sub-assemblies are 90% complete; modified main frame components are complete and their installation is 50% complete; idler roller assemblies are 40% complete. The hydraulic power package has been installed in the cross travel drive assembly and installation of the hydraulic piping is 15% complete. Two console mockup units built of wood were completed.

Design of the magazine support to bridge "C" elevator is complete except for the nozzle and connection. A prototype balancer is being furnished by a vendor for investigation. Design of the adaptor, end plug and free piston for the magazine is complete and comment prints are scheduled for issue at month's end. Tests on optimum magazine end taper and materials and on check valves were completed. A six-degree taper will be used.

NPR Bellows Testing

Spring rate was measured on all bellows. Of ten bellows tested to date, five were satisfactory to 5000 cycles and five failed. Two failures were attributed to flexure, two to galling by the shroud, and one to vibration. The preser design is susceptible to failure from galling between the bellows and the shroud.

PCTR Hot Water Loop

Scope design of this high pressure (1500 psi), high temperature (572 F) facility has been completed and delivered to W. P. Stinson.

Shielding for Fuel Recycle Pilot Plant

Shielding calculations were started for the Fuel Recycle Pilot Plant project proposal at the request of Facilities Engineering Operation. Preliminary planning layouts have used four feet of heavy aggregate concrete for shielding. Initial dose rate calculations for the case of a criticality incident indicate that a thinner shield may be used.

F. W. Albaugh

Manager, Reactor and Fuels Research and Development

FW Albaugh:kb

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

MARCH 1961

FISSIONABLE MATERIALS - 2000 PROGRAM

REACTOR

Exponential Measurements for NP Reactor

The material buckling has been measured for the condensed N-Reactor lattice loaded with dry natural uranium fuel elements 2.3" x 1.8" and 1.1" x 0.5". The lattice spacing is 7.56 inches. The preliminary buckling is $-178 \times 10^{-6} cm^{-2}$. Estimated extrapolation lengths of 1.0 inches side-to-side and 0.8 inches front-to-rear were used in calculating the preliminary buckling.

Fast and thermal extrapolation distances into the control rod with water coolant have been calculated from the results of exponential measurements in the NPR mockup. The fuel elements were 0.946% enriched uranium with H_2O coolant. The control rod was placed in the center of the mockup. The thermal extrapolation distance derived was 5.35 cm and the fast extrapolation distance was 18.02 cm.

As a comparison, the calculated thermal and fast extrapolation distances into the control rod as reported in HW-68407 are 6.06 cm and 15.64 cm, respectively, for the NPR mockup exponential pile.

NPR Fuel Temperature Coefficient

A large error was made in computing the normalizing constants that went into the temperature coefficient reported last month. Re-examination has shown that the temperature coefficient of k_∞ should have been larger by a factor of (2.238). The corrected result is

$$\frac{1}{k_\infty}\frac{dk_\infty}{dT} = -(1 \pm 0.07)\left[(5.26 \pm 0.2) \times 10^{-5} - (2.55 \pm 0.4) \times 10^{-8}\ T\ (^\circ K)\right]$$

The above relation is valid over the temperature range from 24°C to 968°C, but neglects the effects of volume changes at the phase transition temperatures.

The step-changes in reactivity due to volume expansion at constant temperature when the uranium passes through the $\alpha \longrightarrow \beta$ and $\beta \longrightarrow \gamma$ phase transformations can be expressed in terms of unit functions, $U(T_i - T_j)$, and appropriate multipliers.

$$\rho(T) = \alpha f(T) + \beta U(T_i - T_{\alpha\beta}) + \gamma U(T_i - T_{\beta\ \gamma})$$

The unit functions, $U(T_i - T_j)$, are defined as follows:

$$U(T_i - T_j) = \begin{cases} 0, & T_i \leq T_j \\ 1, & T_i > T_j \end{cases}$$

A new method of analysis has been developed which yields the change in k_∞ direct as a function of fuel temperature, in terms of the observed reactivity changes.

$$k_\infty(T_i) = k_\infty(T_o) + R\left[\alpha f(T_i) + \beta U(T_i - T_{o\beta}) + \gamma U(T_i - T_{\beta\gamma})\right]$$

or

$$\Delta k_\infty(T) = R\left[\alpha f(T_i) + \beta U\,(T_i - T_{o\beta}) + \gamma U(T_i - T_{\beta\gamma})\right]$$

The function $f(T)$ has been chosen to be $(T_i^{\frac{1}{2}} - T_o^{\frac{1}{2}})$, following the suggestions of Keane[1], Vernon[2] and others.

Evaluation of the above equation in terms of the measured quantities leads to the following:

$$\Delta k_\infty(T) = -(1 \pm 0.07)(10^{-3})\left[(1.79 \pm 0.03)(T_i^{\frac{1}{2}} - T_o^{\frac{1}{2}}) + 0.81\,U(T_i - 960) + 0.57\,U(T_i - 1090)\right]$$

where T is in °K.

The arguments of the unit functions are selected to correspond to the average fuel temperature at the time that the entire fuel element had made the particular phase transition.

The leading term, (1 ± 0.07), represents the maximized uncertainty due to flux and adjoint flux mismatches. The uncertainty on the term (1.79 ± 0.03) is based on the variance of the fitted data. The uncertainties on the coefficients of the unit functions are estimated to be about 2%.

Neutron Spectrum Studies

The power series representation of the Hurwitz H-function has been programmed. This program has been incorporated into ACE as one of its eight subroutines. Resonance integrals of the lutetium isotopes for neutrons with energies below the cadmium cutoff have been recalculated using the new subroutine. For neutron temperatures below 600°K, the ratios of epithermal resonance integrals to epi-cadmium cadmium integrals were within < 1% of those calculated previously with a polynomial fit to the curve printed in the Hurwitz paper.

Resonance integrals were calculated also for the Pu-239 and U-235 fission cross sections with the Hurwitz function. The results of these latter calculations will be used to compare measurements of the spectral index in the TTR as deduced from lutetium, plutonium, and uranium foils.

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(1) A. Keane, B. E. Seale, AERE R/M 224 (1959), An Investigation of the Temperature Dependence of the Doppler Coefficient in Natural Uranium Lattices.

(2) A. R. Vernon, NSE 7, 252, (1960).

Bare Lu_2C_2-Al_3C_2 foils have been activated in the TTR thermal column for the purpose of calibrating counters for spectral index measurements. The foils have been counted and the data are being analyzed. This calibration work was done in support of future graphite-uranium and graphite-plutonium lattice studies and rethermalization studies.

Optimization of Retubed C-Pile Lattice

All components for the C-pile mockup exponential pile are either received or on order. An 8' exponential pile will be constructed for safety rod measurements with both standard and overbored fuel. Machining of graphite for use with standard fuel has been completed. Machining of graphite for use with overbored fuel is about 50 percent complete. Five hundred fifty-four pieces of the new enriched I & E fuel have been received.

Lattice Parameters for Large Diameter Fuel Elements

Several horizontal traverses have been taken in the 4-foot exponential piles. The data have been analyzed to obtain side-to-side extrapolation lengths, λ. A comparison between the values of λ obtained using fast and thermal source theory is shown in Table I.

TABLE I

Extrapolation Length Comparisons

Fuel Element	λ Thermal Source	λ Fast Source	Lattice Spacing
2.5 x 1.6 wet	2.3	1.1	12 3/8
2.5 x 1.6 dry	2.4	1.8	"
2.5 x 1.6 wet with 1.17	2.4	1.4	"
2.5 x 1.6 dry with 1.17	2.4	1.7	"

The λ's calculated with fast source theory are more reasonable than those calculated with thermal source theory. It is apparent that fast source theory, which is more nearly correct, should be used whenever the neutron sources are clustered about the pile centerline.

A 7090 program was written to perform many of the calculations necessary in deriving lattice parameters from foil activities, cross sections, and reactivities.

A detector with a 1/v cross section is needed for p measurements. Experiments with copper sandwiches indicated that the resonance flux could not be adequately shielded without very large copper thicknesses. Sodium is a good possibility if problems of fabrication and low cross section can be solved. Sodium carbonate

pins were made in the same manner that lutetium pins have been made. The powder is mixed with a hydrocarbon resin and molded in a glass tube. Foils have also been made by molding the resin-powder mixture between glass plates.

New foils are being prepared for the dual chamber that will be used for the standardization of ϵ measurements.

A measurement of k_∞ and f for a 1.66" fuel element in a $6\frac{1}{2}$" graphite lattice has been designed. The results will be used to check calculations and buckling measurements for very hard neutron spectra.

Digital Computer Programs for Reactor Analysis

Development of HFN, the multigroup neutron diffusion theory code, is continuing. Newly added features which have been debugged by being used on at least one computer run are:

1. Criticality Search - a single diffusion parameter is varied in an attempt to make the calculated multiplication equal to some input value.

2. Material Mixing - a homogeneous mixture of as many as ten different materials from the cross section library may be specified for any region.

3. Flux Convergence - the convergence criterion used to terminate the iteration process may be based on the fractional change in group flux at each point. Previously, only the multiplication factor could be used as a basis for the convergence test.

The option which allows partial suppression of output has not been tried. A bug has been located in the section of the program which calculates theoretical detector traverses, but has not yet been eliminated.

FIT-1, the few group neutron diffusion theory code for analysis of experimental detector traverses, is being readied for a final report. Improvements in output formats and error computations have been made. The input data for a test case for the report have been gathered, but have not been run.

Computational Programming Services

INELASCAT, the code which processes inelastic scattering data from the three-axis neutron spectrometer, is operating on a production basis. All revisions and additions thus far requested have been completed.

An informal report (HW-68858) has been issued which describes the changes made at Hanford to the Los Alamos generalized least squares program. The program decks have been put into the SPL in 713 Bldg., and are available for general use.

Instrumentation

Two prototype experimental scintillation combination quasi-logarithmic and multi-range linear beta-gamma area monitors were completed and initially tested. The units are transistorized and use a chopper input. The available quasi-logarithmic range is 1 mr/hr to 100 r/hr, and the four linear decade ranges are 0-10 mr/hr to 0-10 r/hr. The original breadboard circuitry performed continuously for 2½ months with no accumulated drift errors and with day to day readings varying by less than ± 10 percent of the true reading. The two prototypes are now in condition for complete evaluation tests. The units, if successful, will be applicable to all plant area-type monitoring problems, including NPR.

The prototype transistorized NPR Beta-Gamma Scintillation Air Monitor was returned to field service after installation of a new ruggedized meter-relay. Operation to date has been satisfactory.

Specifications were completed, in cooperation with Instrumentation Design, CE&UO, for the slow scan portion of the NPR Fuel Rupture Monitor. The specifications were issued for comments.

The fast scan table and slip-ring assembly for the experimental Fast and Slow Scanning Type Fuel Failure Monitor operated continuously for one month without trouble. Slip ring noise level measurements are being periodically made, and to date, no variation from the initial 50 microvolts peak-to-peak level has been noted. Experimental circuit development continues.

Work is under way towards determining the possible effect on NPR Fuel Rupture Monitor sensitivity due to fission products introduced into the coolant by uranium surface contamination on the fuel. Design was completed for two light pipes and associated light-tight box and necessary electronic equipment for experimental investigations of uranium contamination on the outer surfaces of NPR fuel elements by alpha detection. It was calculated that levels of less than 0.010 $\mu gm/cm^2$ can be detected on the element surfaces.

A specification (HWS-8127) was prepared for Instrument Development, IPD, concerning a chamber-cable assembly for use as a reactor high level flux monitor. In this case, a unified cable-chamber assembly with no cable connectors was proposed. Technical advice was rendered concerning the Intermediate Range Period Monitors, and technical guidance was rendered concerning improvements to the gamma type fuel rupture monitor (CGI-904). In addition, a guide for a general specification was prepared concerning the procurement of replacement fission counters for subcritical neutron monitors.

Advice was rendered to Instrumentation Design, CE&UO, concerning technical aspects of the NPR nuclear instrumentation procurement.

Tests were performed to determine the extent to which emittance affects the output of the radiation ratio pyrometer being developed for reactor graphite temperature measurement. FPD's pyrometer was used for the tests, and the indication of this pyrometer and a silicon solar cell pyrometer were compared to that of a thermocouple for specimens of Zircaloy-clad and bare uranium elements. The silicon solar cell pyrometer shifted calibration as expected, since it is a brightness pyrometer and is sensitive to the difference in

emissivity between Zircaloy cladding and bare uranium. The calibration of the radiation ratio pyrometer did not shift either from drift over a one-month period or from difference in emittance between the two types of specimens.

Systems Studies

Work is continuing on the NPR plant simulator. The purpose of this simulator is to provide a reactor model for the supervisors and operators. This model will allow interested personnel to investigate the behavior of the reactor under actual operating conditions.

The NPR secondary loop study has been completed for the present. The study consisted of transient and stability analyses of the entire secondary system. The analog representation of the system includes the secondary side of the primary heat exchangers, the dump condensers, the surge tank, and automatic control for the heat exchangers, dump condensers, and surge tank. Lack of non-linear analog equipment dictated the use of linear approximations to parts of the system. Almost the entire system was simulated on the GEDA computer. The first analog studies were of the secondary system as proposed by Burns and Roe; this system exhibited a marked instability. Stability was considerably improved by increasing the size of the surge tank by a factor of four. Further stability was attained by removing the dump condenser reset control. In an effort to utilize the desirable features of reset control without undue instability, a low reset value, around 0.01, will probably be used. It is expected that IPD will initiate further analog study of the secondary system sometime in April or May, 1961.

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 easy 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.

The EASE analog computer was used to simulate a two-zone reactor control system in an attempt to determine the behavior of a reactor subjected to zone temperature control. The control system consists of a sampling device which measures the outlet water temperature in each zone periodically, compares this temperature to a reference, and if the error is greater than a predetermined value, moves the zone control rod a fixed distance. The effects of the following parameter changes were studied:

(1) Sampling period
(2) Rod travel per sample (when a correction is needed)
(3) Error limits (dead band)
(4) Relative "worth" of the two ends of the half rod
(5) Cross coupling between the two sections.

In general, the study shows that stable control of each zone temperature is possible with relatively long sampling periods (one minute, or less). However, the quality of control is improved by decreasing the sampling period and reducing

the amount of rod travel per sample. The amount of rod travel needed (per sample) depends on the magnitude of the largest expected disturbance, the sampling period and the maximum allowable temperature, or power level, deviation. Details of the test results will be contained in a forthcoming report.

A reactor control test was made at 100-D reactor in which control logic similar to that used in the above simulation was carried out by the pile operator. Four of the six outlet temperatures normally recorded on a six-point recorder used by the pile operators were used to control four of the long control rods. The four temperatures used for control were chosen to represent temperatures near the four corners of the reactor (in the front face plane). The other two points represented the center sections of the reactor and, for the initial test, these temperatures were allowed to change in absolute magnitude as long as they were approximately equal. A half rod was moved if these two points tended to drift apart. Total power was allowed to drift within a predetermined dead band, but if the band limits were exceeded, the temperature setpoint was moved in 0.4°C steps as required to bring total power back within the limits.

Using this control philosophy, four different tests, each approximately two hours duration, were made on the 100-D reactor. Sampling periods of 48 and 96 seconds, and rod movements per sample of one-half and one inch were used. In each case stable operation was obtained and very few total power or half-rod corrections were necessary. For example, in the test using one-half inch rod movements and a one minute sampling period, neither type of correction (total power nor half-rod) was needed over the two and one-half hour test period. The tests using one inch rod movements yielded slightly larger deviations in power but the control was very stable. Additional reactor tests of this type, but including a larger number of control zones, are planned for the first week in April.

SEPARATIONS

Plutonium Critical Mass Facility

Further pre-startup tests, which need to be made on the solution system prior to commencing criticality experiments, are in progress. These tests were delayed during a portion of the month because of the late delivery of stainless steel valve replacement parts for the valves to the suction header in the mixing hood. The required valve parts were received on March 16, and following installation of these parts, the pre-startup check out of the solution system was begun.

The liquid level indicators of the storage and mixing tanks are currently being calibrated. The liquid level manometer for measuring solution levels in the critical assembly vessels is undergoing tests.

The fast addition pump for the critical assemblies and the transfer pump are working satisfactorily with one exception; there is too much leakage at the packing glands. The metering pump, for making small fuel additions to the critical assembly vessels, operated satisfactorily, but some difficulty was encountered in priming which has not been resolved.

Construction was begun on the mechanical components of the split half machine which will be used for the conduct of criticality experiments with PuO_2-plastic mixtures. The design of the electrical components for the machine has progressed slowly because of a lack of qualified personnel for this work.

Development of Nuclear Codes for Criticality Calculations

The modifications to the HISMC code (A Monte Carlo code to study the behavior of neutrons in homogeneous systems) have been completed. These modifications were described in the February monthly report. An initial run on the code with 100 histories indicated that the running time would be prohibitive. The sources of the time-consuming operations were determined from a comparison of the code before and after the modifications were made. Several programming changes were undertaken which should speed up the code considerably. The code is now ready to be reassembled.

The subroutines which were missing from the AIM-6 multi-group diffusion code, when received from Atomics International, have now been obtained. The AIM-6 multi-group diffusion code has several advantages over the 9-Zoom code, namely a criticality search option, and the fact that the code is written in Fortran, which makes modifications simpler.

Copies of two codes of major interest were recently received from Atomics International. These codes are: 1) TEMPEST and 2) FORM.

TEMPEST is a neutron thermalization code, written in Fortran for an IBM-709. This code will provide either microscopic or macroscopic cross section averages over the thermal neutron spectrum based upon the following: 1) Wigner-Wilkins approximation for light moderators, 2) Wilkins approximation for heavy moderators, and 3) a Maxwellian distribution.

FORM is the Fortran version of the MUFT-4 code, i.e., a Fourier transform slowing-down code. The code will generate a 54-group flux spectrum and provide up to 24 few group constants for a few group code.

Critical Mass Calculations for Homogeneous PuO_2-H_2O Systems

A series of critical mass calculations pertinent to nuclear safety were completed during the month. The systems considered were PuO_2-H_2O mixtures of various compositions. The PuO_2 was assumed to have a theoretical density of 11.46 gm/cc. The H_2O density was taken as 0.99 gm/cc. The compositions of the systems considered are listed in Table I. Pu-240 was considered in amounts of 5 and 10 percent of the total Pu for a range of H/Pu values in which the calculations were expected to give reasonably accurate predictions for the effect of Pu-240. Efforts to more accurately predict the effect of Pu-240 on criticality are continuing. Good agreement was obtained with experimental data in two regions of the curves. In the region of minimum critical mass, the values for the bare and reflected critical mass agree well with those predicted from the Hanford P-11 project data.

The points at H/Pu ratios of approximately 3000 are not well determined, since the convergence on the critical radii are slow and the H/Pu ratio of 3000 is near the minimum concentration which can be made critical ($\sim$8 gm Pu/L).

The critical masses and radii of bare and reflected spheres are given in Table II

TABLE I

Total PuO_2 (gm/cc)	Total Pu (gm/cc)	H/Pu	Atoms* Pu/cc	Molecule* H_2O/cc
11.46	10.107	0	.02546	0
10	8.816	.38	.0222	.004217
8	7.06	1.25	.0178	.009994
7	6.17	1.66	.0156	.01288
6	5.3	2.37	.0133	.01577
5	4.41	3.36	.0111	.01866
4	3.528	4.85	.00888	.02155
3	2.646	7.33	.00666	.02443
2	1.764	12.3	.00444	.02732
1	.8816	27.2	.00222	.03021
.5	.441	57.1	1.1107 (-3)	.03166
.25	.2205	117	5.5553 (-4)	.03238
.1	.0882	295	2.2214 (-4)	.03281
.075	.0662	395	1.666 (-4)	.03288
.05	.0441	594	1.1107 (-4)	.03296
.045	.0397	660	9.997 (-5)	.03297
.04	.0353	742	8.885 (-5)	.03298
.035	.0309	849	7.775 (-5)	.03300
.03	.0265	991	6.665 (-5)	.03301
.025	.0221	1189	5.555 (-5)	.03303
.02	.0175	1487	4.443 (-5)	.03304
.01	.00882	2977	2.221 (-5)	.03307

Note: The numbers in parentheses are the powers of 10 which multiply the given number.

* The numbers given are in units of 10^{24}.

[redacted]

TABLE II

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					6.7	12.74
.38	8.54	23					7.2	13.67
1.25	9.52	25.5						
1.66	10.0	25.9						
2.37	10.5	25.6						
3.36	10.8	24.5					8.8	12.58
4.85	11.7	23.5					9.1	11.06
7.33	12.2	20.0					9.5	9.56
12.3	13.1	16.5					10.2	7.80
27.2	14.5	11.2					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.

In the regions where the critical mass varies slowly with the H/Pu ratio, some estimate of the uncertainty in the calculations can be obtained. The uncertainty, which pertains only to the program and the convergence criterion selected, indicates that the critical masses are known to within about ± 2%. This could be improved at the expense of additional computing time.

Interaction of Subcritical Systems

Encouraging results have been obtained in the calculation of interaction of reflected subcritical systems by a variational method. While the absolute predictions of criticality conditions by this formulation are significantly in error, usually non-conservatively, relative predictions have been within one or two percent of "exact" calculations. These observations are based on the comparison of predictions of the approximation method with calculations of HFN for slab geometry. The quantity compared is the ratio ν'/ν'_0, where ν' is the number of neutrons per fission required to make the particular interacting configuration

critical and ν_o' is the number of neutrons per fission required to make any one of its (identical) units critical in isolation.

Preliminary determinations of this ratio as a function of slab thickness, fuel concentration, slab separation, and number of slabs have been made both by HFN and the approximation. Calculations of this ratio for interacting cylinders and spheres, by the approximation only, have also begun; comparisons to HFN cannot be made in these geometries except for the case of an isolated unit.

The variational formulation is based on two group diffusion theory and is compared with two-group calculations. The results thus evaluate the accuracy of the approximation to the two-group model, and not to actual criticality conditions. The accuracy of this latter comparison, which depends, in addition, on the values of cross sections and on the adequacy of two-group theory, has not yet been investigated.

Miscellaneous Experiments for Nuclear Safety Specifications

The experiment to determine the limiting critical concentration (concentration for which k_∞ = unity) of a plutonium nitrate solution was begun in the PCTR, but it became necessary to temporarily suspend the measurements because of a contamination incident on March 3.

At the time of the incident, a large buffer tank containing about 114 liters of solution was in position in the PCTR core. The contamination incident occurred when a small end buffer tank, which had developed a leak, was inserted in this larger buffer tank.

The contamination was detected when the physicist who inserted the tank checked his hands on leaving the reactor room; since this person was not wearing gloves when the tank was first touched (he had lifted the tank, and then remembering that gloves were to be worn, had set the tank down and put on his gloves), skin contamination was incurred on both hands. Decontamination of his hands was accomplished by RMO personnel; some articles of clothing were lost because of contamination.

The PCTR reactor room is in the process of being decontaminated by personnel of Experimental Reactors Operation. The rails, wooden platform, wooden beams, etc. (used in conjunction with the hydraulic lifting table to insert the large buffer tank into the reactor core), which were contaminated and discarded, are being replaced. The large buffer tank was removed from the PCTR core and easily decontaminated by personnel of Critical Mass Physics; this tank has been sent to the 234-5 Building for inspection. The smaller tanks, which were more highly contaminated, were sent to the 231-Z Building for decontamination by personnel of Plutonium Metallurgy Research; the decontamination process has proceeded without difficulty.

The contamination resulted because of both faulty construction and improper O-ring designs on the sealing plugs and end cap enclosures of the tanks. The tank and jacket design indicated three separate leak seals: An O-ring under the filling plug, another O-ring under the cap that covered the filling plug assembly, and a taped seal around the joint where the jacket top overlapped the jacket bottom. The first O-ring did not seal completely because of improper

fabrication of the plug; the second O-ring did not seal properly either because of incorrect design or choice of O-ring material; and the taped seal around the two parts of the jacket either failed to stand up to pressure buildup in the container, or to the relatively large amounts of liquid present between the jacket and the tank wall. Modifications are being made in the end cap enclosure designs, and other considerations being made, to correct defects in the over-all sealing of these tanks.

It now appears that the k_∞ measurements, which were completed last month with the aqueous U-235 solutions, will have to be repeated. The purpose of the experiment was to determine the U-235 concentration for which k_∞ = unity in an aqueous solution. The experiment had been performed with 93% enriched UO_2F_2 sclution contained in aluminum tanks. On completion of the measurements, when the tanks were being emptied, it was noted that a reaction had taken place between the UO_2F_2 solution and the aluminum walls of the tanks. A layer of some insoluble uranium compound was deposited on the tank walls. The results of subsequent chemical analyses showed the U concentration to have been unduly lowered by this process.

Since there is no way of knowing the exact concentrations at the time reactivity measurements were made, the experimental data are not reliable, and it will be necessary to repeat the experiment.

The reaction between the solution and tank walls was not anticipated because no such reaction was observed when test strips of aluminum had been immersed in the UO_2F_2 solution prior to filling these tanks.

The experiment will not be repeated until the above difficulty has been resolved.

Criticality Hazards Specifications

Nuclear Safety in HLO

A meeting was held with Fuel Fabrication Development Operation personnel to discuss nuclear safety in the 306 Building. The main items discussed were 1) the basis of the nuclear safety limits in specifications F-1 and F-2, 2) the safe handling of 3% U-235 enriched uranium, and 3) the limits proposed for the future handling of 93% U-235 enriched uranium.

The nuclear safety of processing UO_2-0.5 w/o PuO_2 in the 308 Building was discussed with Plutonium Fuels Development Operation personnel. Each part of the process was reviewed and limits suggested for the nuclear safety specifications. It was pointed out that since there was no criticality data available for UO_2-PuO_2 systems, nuclear safety would be based on data for slightly enriched uranium by estimating an equivalent enrichment for the oxide mixture. In the case of UO_2-0.5 w/o PuO_2, the equivalent enrichment is estimated to be about 1.5% U-235.

A meeting of the Hot Semi Works Safety Council was attended to review the Sr 90 program. The crude feed material will come from the 224CR tank farm and will contain no plutonium, consequently, there is no nuclear safety hazard in the process.

A meeting was held with Chemical Engineering Development personnel to discuss the nuclear safety aspects of a molten salt process that may be used for the recovery of PuO_2 from irradiated PRTR fuel elements. After decladding, the UO_2-PuO_2 would be dissolved in a molten salt mixture and the PuO_2 deposited on electrodes. The PuO_2, in the form of fine crystals, would then be removed from the electrodes in a water bath. For nuclear safety, both geometry control and batch control would be used in the process. The molten salt will be treated as an unmoderated system and the removal of PuO_2 in the water, as a moderated system.

Evaluation for Nuclear Materials Operation

The nuclear safety of a 500 gram plutonium metal shipment to Pennsylvania was reviewed and approved.

Mass Spectrometry

The new ion source for the heavy element mass spectrometer for this program was installed in the spectrometer. Some of the operating characteristics of the new source, which is a modification of the original, were examined. The modifications to the original design provide for improved electrical insulation between electrodes and an increased spacing of the focusing electrodes of the ion optical system. It appears that the improved interelectrode insulation has reduced leakage of the accelerating potential to a negligible level. Measurements have also shown that ions from the source are monoenergetic to a degree which is consistent with the geometric collimation of the source slits. Thus the spread in ion energies encountered in the original source appear to have been eliminated by the new design of the focusing electrodes which was intended to reduce the interaction of ions with the electrode structure.

Further comparisons were also made on sample lifetimes which are experienced with different shapes of filaments. The filament design reported last month in which the portion of the filament containing the sample is not heated directly by ohmic heat continued to give useable sample lifetimes significantly longer than directly heated sample filaments.

Several operating days were spent in correcting malfunctions of the ion current measuring and recording system and the magnetic sweep system.

Two measurements of the isotopic content of natural uranium were made to verify the performance of the spectrometer. The results of these measurements indicated a systematic error in mass ratio. The source of this difficulty has not been discovered as yet.

Instrumentation and Control

Technical support to CPD continued in efforts to stabilize the servo systems on six tracer lathes. The new lathes were delivered by the manufacturer presumably in operating condition but when assembled it was found they would not maintain the required tolerance. The tracer lathe is designed to automatically produce a machined part by allowing a metal stylus to trace a contoured pattern. Movement of the stylus is amplified and transmitted to the cutting tool as the tool is moved along the part being fabricated.

Operation was satisfactory at normal machine shop tolerance but not at the closer tolerance required for this application. Any attempts to improve the accuracy by increasing the servo system gain resulted in oscillation. Tests were run on the system components to obtain frequency response data. Results to date indicate that a combination of troubles may be causing the difficulty. These include the following: 1) excess phase shift in the servo-valve driver amplifier, 2) servo-valve sticking, 3) excessively long lines between the servo-valve and the drive piston, 4) pressure pulses from the hydraulic pump, 5) excessive 60 cycle and noise pickup in the electronics, and 6) dynamically unbalanced stylus head.

Attempts have been made to correct some of the above conditions. They include the following: 1) a new servo-valve driver amplifier was installed, 2) a "dither" signal was injected into the servo-valve to prevent sticking, 3) the servo-valve was mounted directly on the piston, 4) an accumulator was installed to damp out hydraulic pulsations, 5) a ripple-free power supply was installed on the electronics, and 6) the stylus head was dynamically balanced. In addition to the above correction measures, a number of networks were connected in the electronics. These were designed to add a leading or lagging phase component to the over-all system response. The most successful of these has been a lag network that decreases the high frequency response starting at about ten cycles per second. With this it is possible to increase the gain to a point where the static accuracy of the tracer system is well within the requirements. The speed of response, however, is too slow. Different network combinations will be tried in the near future.

NEUTRON CROSS SECTION PROGRAM

Evaluation of the Cross Sections of the Fissile Nuclides

A survey is being made of the status of the low energy cross sections and fission parameters of the important fissile nuclides U^{233}, U^{235}, and Pu^{239}. All of the recent experimental results have been compiled and reviewed. The most interesting result to date has been the consistency of correlated experiments on U^{233} and U^{235}. For each of these nuclides the following procedure is used: The absorption cross section is derived from the best value of total cross section measurements and estimated scattering cross sections. Best values of alpha are obtained from experimental determination in reactor spectra and in addition, from monoenergetic measurements for U^{235}. This step is deemed appropriate because of the small effects of neutron spectra distortions on U^{233} and U^{235} cross sections. The best values of eta as determined experimentally for each nuclide are also accepted. This step is indicated by the small effects of spectral distortion and the excellent consistency of absolute determinations of eta for U^{233} and U^{235} with the results of determinations of the ratio of etas for U^{235} and U^{233}. With the input values of absorption cross section, alpha, and eta the other neutron parameters are derived. The most important derived quantities are the fission cross sections and $\bar{\nu}$. These quantities are in excellent agreement (0.5 percent or better) with the best measured values of the ratio of fission cross sections, with the ratio of $\bar{\nu}$, and with the absolute value of $\bar{\nu}$. The only discrepant parameters are the absolute fission cross sections. The disagreement with the U^{235} fission cross section is not disturbing because of the large discrepancies among individual measurements. The discrepancy with the only precision measurement of the U^{233} fission cross section is 1.5 percent. The best values obtained in this analysis for U^{233} and

U^{235} are tabulated as follows:

	2200 m/s Neutron Parameters	
	U^{233}	U^{235}
$\sigma_{n,T}$	587 ± 3	694 ± 4
$\sigma_{n,n}$	12 ± 3	16 ± 3
$\sigma_{n,x}$	575 ± 4	678 ± 5
Alpha	0.00935 ± 0.0038	0.172 ± 0.007
$\sigma_{n,\gamma}$	49 ± 2	99 ± 4
Eta	2.288 ± 0.010	2.077 ± 0.010
Nu	2.502 ± 0.014	2.434 ± 0.019
$\sigma_{n,f}$	526 ± 4	579 ± 6
$g_a = g_f =$	1.0000	g_a, g_f, g_η from CRRP-960

The parameters for Pu^{239} cannot be treated in the same manner, however, because there are no precision measurements of alpha. There is a recent precision measurement of the total cross section by Safford, et al., of 1018 ± 6 barns. The best value of $\sigma_{n,x}$ is found to be 1008 ± 6 barns. Best values have been determined for the ratios of fission cross section, eta, and nu of Pu^{239} and U^{235}. These three parameters plus the absorption cross section and the best values obtained for U^{235} overdetermine the parameters for Pu^{239}. The resultant set of parameters: eta, nu, and fission cross section are discrepant to about four percent although the assigned precisions are 1.0 to 1.7 percent. No reason for the discrepancy has been found. Experiments are in progress elsewhere to redetermine eta and nu for Pu^{239} with high precision but the results of these measurements will not be available for a matter of months.

Slow Neutron Cross Sections

Preparations were made to undertake measurements on two problems. The first is a remeasurement of the Pu^{239} fission cross section in the vicinity of the 0.3 ev resonance. The second is an absolute measurement of the fission cross section. A new set of fission foils was mounted in the fission chamber and excellent fission pulse height distributions were obtained. Measurements of spontaneous fission rate were also obtained for use later in evaluating the absolute fission cross section.

During the course of measurements on the crystal spectrometer it was discovered that the neutron beam intensity had again fallen to a low value. Subsequent investigation during a reactor outage showed further deterioration of the masonite sections of a beam defining plug in the reactor shielding. The masonite powder which was obstructing the neutron beam was removed. The same problem was encountered in December, 1960. The frequent occurrence of this trouble indicates

that an effort is necessary to attempt to replace or modify the rapidly deteriorating plug which has been in use for seven years.

Instrumentation

Detail design of the 1000-channel slow neutron time-of-flight analyzer has progressed to the point where all necessary equipment has been specified and submitted for purchasing. A design change was made to allow storage and arithmetic functions to exist in binary coded decimal form rather than in straight binary. While this complicates the design somewhat, the readout is much more direct and understandable to operators.

Fast Neutron Cross Sections

Analysis of the background measurements made on the time-of-flight system in February has been completed, and several long-standing misconceptions refuted. Under roughly typical circumstances, 3/4 of the asynchronous background originates in the pulsed beam striking the target. It is thus no different in nature from that encountered in unpulsed operation. There does not seem to be any synchronous background.

As a function of distance from the target, the background not associated with the target burst is virtually constant; the measurements do not clarify its composition. Three-fourths of the burst-associated background close to the target is due to neutrons of energy greater than 1.3 Mev. At greater distances the average energy of the neutron component decreases rapidly, while the gamma-ray background of equivalent pulse-height in stilbene remains nearly constant. The gross pulse-height spectrum begins to "harden" again as the rear wall of the experimental area is approached.

The new time-mark generator has been installed and debugged. Its performance is now quite satisfactory. The problems revealed in the event-identification side channel of the chronotron during the February run are being attacked simultaneously by new circuitry. A breadboard version has been built but not tested. Pickup from the RF deflection oscillator was studied with a tuned search coil. Efforts to reduce the energy radiated from the oscillator were largely unsuccessful, but the parasitic signal traveling on the shield of the signal cable to the chronotron was reduced by a factor greater than 100 by rearrangement and better grounding of components.

Slow Neutron Scattering Cross Sections

The series of slow neutron scattering measurements at 0.2 ev incident energy has continued. Energy analysis runs have been made for the 30 mil thick, room temperature water sample at scattering angles of 10, 30, 50, and 72 degrees. An angular distribution run for the empty sample holder was made at 0.1 ev final energy.

A short series of isolated measurements on water at various initial and final energies and scattering angles is in progress 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. Knowledge of this sensitivity will make it possible to convert some of the raw counting data into an unnormalized differential scattering cross

section $\frac{d^2S}{d\Omega dE}$. In order to detect systematic errors in the calibration, a reasonably large amount of overdetermination has been provided for.

A germanium single crystal, 3 inches long and 2 inches in diameter, has been purchased for evaluation as a neutron monochromator. Preliminary neutron measurements to establish crystal orientation indicates a narrow mosaic width but possibly a slightly multiple crystal. Germanium is an attractive crystal for use as a neutron monochromator because it possesses diffracting planes for which second order reflections are forbidden. A germanium single crystal which meets the requirements of resolution and reflection efficiency could be used to extend the range of measurements of the crystal spectrometer to energy regions where second order reflections are a problem.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

The Critical Facility of the PRP

A purchase requisition for a Pu-Be source which will be used in the Critical Facility has been initiated. It is planned to write a requisition for two scalers and a signal generator to be used as an electronic timer. The initiation of this requisition is pending the results of tests which are being conducted by Nucleonics Instrumentation on a transistorized system.

Revisions have been suggested for incorporation in the description of the MTR-RMF experiment.

The Advanced Reactivity Measuring Facility (ARMF) is in operation now and in all probability the MTR-RMF experiment will use the ARMF instead of the RMF. Calibration experiments conducted by Phillips personnel indicate that the ARMF is $\sim$10 times more sensitive ($\sim 10^{-7} \frac{\Delta k}{k}$ than the RMF. In addition, the largest ratio possible between the sensitivies for fissionable materials and "poisons" in two positions of the ARMF is $\sim$33% larger than that which could be obtained in the RMF.

PRTR Startup

The data from one set of gold foils which was activated in a PRTR Critical Test show more scatter than would be expected from statistics. These foils were normalized on the rotator in the TTR to determine if the scatter was caused by something inherent in the foils. Analysis of the data from the normalization show that this is not the case.

Plutonium Fuel Temperature Coefficients

Plans are under way to make a measurement of the fuel temperature coefficient of k_∞ for both high (16% Pu-240) and low exposure Pu-Al 19-rod clusters. The measurements will be made using low exposure buffer cells in both cases.

Specifications for these clusters have been submitted to personnel of Plutonium Fuels Development Operation for cost estimates.

Pu-240 Effective Resonance Integral

Further work has been done in planning the measurements of the effective resonance integral of Pu-240 as a function of Pu-240 content in Pu-Al rods. An approximate analysis of the expected errors indicates that a useful experiment can be done if the quantity of plutonium in each rod can be carefully controlled. The experiment is much more sensitive to this than it is to the homogeneity of the Pu-Al mixture.

Specifications for Pu-Al rods with both high (16% Pu-240) and low exposure plutonium have been submitted to personnel of Plutonium Fuels Development Operation for cost estimates.

Neutron Rethermalization in Graphite and Light Water

In February it was reported that the two thermal group diffusion model of rethermalization was generally valid for graphite and water. This conclusion was based upon the agreement between calculated and observed traverses of the thermal activity of Lu-177 (activated Lu-176) for four independent experiments. This past month five additional experiments have been analyzed and the results support the earlier conclusion. The new results do, however, reduce the average agreement for all experiments from 5-10% to approximately 10-15%. The Westcott model of the neutron spectrum yields the agreement quoted. Contary to the result from a single experiment reported last month the "Hurwitz model" of the neutron spectrum does not improve the agreement in all experiments and in fact for some experiments it makes it worse.

A complete report on this work is being prepared and will be submitted for inclusion in January, February, March, 1961, Nuclear Physics Research Quarterly Report.

Average Energy of Diffusion of Thermal Neutrons in Graphite

In the report "The Two-Group Approach for a System with Temperature Discontinuities" by C. W. Lindenmier (HW-68389) the average energy of diffusion of thermal neutrons is defined as

$$E_{Dn} = \frac{\int E\, D(E)\, X_n(E)\, dE}{\int D(E)\, X_n(E)\, dE} = \frac{\overline{ED}_n}{\overline{D}_n}$$

where D(E) is the energy dependent diffusion coefficient of the moderator at the moderator temperature, Tg, and $X_n(E)$ is the energy distribution of equilibrium thermal neutrons at Tn. Values of $\overline{D}_n(Tg, Tn)$ were calculated for graphite (RLPO, Monthly Report, July, 1960) assuming $X_n(E)$ to be a Maxwellian. This past month the corresponding values of $\overline{ED}_n(Tg, Tn)$ were calculated for graphite. The values of E_{Dn} obtained from $\overline{ED}_n(Tg, Tn)$ and $\overline{D}_n(Tg, Tn)$ are given in Table I. The values of E_{Dn} for the case of a constant diffusion coefficient are $2kT_n$, given in Table I also.

TABLE I

E_{Dn} and $2kT_n$ in (ev) x 10^{-2}

	Tn(°K)				
	100	144	300	478	720
Tg					
100	1.23	2.02	4.79	7.83	12.19
144	1.35	2.14	4.85	7.88	12.21
300	1.50	2.27	4.94	7.93	12.25
478	1.57	2.34	4.98	7.96	12.27
720	1.61	2.38	5.00	7.97	12.28
$2kT_n$	1.72	2.48	5.17	8.24	12.41

The application of these data to rethermalization cross section measurements in graphite may lead to corrections to the rethermalization cross sections of -4% at 144°K to zero percent at 720°K. A complete evaluation of this effect is being planned.

Rethermalization in Graphite Near Absorbing Rods

The experimental apparatus for these experiments has been designed and is scheduled for fabrication by Tech Shops. Copper cylinders 5-5/16 inches and 1-1/2 inches in diameter will be used. The purity of the copper is in excess of 99.9% and contains no objectionable impurities. The flux depressions in the rods, as calculated from simple diffusion theory, will be 97.5% and 33%, respectively.

Traverses of the bare and cadmium covered activities of Cu and Lu in the copper rods and graphite have been provided for in the design of the experimental apparatus. The cu traverses will be made with 0.0625-inch by 1/2-inch pins in the large Cu rod and with 0.032-inch by 1/2-inch pins in the small rod. The Lu traverses in the rods will be made with Lu-resin pins of approximately the same dimensions as the Cu pins. Lutetium oxide-aluminum oxide foils and large Cu pins will be used in the graphite traverses. Calibration detectors will be used where necessary for normalization of traverses made with detectors of different geometries.

Foils of Cu and Lu will be irradiated at the Cu-graphite interface with either the inward or outward flux. Cadmium shields will be used on one side of the detectors and edge effects will be investigated with various shapes of cadmium shields.

A method of determining the rethermalization cross section of a heated light metal rod, such as aluminum, in a graphite core in the PCTR is being studied. This cross section could be used to calculate the magnitude of the shift in the neutron spectrum in a hot fuel element, such as Pu-Al. The method requires only reactivity measurements as experimental data. The three-group (one fast, two-thermal) equations for the neutron flux inside the rod are solved. The reactivity effects of a suitable absorber, such as gold, at the surface of the rod and on the center line are then used as boundary conditions to evaluate the constants appearing in the solutions. The change in the reactivity of the PCTR as the rod is heated is then interpreted in terms of the rethermalization cross section. The sensitivity one might expect from such an experiment is currently being studied.

A modification of the Hurwitz spectrum for a weak v^{-1} absorber has been derived to include neutron leakage in the case of small constant buckling. The resulting flux is a linear combination of three functions of energy: A Maxwellian, the Hurwitz correction for a weak absorber, and the derived leakage correction. Since in this approximation the degree of absorption and buckling enter only in determining the weight coefficients of the three functions, the fluxes for a variety of cases can be obtained directly from the three functions.

Lutetium Pins

In support of the absorbing-rod experiments, a method has been developed for fabricating lutetium oxide-resin pins for use at room temperature. Pins 0.031 inch by 0.500 inch and 0.062 inch by 0.500 inch have been made. The average variation in weight of 150 large pins was found to be approximately ± 1%. This variation is in part due to air bubbles introduced in the mixing of the lutetium oxide and resin. Calibration by activation will be necessary unless this variation is reduced and air bubbles eliminated. It has been demonstrated that this technique can be extended to other materials; sodium carbonate-resin pins and foils have been made.

A brief description of these techniques will be submitted for inclusion in the January, February, March, 1961 NPRO Quarterly Report.

Some difficulty is anticipated in the use of resin as a matrix material because of its moderating effect. The resin is a hydrocarbon. In an attempt to evaluate the resin, pure resin pins and Lu_3O_2-resin pins have been irradiated for 3000 watt-minutes in the TTR. The resin pins were counted. The observed counting rates did not differ significantly from natural room background for a 10 minute count. The Lu_3O_2-resin pins have been counted and the data is being analyzed.

Even in the presence of this potential moderating effect it can be shown that unperturbed thermal activities may be inferred from bare and cadmium covered activities, although epicadmium activities cannot be determined in principle.

Analysis of Uranium Oxide Fuel Temperature Coefficient

Part of the data which was obtained previously from PCTR measurements of the fuel temperature coefficient of an enriched uranium oxide cluster has been reanalyzed. In this latter analysis a function which is predicted by theory is fit to the experimental points. The derivative of the function gives the

temperature coefficient of the resonance escape probability

$$\frac{1}{P(T)}\frac{dP(T)}{dT} = AT^{-1/2}_{(°K)}.$$

In the previous analysis this coefficient was expressed as

$$\frac{1}{P(T)}\frac{dP(T)}{dT} = C_o + C_1T(°C).$$

Data were obtained for two heating runs that differed only in the time required to reach the maximum fuel temperature attained. The data from the 42-minute heating cycle fits an equation of the form

$$\ln P(T) - \ln P(T_o) = (23.67 \pm 0.20) \times 10^{-3} - (1.33 \pm 0.01) \times 10^{-3} \sqrt{T\ (°K)}$$

for temperatures between 322 and 767°K. Thus

$$\frac{1}{P(T)}\frac{dP(T)}{dT} = \frac{1}{k_\infty(T)}\frac{dk_\infty(T)}{dT} = -(6.63 \pm 0.05) \times 10^{-4}\ T^{-1/2}_{(°K)}.$$

The results may also be expressed in terms of the temperature coefficient of the effective resonance integral, $\Sigma(T)$. This coefficient is

$$\frac{1}{\Sigma(T)}\frac{d\Sigma(T)}{dT} = \frac{1}{2\left[T\ (°K) + (128 \pm 6)\sqrt{T\ (°K)}\right]}$$

over the same temperature range.

The uncertainties which are attached to the numerical values reflect how well the chosen function fits the data.

Code Development

RBU

The graphite lattice cell calculation was run through an entire time step, using all parts of RBU, at the beginning of the month. Discrepancies in the U-238 cross section and in the thermalization tables describing the thermal motion of the moderator atoms were noted and corrected. A finer energy group structure was set up to improve the self-shielding of U-238 resonances, for those runs in which the resonance tables are not used. A second simple problem was run to determine the time required to establish good thermal spectrum convergence in a uniform moderator region. Results are not complete, but a fairly good Maxwellian distribution was established in about five minutes. Longer running times would be required for most problems. The Post-Monte Carlo has been further modified to accept cases in which not all macroscopic cells contain flux tallies. The final report (preliminary draft) is nearly complete.

The cross section library edit routine was completed, and copies of the library listing were being prepared for distribution at the end of the month. Several errors in the library were detected and corrected, and the inelastic spectrum tables and evaporation constants were changed from velocity to energy units.

Complete listings of the SOS system tape were prepared by Data Processing personnel. The system has reached the point where it can be recommended for routine scientific programming use, being for many jobs preferable to the FORTRAN-FAP system.

MELEAGER Code Applications

The description of the code, HW-68100, was distributed in rough draft form. Cases were set up for the supercritical-water reactor study, conforming to the results of lattice analysis by the IDIOT code, and for MTR plutonium irradiation samples (PHOENIX fuel study). The repeat calculations for APWR were started.

C-6

Debugging of the Hanford version of C-6 started during the month, and a number of errors have been corrected. Two of these errors existed in the program when it was received from ANPD. The program has run largely successfully on several test cases using ANPD 18-group cross sections. Several modifications are still needed to make the program use the 100-group cross section tape properly.

Miscellaneous Developments

French methods of treating neutron-spectrum and effective cross section problems were extensively reviewed, with a view to adoption of similar procedures in our own work. The theory of the Hanford code "FLUX WEIGHT" was also reviewed. PRT critical test results are mostly in good agreement with predictions of this code but some questions concerning its formulation are as yet unresolved.

Instrumentation and Systems Studies

Experiments were conducted on the thermostat portion of the PRPCF "last ditch" safety fuse using a heater. It was determined that the over-all response time will be limited by the thermal response time of the thermostat. The minimum closing time was determined to be 1.2 seconds. This time of closure permits 0.4 seconds for poison injection for a 100 millisecond period and 4 seconds for a 500 millisecond period from a starting point of 10^6 nv for "normal" neutron flux. The necessary enriched uranium for final prototype fabrication is on order.

Several additional fuel rods containing PuO_2 and UO_2 were received and investigated concerning the development of methods for detecting PuO_2 segregation. One rod contained a PuO_2 concentration imperfection 20 times "normal" and this was readily apparent from the gamma spectra tests. Six- and four-times-"normal" concentration imperfections also were readily detected. The last rod contained a two-times-"normal" imperfection which was not determined by regular gamma scanning; however, by using a subtraction process on the 200-channel analyzer, this imperfection was located. It appears that detection of a concentration imperfection of two times "normal" is about the limit via gamma scanning methods; whereas Plutonium Metallurgy wishes to detect concentration variations of as little as five percent from "normal". Other methods for such sensitivity are being sought.

Work has started concerning the testing of the PRTR Fuel Failure Monitor, and

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which is that of matching power generation to coolant flow.

The need of better working computer codes and of better knowledge of the effective resonance integral of thorium in graphite as a function of temperature and concentration were made very evident during this work.

NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

Two adjustable summing networks were constructed for use in the analyzer section of the broadband eddy current test equipment. One network will be used in an attempt to give independent readout of test specimen parameters. The second network will serve to read out test specimen relative electrical conductivity as a function of depth below the surface. Successful performance of the latter, coupled with the inductive thermometry principle will make possible relative measurements of sub-surface temperature gradients of metals. The design of a segmental time reversal device was firmed and parts ordered.

The first summing network will be used to combine the vector components of the signal in an attempt to give independent readout of test specimen parameters.

This network has provision for six input signals and provides two output signals representing different combinations of the input signals. It accepts the outputs of the six-channel orthogonal filter and time domain sampler which represent the selected orthogonal exponential components of the signal, and forms two new signals from linear combinations of the input signals. Corresponding non-linear circuits will be added as required.

The second summing network comprises a single input channel feeding five parallel high-pass filter channels each having a different cut-off frequency. The filters each drive a rectifier circuit having adjustable output level, and provision is made to obtain the sum or difference of the outputs of the adjacent rectifier channels. Thus the input of the network consists of a single broadband signal, and the output consists of four signals representing the difference or sum of the adjacent channel amplitudes.

Two electric delay lines were ordered for use in the segmental time reversal device to be used ahead of the orthogonal filter. The lines each have a total delay of 100 microseconds and are provided with 100 taps at 1 microsecond intervals.

An informal report titled "Segmental Time Reversal Device", HW-68952, was written, issued, and submitted as a joint invention report by H. L. Libby and J. T. Russell.

Heat Transfer Tests

Tests have shown that the infrared detector output signals produced by circular bond defects in aluminum clad uranium fuel elements during heat transfer testing are approximately linearly dependent upon power input. Heat transfer testing equipment using a plasma arc heat source has been assembled. Mica-produced voids 1/2, 3/8, and 1/4 inch in diameter were detected with an inductive thermometer used in conjunction with a plasma jet heat source.

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Heat transfer tests of aluminum clad uranium fuel elements are presently being made by scanning the outer surface with a single turn induction coil heat source, and an infrared radiometer which senses temperatures distributed over a 1/8-inch-diameter field of view. Surface temperatures over fuel cladding to core heat transfer defects are higher during the test, due to their higher heat impedance, than the surface temperatures of surrounding regions. Tests have indicated that this ΔT increases approximately linearly with increasing power over circular defects.

Several apparent heat transfer defects have been found in type K-IV-N fuel elements which had passed production ultrasonic tests. The apparent defects were near the limit of sensitivity of the present heat transfer testing apparatus; no gross defects were found. These small indications were possibly due to variations in surface emissivity. Comparison of ultrasonic maps of these fuel elements with heat transfer testing maps has shown that ultrasonic defects were not always located in the same region as the apparent heat transfer defects.

Infrared band pass filters for use in development of an emissivity-independent high speed infrared radiometer have been ordered. An initial band pass of wavelengths between 4.5 and 5.0 microns will be used.

Heat transfer testing equipment using a plasma arc heat source has been assembled. Preliminary tests of this equipment using fuel elements with known defects have been completed.

Good results have been obtained using an inductive (eddy current) thermometer in conjunction with the plasma jet heat source in the detection of circular mica-produced voids in fuel elements. Such circular voids 1/2, 3/8, and 1/4 inch in diameter were detected in two different specimens with good signal-to-noise ratios for all three sizes of defects. The fabricated 1/8-inch defects were not detected. Correlation tests are being made on a group of fuel elements which have been tested previously by both infrared heat transfer and ultrasonic test methods.

The inductive thermometer being used in these tests comprises a vacuum-tube self-excited oscillator followed by a detector and amplifier. The plasma jet was operated at about 11 KW power to the arc. Possible effect of the plasma jet on surface corrosion characteristics will be investigated.

A 50 KW, 10 KC induction heater has been obtained to provide a heat transfer tester for immediate application and further evaluation of existing techniques. This will make prototype equipment available for development of new techniques. Arrangements for locating this equipment in the 314 Building have been completed.

Zirconium Hydride Detection

A new program has been initiated to evaluate nondestructive methods for determining the concentration of hydrogen in Zircaloy. There is evidence that hydriding of Zircaloy reactor process tubes could result in structural failures due to hydrogen embrittlement of the zirconium. Because of this and the increasing use of Zircaloy in process tubes, an investigation into possible methods of nondestructive monitoring of hydride concentration has been initiated. Also there is need for a rapid method of measuring hydrogen concentration in a large number of small Zircaloy control samples presently being used in studies aimed

at reducing hydrogen absorption in Zircaloy.

Hydrogen concentrations of interest in Zircaloy samples range from a minimum concentration of 50 ppm by weight to about 1000 ppm. A measurement accuracy of 10-20 percent would be useful. Even relatively inexact in-reactor measurements of hydrogen content in Zircaloy process tubes would be of value.

Two possible methods of hydride detection and measurement are being studied. The first method utilizes fast neutron scattering and the second, Hall Effect measurements. The fast neutron scattering method should be applicable to ex-reactor measurements, whereas the Hall voltage method would be more amenable to in-reactor measurements because of the high neutron background present.

Fast neutron scattering is being given immediate attention, and preliminary scattering measurements are scheduled at the Van de Graaff generator for the first week in April. Fourteen-Mev neutrons will be obtained from the $H^3(d,n)He^4$ reaction using the Van de Graaff generator. The hydrogen concentration can be measured by detection of the number of neutrons scattered from the hydrogen nuclei contained in the Zircaloy sample. Neutrons scattered from the hydrogen have less energy than those scattered from zirconium and thus can be identified. The scattered neutrons will be detected with a LiI scintillation counter and a multichannel pulse height analyzer.

In initial tests, shielding requirements, signal-to-background ratio measurements, resolution of scattered neutron energies, and sensitivity to hydrogen concentration will be determined.

A survey of the literature has revealed no quantitative studies of the effect of low hydrogen concentration on Hall coefficient. Initially the measuring technique will use a permanent magnet, whose field strength is approximately five kilogauss, and a 100-cps alternating current through the sample. The Hall voltage will be measured using the three contact method in conjunction with a narrow bandwidth, high gain, low noise amplifier. The Hall voltage can then be read with an a-c voltmeter. Preliminary calculations indicate the Hall voltage will be in the order of 1 to 2 microvolts. A magnet has been obtained and a sample holder is being fabricated for these studies.

NEUTRON FLUX MONITORS

The study on extended lifetime neutron detectors for in-core flux monitoring in high power reactors proceeded with further computations regarding the application of "breeder" concepts to alleviate burnout problems. Compared to conventional U-235 detectors, plutonium isotope combinations have been found which offer practical extensions of the sensitivity lifetime with little, if any, sacrifice in initial neutron sensitivity. Plutonium and uranium combinations offer greatly extended sensitivity lifetimes but with reduced sensitivity. However, the sensitivity still may be sufficient to give a useful neutron-to-gamma discrimination ratio in some applications. Both types have been considered for several different reactor environments. Arrangements are being made for experimental work to test and demonstrate the validity of the computations.

The potential in-reactor detector environments which have been considered to date are tabulated below in Table I:

TABLE I

Description of Possible Detector Environments

Location	Water Jacket Surrounding Loaded Fuel Element	In Graphite	Air Pocket in Water Annulus	Centered in Water-Filled Process Tube
Neutron Spectrum	Hard	Well Moderated	Soft	Maxwellian
Westcott "r" Values				
r ave	0.075	0.03	0.02	0
r max	0.085	*	*	*
r min	0.065	*	*	*
Flux				
ø ave	5×10^{13} nv	1×10^{14}	1.5×10^{14}	2×10^{14}
ø max	1×10^{14} nv	*	*	*
ø min	1×10^{13} nv	*	*	*
Effective Neutron Temperature				
T ave	625°C	600°C	350°C	150°C
T max	1000°C+	*	*	*
T min	425°C	*	*	*

* = Variations in neutron spectrum not determined to date.
\+ = Not yet examined.

In one class of detectors examined, fissionable Pu-241 is generated to replace the burnout of Pu-239. The characteristics of the initial compositions examined to date which give the least sensitivity change over four months of irradiation are listed in Table II. Data on U-235 for comparison are listed also.

TABLE II

Extended Lifetime Detector Characteristics (Best Cases to Date)

Location	Water Jacket Around Fuel	In Graphite	Air Pocket in Water Annulus	Centered in Water Filled Process Tube
Initial Detector Composition				
Pu-239	40%	20%	12.6%	8.7%
Pu-240	60%	80%	84.3%	87.0%
Pu-241	--	--	3.1%	4.3%
Westcott σ fission (barns)				
U-235	531	524	538	550
Pu-239	1381	1598	1171	875
Pu-241	1500	1633	1373	1155
Initial Sensitivity* (Fissions/mg/sec/nv)	1.39×10^{-3}	8.03×10^{-4}	4.79×10^{-4}	3.17×10^{-4}
Sensitivity Deviation During 4 Months Exposure	± 5.4%	± 9%	± 14%	± 11.6%
U-235 Burnout in 4 Months	29%(477°C)	50%	65%	75%
U-235 Initial Sensitivity (Fissions/mg/sec/nv)	1.37×10^{-3}	1.37×10^{-3}	1.37×10^{-3}	1.37×10^{-3}

* This does not reflect detector optimization since the sensitivity can be changed by varying the detector coating thickness (mg/cm^2).

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The detector lifetime can be greatly prolonged by reducing the total fission cross-section. Best cases to date for this class of detectors are listed in Table III for a 24-month irradiation.

TABLE III

Very Long Lifetime Detector Characteristics (Best Cases to Date)

Location	Water Jacket Around Fuel	In Graphite	Air Pocket in Water Annulus	Centered in Water Filled Process Tube
Initial Detector Compositions				
U-238	96.59%	99%	99%	No solution to date.
Pu-239	1.96%	1%	1%	
Pu-240	0.98%	-	-	
Pu-241	0.47%	-	-	
Westcott σ fission (barns)				
Pu-239	1381	1598	1171	875
Pu-241	1500	1633	1373	1155
Initial Sensitivity* (Fissions/mg/sec/nv)	8.69×10^{-5}	4.04×10^{-5}	3.97×10^{-5}	--
Sensitivity Deviation During 24 Months	± 3.2%	± 6.8%	± 4%	--
U-235 Burnout in 24 Months	86%	98%	99.7%(400°C)	99.97%
U-235 Initial Sensitivity (Fissions/mg/sec/nv)	1.37×10^{-3}	1.37×10^{-3}	1.37×10^{-3}	1.37×10^{-3}

* This does not reflect detector optimization since the sensitivity can be changed by varying the detector coating thickness (mg/cm^2).

Arrangements are being made concerning the experimental fabrication of fissile detector material in the form of a carbide for coating chamber walls. Arrangements also are being made for irradiations in a 100-K reactor for both short and long exposures. For fissile material in the form of foils, measurements will be made before and after irradiation to determine the change with exposure. Several calibration and measurement methods are being considered. Possible experiments in which the detector sensitivity will be continuously monitored during irradiation also are being investigated. Mechanical limitations may preclude this latter approach in the K test hole facilities. However, it may be

possible to use the foil in a conventional in-core flux chamber within a process tube. While the primary present objective is the development of optimum detector compositions, the ultimate success of practical flux monitors also depends largely on successful chamber-cable assemblies which are under development by various manufacturers.

Experimental studies on the new ideas for using microwave techniques for in-core flux monitoring are still awaiting delivery of ordered components.

PHYSICAL RESEARCH - 5000 PROGRAM

Mechanism of Graphite Damage

A study was made of the possibility of using thermistors as absolute thermometers. The results indicated that accuracies of about 0.5°C were possible.

A test was made to see if radiation damage could be observed in graphite with electron paramagnetic resonance equipment following electron irradiation. None was seen. The irradiation time was short and may have been too short for the purpose of the test.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

New data on atmospheric dispersion and deposition processes became available during the month with completion of reduction of measurements made during the 1960 field test series. Summaries include measurements of both the horizontal and vertical dispersion of tracer material to a distance of 2 miles from a source near ground level. Atmospheric density gradients ranged from very stable to moderately unstable, extending substantially the range of experimental data for use in establishing diffusion-deposition models. Summarization and reduction of the meteorological measurements taken during these experiments continued.

Work continued into the theoretical formulation of atmospheric diffusion-deposition equations to guide analysis of the 1959 field test data. Special attention was given to a model to describe the characteristic shear flow found in most of the experiments conducted during temperature inversions. Of the 28 experiments in the series, only 4 were selected for deposition and vertical diffusion calculations. Confounding interactions were found between vertical diffusion, deposition, height of release, and variation of height of plume center with distance. Empirical methods of separating these effects were tried and an equation derived for the loss of tracer material due to deposition for one experiment.

Four additional diffusion experiments were attempted during the month, with three successes, bringing the totals for the year to 7 successes in 10 trials. The experiments were 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 1 mile on a horizontal grid.

Further analysis of 2 minutes of record from the wind component meter by hand calculation methods were made to assist in evaluating the data recording requirements of the instrument. Values of the mean square turbulent velocities in the vertical and longitudinal directions were combined with the turbulent shearing stress in that plane to yield a correlation coefficient of -0.324. This value is smaller than expected, but not unreasonable for the very stable temperature gradient associated with the measurements.

In Air Force supported activities, field engineering and technical assistance were provided upon request. Procurement was initiated on all equipment to be supplied by APO for conducting the off-site diffusion studies. Preliminary analysis of climatological data for the test sites was begun.

DOSIMETRY

A cooperative experiment was begun with Dr. E. E. Osgood of the University of Oregon Medical School. We will use the whole body counter facilities to measure the bremstrahlung from the bodies of some of his patients to whom he has administered P-32. From these measurements we will gain knowledge of body distribution and retention and of the sensitivity of our counting methods. One man who received 2 mc of P-32 has been counted twice. Arrangements are being made to count another man in June.

Radiation Protection Operation was assisted in the identification and measurement of body burdens resulting from two contamination incidents. The subjects involved were also studied to find out how the radioactivity was distributed and eliminated. Three men had body burdens of Mo-Tc-99. A few hours after the incident the activity was in the nose, chest, and abdomen. After the first day it was all in the abdomen. Two men had eliminated all of it within three days and the third within seven days. Four men had body burdens of Na-24 and Zn-65. After the decay of the Na-24 and initial elimination of Zn-65, two of them had sufficient Zn-65 to merit continued study.

The current regulator system for the analyzing magnet of the positive ion Van de Graaff failed. The difficulty was traced to a faulty current generator. After repairs the accelerator was restored to satisfactory operation.

Experiments were carried out with the decontaminated SbBe source. The precision long counter and the double moderator were used to obtain measurements at 25 Kev neutron energy that had not been available before. The results were in good agreement with what had been expected from measurements at higher energies.

By comparing neutron measurements of PuBe and PuF sources with measurements on RaBe (gamma ray or alpha particle) sources, the rates of growth of the neutron emission from the various plutonium sources were determined. Some sources showed negligible growth while others showed up to 2.6% per year. The results brought order into all our precise measurements of these sources.

INSTRUMENTATION

A new experimental transistorized circuit was developed for use with the miniature alarming personnel dosimeter which uses a modified "pencil" ionization chamber as the detector. The new circuit, satisfactorily breadboard tested, chops the output of the detector, which has its readout CdS cell in a bridge

circuit, amplifies the resultant signal, and energizes a solid state memory which permits the supply voltage to be impressed across the alarm circuit. The no-alarm battery power requirement was reduced by holding most of the circuits in an "off" condition. If the lamp light source, the photocell, or the bridge voltage fails, the alarm energizes to provide fail-safe operation. The alarm is a resonant air column and is quite audible.

Final prototype fabrication continues on the experimental scintillation air monitor which uses coincident count techniques to eliminate interference from radon-thoron buildup. Fabrication is 50 percent complete.

Experiments were essentially completed on the inexpensive, small, high-level dose-rate detection method using a photocell and a small organic detector. Dose rates from 5 r/hr to 10^6 r/hr are readily measurable and the response is linear to greater than 10^4 r/hr. The unit is gamma energy independent from 80 Kev to 5 Mev, and it shows less than a 2:1 change in response from 0°F to +140°F. Accumulated dose damage was found to be negligible up to 5×10^6 r with increasing damage, which resulted in a lower output voltage reading, up to 10^8 r. At 10^8 r, the reading output, at a constant dose rate of 10^6 r/hr, was about one-half of the initial reading. Necessary parts have been ordered to fabricate two prototypes with waterproof, shockproof construction. Overall detector probe size will be about one inch diameter by one and one-half inches long.

Design-development work continued on a new type of monitor for airborne alpha detection. Eventually, the prototype using the approach will be installed in the 325 Building. In this unit, the alpha-particle-caused pulses from the phototube drive a transistorized amplifier and a series of binaries. The last binary drives a miniature stepping motor, and a contact, driven by the motor, advances one step for every 256 alpha-caused (plutonium, radon, thoron) pulses. A timing motor with a second contact on its shaft is used as a reference. If the stepping motor advances more rapidly than the timing motor, the contacts close to cause an alarm. A directional clutch is placed between the timing motor and the stepping motor to prevent the timing motor from driving the stepping motor thus keeping the contact spacing constant. The breadboard model has performed satisfactorily in laboratory tests with an airborne continuous concentration sensitivity calculated as 2×10^{-10} μc/cc in about 30 minutes.

The final design and packaging, in prototype form, was completed on the transistorized, gated oscillator, annunciator circuit using a resonant air column speaker. The unit can be used directly with all portable HAPO count-rate type survey instruments to eliminate the use of headphones.

Development work continues on a decade scaler with very low power requirements for use in portable and other battery-operated instruments where power consumption is expensive. The scaler is a transistorized binary-quinary type requiring 180 milliwatts per decade for a meter readout and only 300 milliwatts per decade for incandescent light readout. The best commercial scaler requires about 3000 milliwatts per decade. Only seven transistors are required per decade unit and a resolution of less than 10 microseconds is easily attained.

The previously-developed and now standard, single-transistor, high voltage supply for portable radiation protection instruments was modified to include use

to ± 2000 VDC at 50 microamperes (maximum) output for use with BF_3 tubes, etc., which require more than the ± 1200 VDC maximum originally obtainable. The modification simply added a doubler circuit as the high voltage secondary circuit. Standard HAPO prints are being prepared. No primary circuit modifications were necessary. Conversion efficiencies, for 4 VDC input, range from 60 percent for ± 900 VDC output to 35 percent for ± 2000 VDC output.

Technical progress was made on the Automatic Film Badge Densitometer. The designed printed circuits are 50 percent completed. A "no go circuit" was designed to stop the operation if the reading on the digital voltmeter exceeds a preset threshold, and this logic circuit will be operator adjustable. The design of the sequencing circuit is 70 percent complete, and it uses the auxiliary duplicating drum to control selection and printing for the addenda IBM unit. The complete control circuitry is being fabricated in the 328 Electronic Shop.

An experimental pulse height selector or discriminator circuit is under development. The circuit uses tunnel diodes as gating elements, has a variable window width, and triggers on pulses exceeding 0.5 volts in magnitude. Operation to - 125°F has been achieved. The circuit has wide application use in portable gamma energy analyzing instruments.

A journal paper was prepared on the mechanism of thermoluminescence in CaF_2:Mn dosimeters. The necessary induction heater for further dosimeter development was received and modified, and an experimental crystal furnace was assembled. Investigations continue to improve the dosimeter from its present 2π configuration to a 4π type and to reduce the storage losses associated with the units.

A recommendation was made to Atmospheric Physics Operation that an Ampex FR-1100 7-track tape transport be purchased for use in recording continuous meteorological data. This unit is compatible with the tape delay units now being used with the analog computer facility, and will permit interchange of the electronic amplifiers and power supplies between the two units.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis

The mass spectrometer for this program supplied isotopic analyses of the program samples received this month. In addition, two analyses were provided on plutonium standard samples to verify the performance of the Analytical Laboratories mass spectrometer. Four days were spent on maintenance and correction of malfunctions of the mass spectrometer.

The data previously obtained on the results of analyses on standard uranium samples are being examined in detail by Operations Research.

TEST REACTOR OPERATIONS

The PCTR operated two days during March, and there were no unscheduled shutdowns. On March 3, 1961, there was a plutonium solution spill in the reactor room, and the reactor was shut down for reactor room decontamination during the remainder of the month.

One experiment was completed to determine the fuel loading necessary to make the reactor critical with a 4 x 4 x 37½ inch copper bar in the center of the core. The copper bar was simulated by using a cadmium wrapped graphite bar 3½ x 3½ x 36 inches. The fuel was loaded in the outer fuel positions. The final loading required was 36 drivers, 4 columns each containing three 8-inch U^{235}-Al pieces and one 6-inch U^{235}-Al piece, and 47 columns each containing four 8-inch U^{235}-Al pieces. One lucite rod added to a driver in this configuration was worth approximately 13 cents.

Two groups of foils were irradiated in the TTR during the month. One group was irradiated to obtain data for resonance correction in copper. The other group was irradiated to get data pertinent to the making of Lu_2O_3 pins. There were no unscheduled shutdowns of the reactor.

Data were taken to determine the difference, if any, in the TTR prompt neutron lifetime when air and helium were used to fire the poison piston into the core. The data are being analyzed.

The lifetime of the prompt neutrons has been measured by two methods: One by poison injection by air and the other by noise analysis. The result was 2.7×10^{-4} sec with agreement to 4% between the two methods.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

The first in a series of three scheduled reports on prospective 1961 crests of the Columbia River flow at Hanford was issued on March 27. Because of the abundant precipitation during February and March, much of which occurred as snow at high elevations, the outlook is for higher crests this year than last. The preliminary outlook for 1961 follows, together with the comparative figures for 1960 and 1959.

	1961 Forecast	1960 Observed	1959 Observed
Peak flow (units of 10^3 CFS)	360-450	311.4	438.8
Peak stage (feet MSL) at:			
100-B	404.5-408.0	403.4	407.8
100-K	399.5-403.0	397.7	402.8
100-D	393.5-396.5	392.2	396.2
100-H	386.0-389.0	384.0	388.5
100-F	380.5-383.5	378.8	383.2
Richland	348.5-352.5	346.5	350.5

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	93	84.2
24-Hour General	62	86.5
Special	171	91.8

Precipitation for March was more than twice the normal amount. Although the total of 1.02 inches was less than half that of February, there were actually 3 more days of precipitation occurrence. Unlike February, March precipitation was well distributed over the month and there were no heavy downpours.

A tornado funnel was observed at 1500 on March 24, but dissipated 5 minutes later, before photographic equipment could be summoned. It was estimated 10-15 miles SSE of the station. There was considerable sideways lashing of the tail, but it apparently stayed well above the ground. It was also viewed by some from Richland. There was scattered thunderstorm activity at the time.

Instrumentation and Systems Studies

Specifications were prepared for Environmental Monitoring Operation, RPO, concerning a solid-state DC amplifier to replace the defective vacuum tube units originally used by RPO in their River Monitor.

Design, fabrication, and satisfactory testing was completed for the modified Sensitive Gamma Airborne Monitor for Environmental Monitoring, RPO. The added circuitry provides a fast (0.5 seconds to full scale) chart recorder response time and provides several selectable time constants.

Most of the necessary transistorized circuitry design was completed on a special sensitive scintillation Beta-Gamma Portable Field Monitor for the Biology Operation, HLO.

Fabrication continued on the experimental mixed fission product Air Monitor for the 327 Building using a moving-tape filter head.

Fabrication also continued on a designed combination alpha-beta-gamma Air Stack Monitor for use by Chemical Research Operation, HLO.

Minor adjustment work was completed on the experimental transistorized Aural Alpha-Beta-Gamma Monitor in use (for one year) by Calibrations Operation, RPO. Since no troubles, other than necessary adjustments, developed during the year of use, the unit was turned over to Calibrations Operation, and drawings and maintenance information were prepared and given to the technicians who will be responsible for future maintenance.

Advice was rendered concerning the Scintillation Criticality Alarm Units in use in the 325-A Building after one false alarm. The reason for the false alarm was not determined; however, actual tests after the incident showed the instrument to be performing completely correctly.

Design information was given to Radiological Chemistry Operation, HLO, concerning the large NaI crystal mechanical holder and positioner designed by Nucelonic Instrumentation and now in use at the Biology Operation. Radiological Chemistry Operation is going to fabricate a similar unit for their use.

Calibration of the micro-displacement readout systems to be used by Physical Metallurgy for in-reactor creep measurements has continued. To date, calibration of the Schaevitz DRS-100 system is 35 percent complete. Calibration runs made during March include drift tests on the 0.3-inch scale at 100°C, 200°C, 300°C, and 400°C, and calibration runs on the 0.3-inch scale at 300°C and 400°C. Drift testing and calibration of the 0.3-inch scale are now complete, and the reference system has been converted for calibrating the more sensitive scales (0.04 and 0.004-inch). Preliminary evaluation of the data indicates the DRS-100 recorder exhibits a definite and consistent non-linearity with a maximum value of approximately 0.005 inch occurring at about 65 percent of full scale. The DRS-100 indicator also exhibits a definite non-linearity which is smaller in magnitude (0.003-inch average), but considerably less consistent. In both cases the non-linearities exceed the required linearity specifications of ± 0.5 percent or ± 0.0015 inch. Continued use of the DRS-100 has resulted in a definite deterioration of its operating characteristics. Alignment of the equipment is becoming increasingly difficult and the indicator unit is developing a random oscillation which further complicates alignment and operation. Installation of a 1/16-inch-thick copper shield did not appreciably reduce the adverse transient effect of stray fields from the heating elements, but it did improve the stability of temperature control. The temperature drift of the transducer itself is continuously monitored and has been found to be less than ± 0.25°C over an eight-hour period. However, the copper shield oxidizes and has a tendency to flake at 400°C and is being replaced by a shield made of stainless steel. To improve the operation of the reference system, an extensometer holder was fabricated with provisions for an external prism adjustment. Room temperature variations in the laboratory are expected to influence the accuracy of the reference system, and an attempt to obtain a quantitative measurement of this effect will be made.

The Pulsed Extraction Column Dynamics Analog Simulation has been initiated by Chemical Research and Development. The problem consists of the determination of the displacement of the column interface as a function of the frequency and amplitude of the air pulser. This problem has not been completely formulated yet.

Ceramic Fuels Development Operation requested that two existing edge-control amplidyne units be converted to provide speed control of their swage machine drives, if economically feasible. A test procedure to determine the characteristics of the existing units has been recommended. The results of these tests should indicate the feasibility of the requested conversion.

Physical Testing

A total of 4986 tests were made on 3387 items representing 73,213 feet of material. Most of the footage was on fuel sheath tubes and reactor process tubes. Test work included autoclaving, boroscoping, fluorescent penetrant tests, X-ray and gamma-ray radiography, strain measurement, ultrasonic flaw detection, ultrasonic thickness measurement eddy current tests, and magnetic particle tests.

Production testing and treatment of the NPR process tubes proceeded routinely. The penetrant test continued to be slow because of the need to check indications revealed by white light boroscoping. Apparently most of the indications are due to penetrant held in burrs caused by scratching of the tubes at the vendor's final inspection. Work is continuing on the implementation of an

ultrasonic method for detecting transverse internal discontinuities in the tubes. Standards containing electro-machined 1- and 5-mil-deep transverse notches have been prepared for establishing test parameters. Pickling and autoclaving processes also have been improved.

The major emphasis in field testing work this month concerned the reactor nozzle modification program for the bumper fuel element, radiography at the PRTR, and radiography for 200-W vessel fabrication. A mobile laboratory was put into operation. This consists of a one-ton truck chassis on which is mounted a closed van containing a dark room, film developing equipment, instrument storage, a power generator, and a hoist. The mobile lab provides a self-sufficient facility for expediting and improving field tests.

A second new ultrasonic flaw detection test unit for fuel sheath tubes has been placed in operation in the 314 Building. Efforts are being made to fabricate sheath tube ultrasonic test standards. Extrusion of a defected billet was unsuccessful. It appears more feasible now to try to close prior machined defects in tubing by swaging. An eddy current test also is being evaluated with respect to ability for detection of hole-type defects.

DeForest scratch gage capabilities have been established. It was concluded that scratch gages, if properly applied, can be used for strain measurements on reactor downcomer "I" beams. Results and recommendations were reported by memorandum.

Some further work was completed on a gamma-ray scanning method for testing irradiated fuel elements for radial power asymmetry. Two fuel elements from a column of metal which had a poison spline beneath it for the entire exposure were tested. Both elements showed a 17% ± 3% fission product gamma (power generation) asymmetry. No further work is planned on this at this time because of lack of time and funding. A final report will be issued.

Work is continuing towards placing the Van de Graaff electron accelerator in the 306 Building into operation. The tank has been closed and is being checked for leaks. A leakage rate of about six pounds per day persists. A new generating voltmeter has been ordered. Design work for building modifications which will allow more convenient dismantling of the unit has been started.

Optics

Good progress has been made in the development of an optical mechanism for measuring horizontal and vertical displacements of channels and process tubes in the reactor. Design sketches for the first developmental unit have been prepared and fabrication is about 90 percent complete.

A total of 612 manhours of shop work was performed during the five-week period (February 26 to April 2) included in this report.

The work included:

1. Fabrication of adapters for a telescope camera for 327 Building.
2. Evaporation of gold on Mylar films for Radiological Chemical analysis.
3. Fabrication of 20 glass bearings.
4. Fabrication of three silicon solar cell pyrometers for FPD.

5. Fabrication of adapters for a super pressure mercury vapor microscope illuminator to be used by Ceramic Fuels.
6. Resurfacing of four pump seals.
7. Coating of ten lamps with stainless steel to facilitate inspection of NPR process tubes.
8. Fabrication of a flash lamp for Photography Operation.
9. Fabrication of components of the traversing mechanism for measuring reactor channel contours.
10. Repair of four crane periscope heads.
11. Servicing the Redox crane periscope.
12. Fabrication of parts for an ultrasonic wall thickness probe.

Analog Computer Facility Operation

The major analog computer problems considered during March include:

1. NPR Plant Simulator.
2. NPR Secondary Loop Analysis.
3. Two-Zone Reactor Control Simulation.
4. Gas Balance System Analysis.

The computer operation was as follows:

GEDA	103 hours up	EASE	105 hours up
	45 hours scheduled downtime		64 hours scheduled downtime
	16 hours unscheduled downtime		7 hours unscheduled downtim
	12 hours idle		0 hours idle
	176 hours total		176 hours total

Instrument Evaluation

Evaluation tests were conducted on the miniature organic (NE-102) detector and photocell probe for use in measurement of dose-rates from 5 r/hr to 10^6 r/hr. The probe was quite linear in response (voltage output change versus dose-rate) to greater than 10^4 r/hr. Non-linearities for dose-rates above 5×10^4 r/hr may be caused by the calibration method available which is the 12 Kilocurie Co^{60} source. The exact positioning of the probe was exceedingly difficult in the well. The lower dose rates, to 10^4 r/hr, were accurately obtained using the electron Van de Graaff. Further tests will be conducted when the prototype units are fabricated and assembled.

Final evaluation tests on drift characteristics of the 614 Building Scintillation Monitors were completed, and a procedure was devised for proper calibration.

All twelve of the Sentinel portable scintillation, settable-alarm-point dose-rate meters for 100 Area use were tested satisfactorily and released for field use.

Acceptance tests were started and complete procedures prepared on a new group of self-reading dosimeter "pencils" of the 50 r, 10 r, and 200 mr types. The high level units are for emergency monitoring. Of the 100 dosimeters of the 200 mr (routine use) type, 21 percent were rejected because of excess leakage. Previous orders from the same vendor showed only a 6 percent rejection for leakage.

A "new" version of the commercial NMC "Gammaguard" scintillation area monitor was calibration tested. Below 1 r/hr, results were accurate to ± 20 percent of true values for Ra^{226} dose rates; however, above 1 r/hr, saturation effects occurred, and the unit indicated only 2.4 r/hr in a 6 r/hr field. This effect could be dangerous.

A Nucleonic-Instrumentation-developed quasi-logarithmic response scintillation Elevator Monitor was calibrated for IPD and returned to service.

Advice was rendered to maintenance personnel concerning the conversion of an old model 5-fold beta-gamma hand and shoe counter from glass organic-quenched GM tubes to Amperex metal wall, halogen-quenched GM tubes.

A radiation sensitive unit, using a Nucleonic-Instrumentation-developed, transistorized GM portable instrument modified to include a meter relay and a power relay, was devised for use by the local AEC. The unit, when activated with a radioactive source, will actuate a gear motor used to raise the Flag during the April 8 ceremonies honoring the selection of Richland as an All-American City.

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Uranium Oxidation and Fission Product Volatilization Studies

The investigation of single slug "burning" incidents was continued. Four unirradiated I & E fuel elements were heated by induction in a flowing air atmosphere to determine the mode of meltdown, extent of uranium reaction and the time versus temperature relationships. Two of the slugs were aluminum clad, two were bare. One of the clad elements had been purposely defected by drilling a 5/32-inch diameter hole through the cladding.

Both of the bare slugs flowed extensively upon melting. Oxidation rates were about as predicted from small scale experiments (HW-58022). The two aluminum-clad pieces, however, behaved differently. In one, a retentive U-Al alloy formed, identified as UAl_3 by x-ray diffraction. No uranium flowed out from the jacket and only four percent of the uranium oxidized in about 30 minutes at temperatures above 1130 C. In the second experiment, the alloyed jacket fragmented as soon as it was formed. About half of the uranium flowed out of the work coil area and onto the floor of the container. After freezing, it oxidized over a several hour period until all the metal had been converted to oxide. About 25 percent of the metal remaining within the work coil area oxidized. The flow of the uranium did not originate at the point of the defect.

These tests confirm the conclusion made previously that the extent of uranium oxidation (and hence of fission product release) of aluminum clad fuel elements can vary from essentially none to extensive under conditions postulated for rear face incidents.

Two fission product release experiments were made during the month on specimens irradiated to 6.6×10^{19} nvt. One specimen, heated in air at 1200 C for 24 minutes, was 88 percent oxidized and released 99.8, 97.2, and 2.8 percent of its Xe, I, and Ru content, respectively. The other specimen, heated in air at 1440 C for ten minutes, was 66 percent oxidized and released 99.8 percent of its Xe. The higher than expected oxidation in the first experiment was a function of an increase in the area-to-weight ratio due to flowing as indicated by the loose oxide product. The sintered mass product from the other run was of normal appearance.

NPR Effluents

Current laboratory research experiments for studying disposal methods for NPR decontamination solutions were completed and the results published in HW-68863. The major decontamination waste volume to be routinely generated in the NPR consists of a phosphoric acid solution used to clean up carbon steel portions of the reactor loop. Disposal of this material is complicated by the desire to prevent the phosphate ion from reaching the river above any of the reactors. From soil column experiments it was found that ground disposal of the waste is a feasible method if the disposal site is one from which the ground water moves to a river discharge point below 100-F. The plant coordinates N 69,000, W 47,000 (just north of Gable Mountain) were suggested as a possible location for such a crib.

Reactor Effluent Treatment

The pilot scale aluminum bed facility for reactor effluent decontamination was operated during the month at 5 feet per minute. An attempt was made to reduce pressure drop across the front section of the bed by drawing water at high velocity from local areas on the front surface of the bed. This was effective in reducing the pressure drop by about one inch of water, which is the present pressure drop over about three linear feet of the bed. Debris collected on a 100 mesh screen consisted of fly ash, fibrous material, tumble weed stems, and other unidentifiable organic material. The fibrous material was identified in part as a fresh water plant growth. This examination gave assurance that the material responsible for the pressure drop was entering the water after arrival at the basin, thus should not be of great concern in a closed system.

The adsorption of phosphorus by beds of the minerals pyrrhotite, pyrite, and olivine was studied by comparing the results of column experiments using these materials with the results from similar experiments using columns of 8001 aluminum turnings. None of these minerals showed particular selectivity for phosphate ion. The minerals adsorbed only slightly more phosphate than did the aluminum columns. After passage of 1300 column volumes of 80 C tap water containing 0.01 uc/ml P-32 all of these materials had a breakthrough somewhat greater than 60 percent.

Reactor Effluent Analysis

A promising method was developed for monitoring radioarsenic in reactor effluent water to guide water treatment processes. Continuous, current data on radioarsenic would be a measurement of the effectiveness of the water treatment process for reducing both the As-76 and P-32 since these isotopes behave similarly in the flocculation process. This measurement then would provide data for the two radioisotopes of main radiological interest. The monitor is based on gamma spectrometric measurement of the As-76 after cation exchange removal of all interferring materials but Mn-56. By using large crystal counting techniques the Mn-56 interference can be made small.

SEPARATION PROCESSES

Diluent Studies

Further characterization of diluents for Purex application has resulted in the following arbitrary classification:

1. N-paraffin hydrocarbons, such as the synthetic dodecane, Adakane-12; and fractions isolated from petroleum by the urea process.

2. Non-aromatic petroleum fractions. These are remarkably alike differing only in the quantity of their constituents. This group includes Shell E-2342, Bayol D. Ultrasene, Supersol, Shell 16550, and Shell 82000. Compositions range from about 60 to 70 percent napthenes and 5 to 10 percent n-paraffins in E-2342 to 20 to 30 percent napthenes and 50 to 60 percent n-paraffins in the Shell 82000. Branched hydrocarbons probably make up the balance of the composition. The napthene fraction is fairly reactive toward nitric or sulfuric acid; however, the chemical stability is not appreciably improved by a simulated cycle of acid degradation and caustic clean up.

3. Highly aromatic diluents such as Penola-100 and Amsco D-95-E1.

4. The synthetic alkylates produced by polymerization and hydrogenation of short chain olefins. Most of these commercial products are apparently copolymers and contain many different species; however, by polymerizing a pure monomer, iso-butene for example, it is possible to prepare a diluent consisting almost entirely of a single species. Soltrol 170, Amsco 125, and Amsco 450 are members of this class of diluents. They differ primarily in the relative concentrations of the branched chain hydrocarbons.

Chemical stability of the paraffin hydrocarbons is expected to decrease in the order, normal, branched chain and cyclic compounds with the difference in stability between the first two compounds being less than that of the latter two. It is believed that compounds having tertiary hydrogens are particularly susceptible to solvent degradation and that nitration of carbon atoms having adjacent hydrogen atoms (for enolization) is perhaps particularly undesirable. Thus, compounds made up of $-CH_2CR_2-$ groups may be particularly stable to the effects of nitration. The theoretical basis for a choice of diluent is very helpful; however, the complex nature of the materials (as has been emphasized in the past) points up the desirability of a "use" type test.

Observation Wells

Analyses of routine samples from well 699-20-20. 6.5 miles southeast of 200 East Area, continued to verify the low concentrations of radioisotopes in the ground water at that location as reported last month. The average concentration is 1.1×10^{-7} uc/cc (beta) which is essentially the same as that noted in February 1961. Radioisotope concentrations in well 699-26-15, 6.5 miles southeast of 200 East Area and 1.5 miles northeast of well 699-20-20, are just slightly below the routine detection limit of 8×10^{-8} uc/cc (beta) at the 95 percent C.L. but have shown a definite increasing concentration trend over the past several months. If the increase continues at its present rate, the concentration of contaminants will be above the routine detection limit in one or two months. The latter well is about five miles from the Columbia River but at a location where ground water is flowing parallel to the river. The sources of waste in this locale are Purex plant disposal facilities and possibly abandoned scavenged waste cribs in 200 East Area.

Disposal of Wastes to the Ground

A laboratory experiment was performed to study further the adsorption of plutonium from 234-5 Building sump waste by a bed of Florida pebble phosphate rock. Acidic waste was passed through a bed of the mineral until a 20 percent breakthrough was reached, at which point the plutonium concentration in the influent was suddenly increased. The plutonium concentration in the effluent increased sharply in response to the influent concentration change and appeared to maintain about the same breakthrough percentage. The results indicate rather stable proportionality between influent and effluent concentrations under realistic operation conditions.

Mineral Bed Removal of Cesium

Laboratory experiments were performed in the study of the elution of cesium from a bed of clinoptilolite. The selective adsorption of cesium by this zeolite is known to be related to the particular size and charge of the cesium ion. Elution

experiments were therefore performed with ammonium and potassium ions because of their similarity to cesium. A solution of ammonium nitrate is the most efficient eluate of those tested but may be too unstable for later calcination. At 2 M concentrations ammonium chloride and potassium chloride were found to be about 60 percent as efficient for eluting cesium from clinoptilolite as ammonium nitrate solutions. Solutions of 2 M ammonium nitrate are more efficient for cesium elution per mole of ammonium ion added than are 5 M solutions.

WASTE TREATMENT

Batch Calcination

Bench-scale studies of the calcination of simulated Purex high-level wastes by the batch process were continued. Four runs were made in an induction-heated 6-inch diameter by 15-inch high annular pot. The objective of the runs was to study solution foaming and solids removal.

Foaming during the boil-down step appears to be a function of the solution composition and concentration. Severe foaming occurred in the run reported last month. However, in another run with the same constituents but with a 42 percent increase in concentration of the constituents, only mild foaming was observed. The boil-off rate in the latter run was three times higher than the run which foamed.

Another run was made with a solution high in phosphate and the severe foaming which is a characteristic of such solutions. However, the foaming was effectively controlled by the tangential introduction of an air sparge into the boiling solution so that a mild swirling action was produced.

The calcined solids were removed from the pot by repeating the process of adding water or nitric acid, boiling and siphoning off the resultant slurry. In all cases the volume of the slurry collected was less than that of simulated waste solution used as feed. Increasing the nitric acid concentration of the removal solution from zero to two molar appears to decrease the volume of slurry collected. All of the slurries contained twenty to thirty volume percent solids. Foaming during the calcine removal operations was effectively controlled by adding a silicone antifoam agent.

Waste Calciner Feed Concentrator

The radiant heat spray calciner is being modified to allow testing of both the attractiveness of its use as a spray concentrator for waste calciner feeds and the feasibility of channel recycle. Such a preconcentrator is needed to reduce batch calciner time cycles since water evaporation constitutes the largent portion of the heat load in such a calciner. The channel recycle feature should simplify the heating problem.

The modification is an approximately 6-inch diameter sleeve which will fit concentrically into the 8-inch diameter barrel of the laboratory spray calciner. The sleeve has a length of four feet and is double walled with one-half inch of insulation between the walls.

In operation, the liquid wastes will be sprayed into the top of the insulated sleeve and will be joined by hot recycled gas. The heated gas will then vaporize a portion of the sprayed liquid and the mixture will exhaust out of the bottom of the sleeve.

After passing through a wire mesh screen acting as a demister-coalescer, a portion of this mixture will then recycle through the annulus between the hot outer wall and insulated sleeve to complete the channel recycle. The residual gas phase and coalesced liquid proceed to additional disengaging, liquid collection, and off-gas train auxiliaries. The purpose of both the channel recycle and spray features of the concentrator is to minimize scaling of heat transfer surfaces by eliminating access of solids bearing streams to such surfaces.

Thermal Effects in Solidified Radioactive Wastes

A solution to the Poisson's equation has been derived to give temperature distributions in a cyclinder having a strip discontinuity in the bonding of calcine to container wall. This strip discontinuity gives rise to an angular step function in the overall heat transfer coefficient from calcine to coolant stream. Numerical values of temperature distributions are now being prepared for various cylinder diameters, non-bonded strip angular widths, relative film transfer coefficients, heat generation rates, and thermal conductivities of the calcines.

Thermal Conductivity Measurements

The Line Heat Source apparatus for measurement of thermal conductivities under unsteady state conditions was calibrated using 18-40 μ glass spheres as the test material. Using a 0.025-inch diameter source, a thermal conductivity of 0.101 Btu/hr. ft^2 F/ft. was obtained as compared to 0.093 determined by steady state methods.

Waste Transfer Program

A program has been outlined for developing technology necessary for transfer of both solid and liquid underground stored wastes. Development of hydraulic mining test equipment is in progress.

Corrosion of 304-L Stainless Steel by Purex Acid Waste Solutions

Samples of 304-L stainless steel have been exposed for a total of 900 hours to synthetic, 60 percent concentrated Purex 1WW solution at 80 and 95 C. The test solution was 0.5 M HNO_3 corresponding to the residual acidity to be expected after formaldehyde destruction of nitric acid in 1WW solution. Corrosion rates were one and five mils/mo, respectively.

Samples of 304-L stainless steel and A-55 titanium have been exposed to the liquid, vapor, and interface of a boiling synthetic solution corresponding to the currently proposed waste solution for interim storage. All samples have been exposed for a total of 830 hours. The 304-L samples exhibited corrosion rates of 0.2 mil/mo in the vapor, 3 mils/mo in the interface, and 6 mils/mo in the liquid. The attack was intergranular in nature. All three titanium samples corroded at rates of 0.02 mils/mo or less.

Corrosivity of Phosphate-Containing Calcined Waste

Samples of Inconel, Inconel X, and 304-L stainless steel have been exposed at 900 C for 24 hours to synthetic calcined waste containing phosphate equivalent to the total cation concentration. The synthetic waste was prepared in the radiant heat spray calciner; phosphate was added; the mixture heated to 900 C and allowed to cool. Metal samples were exposed in the remelted mixture at 900 C. Corrosion rates of Inconel, Inconel X, and 304-L stainless steel were 0.8, 2.0, and 20 mils/mo,

respectively. Metallurgical examination indicates, however, that the penetration rate of the Inconel may be as high as 30 mils/mo. The 304-L sample exhibited intergranular attack, and the 20 mils/mo rate is a factor of ten higher than a rate reported for 304-L in this same environment by ORNL investigators. One exposure of type 330 stainless steel indicates that this system may be very temperature sensitive; another series of exposures is planned to determine if this is so.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium-90 Program

325-A Strontium Purification - Repair of the A-Cell equipment was completed, and a strontium-90 purification run (#3 of the series) was made during the month. Essentially the same flowsheet was used as in run #2, equipment functioned satisfactorily, and the run was uneventful--except for a difficult loading cycle caused by copious solids in the feed. Final product elution (from column 6) was with 0.1 M HEDTA at pH 8.8, vice nitric acid, in order to obtain a solution more suitable for direct loading on Decalso. About 8,000 curies of purified strontium-90 were obtained from the run, compared to 5,000 from run #1 and 8,350 from run #2. This strontium was loaded, with the product of the other two runs, into the HAPO-1A cask.

The feed material was identical to that of run #2 except for age; however, a different feed make-up procedure was used in an attempt to minimize ammonium ion concentration and thereby improve loading capacity. The procedure, which involved clarification with HEDTA and ammonia alone (rather than solids dissolution with nitric acid followed by ammonia neutralization and HEDTA complexing), had been piloted in B-Cell on small volumes of feed followed by successful loading onto a 100 ml ion exchange column. In feed makeup for run #3, however, much larger volumes of HEDTA and ammonia were required and complete clarification was not obtained, implying that the small samples were not truly representative of the solids in the storage tanks (presumably because of a small diameter sampling line). The large amounts of HEDTA and ammonia which were required resulted in an ammonium ion concentration, and hence a strontium capacity, about the same as in run #2. Although all of the feed was filtered, as an added precaution, prior to introduction to the columns, pressure drop across the columns was excessive and column plugging finally necessitated premature termination of loading and initiation of the elution cycle while some 80 liters of feed remained.

Strontium Cask Filling - The HAPO-1A Decalso-insert cask was successfully filled (for transfer to Oak Ridge) with the purified strontium product from runs 1, 2 and 3. Filling was uneventful except for difficulty with air in-leakage around the Snap-Tite fittings. Twenty thousand curies of strontium-90, representing 93 percent of that passed through the cask, were loaded onto the Decalso for shipment.

Nine gallons of 30+ mesh Decalso was slurried into the cask (ten gallon void) and pretreated with six bed volumes of 4 M NH_4NO_3 and water washed. This treatment, with strontium loading from an ammonium-neutralized rather than caustic-neutralized solution, was requested by Oak Ridge in order to minimize sodium content of the eluted strontium, a recommendation based on recent evidence that even small amounts of sodium are deleterious to strontium titanate production. Laboratory studies with synthetic 325-A product showed that strontium is less readily absorbed from ammonium solution than from sodium by a factor of about two. This fact, and the relatively small (nine gallon) volume of the Decalso, made loading the customer's

required 20,000 curies of strontium-90 marginal, even when advantage is taken of high dilution and elevated temperature (both of which aid absorption). Further experiments to define a flowsheet showed that capacity is maximized and loading time minimized by a step-wise loading scheme whereby loading is carried out at relatively high concentration till incipient breakthrough is reached followed by loading the remainder at high dilution. It was also found that strontium is absorbed on Decalso at even higher capacity if elution from the isolation column (in the ion exchange purification process) is done with EDTA or HEDTA, rather than nitric acid, and neutralized to a low pH (two to four) for absorption on the Decalso. HEDTA works best. A further advantage of HEDTA is that copper is not absorbed on, and indeed is eluted from, Decalso by acidic HEDTA. Use of the HEDTA elution and loading scheme assumes, of course, that the cask is available when elution occurs since the HEDTA containing solution undergoes radiation induced decomposition on standing.

Ammonia neutralization and step-wise dilution was used for the (nitric acid) product from runs 1 and 2, followed by HEDTA elution and loading of the product of run 3.

Rate of Gas Evolution from Strontium Concentrates - A series of measurements were made of the rate and composition of radiolytic gas generation from strontium containing solutions (because of the applicability of the data to storage and shipping problems). Solutions studied included (1) 200 gallons of F-8 Purex concentrate stored in a 250 gallon shipping cask, and (2) 10 gallons of purified strontium concentrate (run 1 and 2 product) stored in a 40 gallon cask. The 250 gallon cask contained about 20,000 curies of strontium-90 and 200,000 curies of cerium-144, plus 8.5 g/l iron and 4 g/l lead (mostly precipitated) at pH 2 to 3. The 40 gallon cask contained 13,500 curies of purified strontium-90 in 2 M nitric acid. Total fission product decay energy was about 1,400 watts in the case of the 250 gallon cask and 120 watts for the 40 gallon cask. Rate of gas evolution from the 250 gallon cask was about 500 to 600 cc/hr, or 0.4 cc/watt,hr. That from the purified strontium was 150 cc/hr, or 1.2 cc/watt,hr. These figures may be compared with a calculated value of 18 cc/watt,hr if all of the energy is assumed to produce gas with a G value of 2 molecules per 100 electron volts. In practice (because much of the decay energy is dissipated in other ways), it would be expected that the observed values might be an order of magnitude lower; i.e., about 1.8 cc/watt,hr, in reasonable agreement with the observed rates. The gas issuing from both casks contained hydrogen and oxygen in a 2:1 ratio and was explosive.

Laboratory Solvent Extraction Studies - Further mini-mixer settler runs testing flowsheets for solvent extraction recovery of strontium from Purex plant "crude cut" solution were made in the 222-S Building cubicle. Two 1A column runs were made at 10 percent full level activity. Feed for these runs was prepared by diluting plant crude cut solution with a synthetic crude of approximately the same gross salt composition.

Feed for the first run was made 0.15 M EDTA and 0.40 M sodium acetate and adjusted to pH 4.3 by addition of an EDTA-sodium acetate-NaOH stock solution; the scrub for this run was 0.5 M $NaNO_3$-0.02 M EDTA at pH 3.6. Feed for the second run was also 0.15 M EDTA and 0.40 M sodium acetate but was adjusted to pH 4.7. The scrub in the second run was 0.6 M citric acid at pH 2.6. The extractant in both runs was 0.1 M D2EHPA-0.2 M TBP-Shell Spray Base not previously washed with either caustic or nitric acid. Seven extraction and five scrub stages were used in both runs. Flows corresponded to those of Study Flowsheet No. 2.

Hydraulic performance of the mini-mixer settler was excellent in the run with the sodium nitrate scrub. Intermittent flooding occurred to a small extent in the second run but did not seriously interfere with mini operation. The pH of the aqueous raffinate in the first run was 4.3 while in the second run the raffinate pH was 4.5.

Strontium recovery was excellent in both runs. Less than 0.1 percent of the strontium was lost to the 1AW stream in the run with the sodium nitrate scrub and about one percent in the run with the citric acid scrub. Gamma emitters in the organic product samples from these runs were determined by gamma scan techniques after prior removal of the strontium-89 and -90 by a double precipitation with fuming nitric acid. Based on such analyses, the cerium decontamination factor in the first run ($NaNO_3$ scrub) was about 11 and the Zr-Nb decontamination factor was about 1200; cerium decontamination factors in runs at tracer level using the same flowsheet ranged from 10 to 15. The cerium decontamination factor in the run with the citric acid scrub was about 22; the Zr-Nb decontamination factor was about 3000 in this run while the Ru decontamination factor was greater than 200. The cerium results compare very favorably with the decontamination factor of 24 obtained in tracer level runs using the same flowsheet.

The flowsheet used in the second run is favored over that used in the first run not only because higher cerium decontamination is obtained but also because the organic product obtained with a citric acid scrub at pH 2.6 contains less sodium and consequently constitutes a more acceptable feed to the 1B column. Accordingly, at month's end these flowsheet conditions were used in a 20-hour A-column run at 40 percent full level activity to produce sufficient organic product for a six-hour B-column run. Analytical data from these last runs are not yet available.

Ion Exchange Separation Studies - A small (1 cm x 62 cm) ion exchange column is being used to study ion exchange treatment of the 1B column product stream for further purification of strontium. Biorad Dowex 50W-X 12 resin is used. In a run to determine cerium decontamination, the column was loaded to about 50 percent capacity by passage of a feed solution containing 0.0625 M Sr - 0.0075 M Ca - 1.0 M citrate and traced with Sr-85 and Ce-144. The column was washed with 1.0 M citric acid (pH 3.0) and with water and then eluted with 3.0 M $NaNO_3$ previously adjusted to pH 11.0 with ammonium hydroxide. Elution with three bed volumes removed 71 percent of the strontium at an average concentration of 0.055 M and with a cerium decontamination factor in excess of 350. Further elution with one and one-half volumes of 1.0 M sodium citrate at pH 11.0 removed an additional 15 percent of the strontium.

Hot Semiworks Operation - Work at Hot Semiworks has moved into a cold testing period after completion of work by construction. Testing conducted on a three-shift basis included acid and water flushes of equipment followed by solvent extraction flooding tests. Column flooding performance met expectations as predicted from other development work. Minor equipment adjustments are continuing throughout the cold tests.

Instrumentation in Support of Hot Semiworks - The shielding and collimators for the gamma scintillation probes have been redesigned to handle the radiation levels expected during strontium recovery runs. High intensity ion chambers similar to those designed for the cesium-137 isolation facility are also being fabricated for installation in "B" cell for measuring gross gamma activity directly in process lines. The pH monitoring systems have been installed and are in operation on current "cold" runs.

Strontium Carbonate Filter Cask - Construction of the full scale strontium carbonate filter cask simulator is now 90 percent complete. The finished unit will be available for mockup testing at Hot Semiworks in early April. "Practical" strontium carbonate synthetic products were prepared for Van de Graaff radiolysis studies.

Development of Closures for Shipping Casks - Performance of "Snap-Tite" fittings and a Pacific ball valve to be used on HAPO I, IA, and II fission product shipping casks was evaluated in hydrostatic and steam bomb tests. In general, "Snap-Tite" fitting leaked at low pressures but held at high pressures (1000 psig). The pressure activated "Viton" seals appear suitable for temperatures to 400 F. The Pacific ball valve after installation of new Viton seals, held from zero to 1000 psig at room temperature and zero to 75 psig at 350 to 400 F.

In other closure development studies, 2-3/4 inch unlubricated stainless steel "O" rings sealing screwed type stainless steel surfaces, failed at pressures over 100 psig. Molykote lubricated "O" rings withstood 1200 psig hydrostatic tests but failed at 500 F with Molykote burning. A 2-3/4 inch stainless steel "O" ring seating stationary, non-rotating faces withstood 1000 psig hydrostatic test but failed at 300 psig, 400 F.

Natorq and Conoseals (one inch) were steam bomb tested at 300 to 700 psig and 200 to 700 F and showed leakage rates of less than 1.5×10^{-2} cc/hr., based on bomb water loss.

Bulk Fission Product Packaging - A full scale (for 50,000 strontium-90 curies) development model of the filter canister shipping container has been tested using strontium peroxide as a filterable intermediate to strontium oxide. Initial results confirm that the equivalent of 50,000 curies strontium-90 can be deposited in a four-inch diameter by 18-inch long canister containing an integral two-inch diameter filter stick. The filter canister approach permits bulk packaging of filterable and convertible fission product compounds without necessitating powder handling. The customer can employ either wet or dry chemistry for further processing. Tests employing cerium and rare earth oxalates (convertible to oxides at reasonable temperatures) are planned.

In other work, strontium nitrate solution has been evaporated to dryness and calcined to the oxide in a small vessel suitable in size for a shipping container. The necessary freeboard for boiling and foaming during the reactions was provided by a removable disengaging space and vapor line, but the practical maximum of material that can be handled at one time is approximately 500 grams of SrO (30,000 curies) in a two-inch diameter canister. The calcined oxide is dense, hard, and adheres tightly to the vessel. It can be disintegrated to a crumbly powder by reacting with steam at 150-200 C, forming $Sr(OH)_2$.

Cerium oxalate (solid) was easily calcined to cerium oxide in a shipping-canister calciner by heating above 350 C. The reaction was quiet and required no freeboard. The product had a tap density of 1 g/cc and was probably a mixture of Ce_2O_3 and CeO_2. To prevent pressurization of shipping containers it will be necessary to halt the decomposition at cerous oxide. Ceric oxide would produce oxygen as the cerium(IV) decays to form trivalent rare earth oxides.

Solid Strontium Product - Filtration characteristics of SrO_2-CaO_2 precipitated from simulated ion exchange product solution were studied. The chief variables affecting filterability were terminal pH and the rate of caustic addition. A slow caustic addition rate to a terminal pH $\leq$11.5 produced an easily filtered product.

Thermal decomposition studies of strontium peroxide were made at 350, 370 and 400 C. After one-half hour exposure at temperature, the residual peroxide content (calculated as H_2O_2) was 0.23, 0.023 and 0.007 percent, respectively. An additional one-half hour exposure produced no change in the sample heated at 400 C whereas the peroxide content of samples heated at 350 and 370 C decreased ten and two-fold, respectively.

Electron diffraction studies show that strontium titanate is formed when SrO_2-H_2TiO_3 precipitates are ignited at 400 C. Production of a filterable SrO_2-H_2TiO_3 precipitate requires that H_2TiO_3 be formed by hydrolysis of $TiO(NO_3)_2$ at 100 C rather than by addition of caustic.

Determination of Cerium in Strontium Samples

The determination of cerium-144 in the presence of strontium-90 is difficult because of the intense beta activity and bremstrahlung of the strontium and its yttrium daughter. A rapid, sensitive, and novel method has been developed which eliminates this difficulty. The sample, in nitric acid solution, is passed through a small column packed with a mixture of anion exchange resin (Dowex-1) and lead peroxide. The lead peroxide oxidizes the cerium to the (IV) state and it is absorbed by the resin while strontium, yttrium and any trivalent rare earths which may be present pass through. The cerium is eluted with hydrochloric acid and counted. Decontamination factors from strontium and yttrium (and trivalent rare earths) exceed 10^4. The new method has been introduced into the HLO and CPD analytical laboratories and should eliminate a serious bottleneck which was troubling development and demonstration of the HSW solvent extraction process. It should also prove valuable in determining cerium contamination in purified strontium product.

Determination of Neodymium

The feasibility of neodymium determination in cold semiworks strontium recovery samples was demonstrated. The copper spark method, useful for cerium analysis, was applied to neodymium through selection of an analytical line at 4446.4 angstroms. That line is not the most sensitive but is free from interference in this application. Determination of 0.004 g/l of neodymium was accomplished with a coefficient of variation of ±12 percent.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Determination of Nitrate by Controlled Potential Coulometry

L.R. Duncan gave the subject paper at the 139th American Chemical Society National meeting.

Low Concentration Thorium Analyses

Preliminary results from the intercomparison of thorium determinations by emission spectrograph and neutron activation analyses and from comparison of determination of replicate samples by activation analysis have disclosed discrepancies amounting

to nearly a factor of two in some samples. In about half of the cases the agreement has been within 20 percent. Additional work with control standards and replicate analyses is currently in progress to reduce the uncertainty of the methods and to resolve the existing discrepancies.

An approximate sensitivity of 1 x 10^{-4} µg was determined for the analysis of Th-232 by the activation analysis method currently used. This figure is based on the quantity of Th-232 (per sample) necessary to give a counting rate of twice background at the 0.31 Mev gamma peak of the Pa-233 daughter of the (n, γ) produced Th-233.

EQUIPMENT AND MATERIALS

Continuous Centrifuge

The 6-inch continuous centrifuge has been operated for process testing with a feed slurry of freshly precipitated cerium oxalate (stand-in for plutonium oxalate), approximately 95 grams of solids per liter, at a feed rate of 400 ml/min. The solids product contained 63 to 68 percent solids under nearly all combinations of speed (6000, 4000, or 3000 rpm); pool depth (1/3 inch or 3/8 inch); and conveyor speed with respect to the bowl (1 percent or 0.25 percent of the bowl speed). At 6000 rpm and 1/8 inch pool depth, the product contained 50 percent or less solids. At 4000 rpm and conveyor speed of 10 rpm with respect to the bowl, the conveyor flights plugged because the solids were not removed rapidly enough from the vicinity of the feed ports. At 3000 rpm, the solids discharge nozzle became plugged with product after 30 minutes of operation. The equipment manufacturer claims that in similar tests at the plant he had produced product with 85 percent solids. The feed rate during those tests was about 1000 ml/min, or 2-1/2 fold greater than used here.

Further testing is underway to check the effect of feed rate on product quality.

Agitation Studies

Mockup agitation studies of the Purex 3AF annular tank were completed. Phenolphthalein indicator was employed to visually follow the neutralization of acidic or alkaline solutions in a lucite tank. It was found that mixing times were little affected by sparger air rate, intimate blending being accomplished in 24 seconds with 1.5 scfm and 18 seconds with 19 scfm. Pump recirculation at 25 gpm required 2.5 minutes for homogeneity.

Non-Metallic Materials

Four different transparent materials were tested in a mixture of 25 percent dibutylbutylphosphonate and 75 percent carbon tetrachloride. Three of the materials were undamaged. These were Plexiglas UVA, Homalite Cr 39, and a Teslar-Plexiglas laminate. The fourth, Plexiglas 5009 was damaged severely after one day and disintegrated after one week.

A sample of Gusco paint was tested in 60 percent nitric acid at 37 C. The coating failed completely after 20 hours. Gusco is a hot spray epoxy system.

Samples taken from a spare Purex centrifuge cushion ring have been exposed to dry heat and the change in hardness noted. After 36 days at 90 C the hardness had increased from 60 to 85 Durometer C. This is a marked increase in hardness and

could possibly be more than the design of the equipment could tolerate. Exposure to 75 C has caused hardness to increase at about half the rate obtained at 90 C.

Two magnesia-titania crucibles of local fabrication were tested with the barium-potassium-sodium chloride mixture being used by 234-5 Development Operation. After 200 hours at 800 C the solution had percolated through both crucibles. Chlorine gas was bubbled through the solution for at least 150 hours during the test.

A third crucible similar to the above was tested with the same salt for 100 hours at 800 C. For this test metallic aluminum was introduced into the melt. No chlorine was used. No significant reaction between the aluminum and the salt or the crucible was noted. The crucible did not leak.

A Berlox crucible (pure BeO) was tested at 800 C with the same salt. After 100 hours the solution had percolated through the crucible.

PROCESS CONTROL DEVELOPMENT

Calciner Furnace Control System

Plots of K calciner finish section shell temperature vs. time were made for four startup runs and two shutdown runs for use in designing a shell temperature programming cam. The data indicated that no two startups or shutdowns are the same so that for any given cam design, errors of up to 85 F might develop between controlled shell temperatures in the finish section and uncontrolled shell temperatures in the feed sections. Use of a feed section temperature recorder to program the finish

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Hot Cell Experiments - A run with irradiated feed was made for the purpose of testing a higher temperature in the by-product deposition step and the effect of dry air atmosphere on the product deposition step.

Dissolution of the irradiated U_3O_8 proceeded uneventfully. However, a tighter fitting lid was used over the vessel during this step than had been the case in earlier runs. Activity collected on the cell exhaust filters was lower by a factor of ca. 10 than had been the case in the earlier runs.

Conduct of the by-product deposition step at 800 C (vice 750 C in earlier runs) yielded decontamination factors of ca. 140 for plutonium, ca. 600 for cerium, ca. 1600 for other rare earths, and ca. 1600 for strontium. These results are quite comparable with those obtained in earlier runs with the exception that the cerium decontamination was slightly improved and the plutonium decontamination factor was slightly worse. However, it may be noted that the removal of 15 percent of the total melt uranium with a plutonium decontamination factor of 140 corresponds still to removal of only ca. 0.2 percent of the melt plutonium in the by-product.

The product deposition was made under conditions duplicating those of earlier runs except that the air employed as the sparge and sweep gas was passed through a drying tower packed with "anhydrone." About 46 percent of the uranium which had been in the melt before the by-product, product sequence was removed in this step. Analysis of two samples of the product deposit showed that, relative to the salt phase at the start of this step, plutonium had been enriched by factors of 1.32 and 1.48. Fission product decontamination factors were ca. 2 for cerium, 7 and 8 for other rare earths, and 130 and 250 for strontium. Once again, the cerium decontamination represents the only perceptible change, being about twice that of earlier runs.

Difficulties were encountered in analyzing the moisture content of the "dried" air, and it is not known to what degree this drying technique was successful.

Plutonium Behavior - A visible cathode deposit was achieved on electrolysis of a NaCl-KCl-1 w/o $PuCl_3$ system under dried air. The deposit was very fine and fragile and dissolved rapidly in 8 M HNO_3-0.1 M HF. About four percent of the total added plutonium was found on the cathode after its removal from the melt.

Electrolysis of a NaCl-KCl - 1 w/o UO_2Cl_2 - 1 w/o $PuCl_3$ system gave results somewhat beclouded because most of the deposit fell off the cathode. However, the Pu/U ratio in the fraction of the deposit remaining on the cathode was about ten percent higher than that of the initial melt.

Such observations are slowly bringing electrophoretic processes to the forefront in speculation relating to the manner of incorporation of plutonium in electrodeposited UO_2.

Electrolyses of NaCl-KCl-UO_2Cl_2-$PuCl_3$-$CeCl_3$ systems under "by-product" conditions (oxygen-free, moisture-free, anode-generated chlorine gas blanket) with the cathode "driven" at high cathodic overpotentials gave the following results:

Cathode Potential (vs Ag/AgCl reference cell)	Pu DF	Ce DF
- 1.45 volts	37	31
- 1.7 volts	18	21

Under these conditions over 60 percent of the uranium remaining in the melt after electrolysis for 2-1/2 to 3 hours was found to be uranium(IV) on dissolving the melt into aqueous solution.

The foregoing observations confirm a suspicion that the M(III) $\longrightarrow$ M couples for plutonium and rare earths may be too close in potential to achieve any selective removal of rare earths from plutonium. Deposition potentials of the other rare earths lie between cerium and plutonium.

Manner of Growth of Electrodeposited UO_2 - Exploratory studies of the effect of gaseous atmosphere on the manner of growth of electrochemical UO_2 deposits have been largely completed. Results are as follows:

Atmosphere	Rate of Deposition	Deposit
Dry He	Very slow	Polycrystalline deposits having very smooth (polished) surface. Grain boundaries not visible or barely perceptible on surface (without preparation) measured density 10.76 g/cc (98 percent of theoretical).
Dry air	Very rapid	"Mace" composed of "Christmas tree" or "spear-point" crystals in radial orientation. Individual spear-point crystallites as much as 8 mm long.
Cl_2	High current but low net deposition rate	Smooth but unpolished surface. Grain boundaries barely discernible on surface.
Moist He	Fast	Irregular surface. Deposit has "amorphous" appearance.
Cl_2 + air	Moderate	Smooth but unpolished surface. Grain boundaries visible because of exposed crystal faces of different "sheen."
HCl + air	Moderate	Tightly cemented crystals of substantial size. "Faceted" surface composed of many slightly tilted planar crystal faces.

The foregoing were all grown out of NaCl-KCl melts containing ca. 12 w/o uranium and on a platinum "pin point" cathode and, despite the fact that the electric field is non-symmetric, exhibit spherical symmetry.

Perhaps the most interesting type of deposit is the very dense deposit achieved by electrolysis under dry helium. Although polycrystalline, void volume is low, as indicated by a bulk density (measured by displacement) about 98 percent of theoretical UO_2 crystal density (10.76 g/cc via 10.9 g/cc). Other properties of interest include O/U ratios of 2.0015 to 2.0048, total alkali metal content of 100 to 200 ppm and chloride content of ca. 80 ppm.

Growth under the same conditions but on a platinum wire about one-inch long in a non-symmetric electric field yielded a "sausage" of approximately cylindrical shape.

Studies of $KCl-PbCl_2$ Systems - A study was made of the effect of K/Pb ratio on the properties of electrodeposited UO_2. The depositions were all made out of a melt containing 10 m/o uranium and at 600 C. Potassium to lead ratios of 1, 1.5, 2.0, and 2.5 were studied. The UO_2 deposits from all these melts were very similar. Oxygen to uranium ratios were less than 2.01 in all cases. Lead contents varied from ca. 500 ppm at K/Pb ratios of 1 and 1.5 to ca. 200 ppm at ratios of 2 and 2.5. Sieve analyses showed 10 to 20 mesh, ca. 50 percent; 20 to 35 mesh, ca. 25 percent; 35 to 60 mesh, ca. 15 percent; 60 to 100 mesh, ca. 6 percent and ca. 4 percent less than 100 mesh.

Variation of temperature likewise had little effect on the properties of UO_2 electrodeposited out of $2KCl-PbCl_2$. Products made at 500, 550, 600, 650, 700 and 750 C all exhibited O/U ratios less than 2.006 and with the exception of the products at 700 and 750 C lead contents less than 500 ppm. At 700 and 750 C the lead impurity was ca. 1000 ppm. Build up of soluble uranium species of lower oxidation state was appreciable at 650 to 750 C, uranium (IV) contents of aqueous solutions prepared from the residual melts being equivalent to 16, 22 and 30 percent of the total uranium at 650, 700 and 750 C, respectively.

The deposits made in the $KCl-PbCl_2$ systems are all of the "mace" type, consisting of large and well-formed crystals. The indication is that larger crystals are favored by higher uranium concentrations. No indication has yet been seen of any inherent cut-off point. Individual crystals of 0.200 to 0.380 grams have been grown on single day shift operations. The single experiment to date in which the apparatus was allowed to run overnight produced individual crystals of the order of 0.5 grams.

Chemical Decladding - The use of chlorine-nitrogen gas mixtures was investigated for decladding UO_2 fuels clad with oxidized Zircaloy. In tests made on oxidized Zircaloy coupons at an initial temperature of about 415 C it was determined that the reaction rate and therefore the temperature of this highly exothermic reaction could be controlled by adjusting the gas flow rate and the nitrogen-to-chlorine ratio.

Two oxidized Zircaloy-clad fuel pins containing UO_2 were declad in a Vycor reaction tube. In the first run the initial nitrogen-to-chlorine ratio in the feed was 4 to 1, with a gradual decrease to 1 to 1 during the run. The UO_2 was exposed but not completely declad in 2.5 hours. The failure of the reaction to go to completion is attributed to condensation of the $ZrCl_4$ product on cooler parts of the reacting surface. In the second run the initial nitrogen-to-chlorine ratio was 1 to 1; after one hour of operation it was decreased to 1 to 2. The maximum temperatures observed

adjacent to the pins during the first and second parts of this run were 535 C and 645 C, respectively. All the cladding except for a small part of one end plug was removed within 2.5 hours. In both runs part of the $ZrCl_4$ condensed on the walls of the reaction tube and contained about 0.1 percent U.

Engineering Studies - Molten salt was recirculated between two 20-liter salt baths by means of gas lifts. The uninsulated dual gas lift system was made of fused silica and was tested with air and equimolar NaCl-KCl at 750 C. Steady state operation was maintained for 30 minutes with 15 to 20 inch lift and a 15 to 10 inch depth. Because of its self-adjusting nature, the gas lift system maintained equilibrium liquid levels in the two baths during the operation period.

Continuous Ion Exchange Contactor Development - Jiggler Contactor

Search for a simple device to provide a net one-way flow of resin under pulsed bed conditions has led to the design and application of two check valves in the pulser chamber of the Jiggler. These valves in combination with the pulser provide the basic elements of a pump. Initial experimental evidence indicates that the resin thus moves with a positive displacement action. The resin "pump" appears to have eliminated the necessity of having dense bed conditions above the pulser chamber to provide necessary driving force to propel the resin. The new valves are simple and appear to be dependable. The only moving part is a small plastic sphere which is activated by the hydraulics of the system.

Tests of several hours duration each, with no process liquids being pumped through the system, demonstrate that both 20-50 and 50-100 mesh resins can be readily pump through 4-inch glass pipe. The smaller particle resin moves easier than the larger. Slip water, under these conditions, was negligible in both cases. The quantity of resin moved appeared to be directly related to the amplitude-frequency product. The new pumping arrangement developed 40 psig while recirculating the 20-50 mesh resin through a column comprising a combination of 4-inch glass pipe and 1-inch plastic tubing to a net height of 15 feet. Considering a flowsheet for a plutonium-anion exchange system with a feed flow of 1.5 liters per minute, this pressure is several times greater than the back pressure that would be imposed on the system by countercurrent flowing process streams.

RADIOACTIVE RESIDUE FIXATION

Meltable Waste Solids

Because of current interest in continuous melt pots for waste calcination, or for the re-melting of powders, additional work was done on the rate of decomposition of sulfate in sodium sulfate based systems and on the melting range and fluidity of phosphate systems.

The rate of thermal destruction of sulfate in fluid sulfate melts containing a 5:1 atomic ratio of sodium to iron was measured as a function of surface to volume ratio. It was found that most of the sulfate is expelled during the early stages of heating but that the process is inhibited as a crust of ferric oxide forms. Thus the reaction is, in practice, dependent on the surface to volume ratio.

Melting point and "drip temperature" measurements were made on synthetic wastes containing 1.82 M Na, 0.45 M Fe, 0.06 M Al, 0.043 M Cr, 0.034 M Mn, 0.020 M Ni, and

phosphate ranging from 50 percent to 125 percent of stoichiometric. Only those systems containing at least 80 percent phosphate melted. The 80 percent phosphate sample melted at 1000 C, and those with 92.5 percent (or more) phosphate were fluid at 900 C. Drip points decreased from 962 C at 92.5 percent phosphate to 778 C at 125 percent. Qualitatively, however, fluidity decreased as phosphate increased.

Spray Calcination

Additional runs were made in the calciner to further test the ceramic cloth filters, perfect off-gas sampling methods, and obtain data on the de-entrainment effectiveness of the various units in the off-gas system. The cloth filter has continued to operate well and with very low pressure drop. Also, the jack-leg unit has shown no tendency to hold up large amounts of powder. The de-entrainment factor across the filter was 1000, that across the condenser was 100, and across the scrubber 1.5, for a total for the system of 1.6×10^5. Post-run cleaning of the filters and column by water flushing seemed to work quite well.

Tests were made of Nucerite coating (a high temperature ceramic glaze applied to metals by the Pafauder Chemical Company) both for spray calciner application and for use on waste storage containers. Some softening was observed in all tests, and it appears unsuitable for heat transfer surfaces. However, the material might be quite useful for normal processing equipment and on waste containers which are heated for only a short time.

Mineral Reactions

Equilibrium distribution measurements were made to compare the adsorption of cesium, cerium, and strontium from synthetic Purex 1WW waste by a commercial phenolic resin, a synthetic zeolite, and clinoptilolite. Clinoptilolite was superior for cesium adsorption in the pH range studied, from pH 2 to 10. The phenolic resin had a significantly improved K_d at the high end of the pH range, consistent with previous experience that indicated optimum cesium adsorption above pH 12. Further measurements at higher pH are being made. The K_d measurements for both cerium and strontium were somewhat anomalous and difficult to interpret. However, the phenolic resin seemed to give the highest cerium K_d values in the lower pH range of the three adsorption materials. The removal of cerium from solution at a higher pH was the greatest for clinoptilolite systems. The strontium distribution coefficients measured were essentially the same for all three adsorbers.

Condensate Streams

The low capacity of sulfonated polystyrene resin for Cs-137 in Purex tank farm condensate was found to be the result of ammonia in the condensate. Concentrations of ammonia as high as 0.013 M were measured in samples of this waste; recently some fission product recovery waste containing about 0.8 M NH_4^+ had been added to the waste storage tanks. The ammonia is vaporized from the basic salt waste and appears in the condensate; about half of the condensate is recycled back to the waste tanks so it takes a significant time to clear the ammonia from the system. The possibility of other sources of ammonia, such as radiolysis, is being considered. In laboratory column experiments, fifty percent breakthrough for NH_4^+ and Cs^+ was attained after 150 and 240 column volumes, respectively, when condensate containing 0.013 M NH_4^+ at pH 3 was passed through a bed of resin. For a different batch of condensate containing 0.0083 M NH_4^+, 50 percent breakthrough for NH_4^+ and Cs^+ was attained at 230 and 340 column volumes, respectively.

Micro Pilot Plant Runs 14 and 15 were designed to explore the ability of a synthet cation exchange resin (Amberlite IR-120) in the hydrogen form for removing radioisotopes from Purex Tank Farm condensate having an adjusted pH of 2.5 to 3.5. The acidified waste was passed through activated carbon to remove organic matter before passage through the resin. Run 14 was prematurely terminated because the resin column became plugged with precipitated iron hydroxide formed after being dissolved out of the carbon column. Acid soluble materials in the carbon were leached out with dilute nitric acid before starting Run 15. During Run 15 about 1200 liters of the acidified waste were treated. Radiochemical analyses showed that little or no radioisotope removal was obtained during the test.

Efforts to explain this poor performance resulted in the identification of ammonia in the Purex Tank Farm condensate in concentrations ranging from 0.004 M to 0.013 M. The presence of this base explains the failure to achieve the expected decontamination during Runs 14 and 15. Samples of feed for Runs 11, 12 and 13 were also analyzed for ammonia; it was present in amounts varying from 0.002 M to 0.004 M.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

The Corps of Engineers, Seattle office, again began explorations at the dam site at river mile 348. Coring is achieved by means of rotary (coring or diamond-drill) machines, following which, at periodic intervals, the casing is driven to hole bottom by churn drill machines moved over the hole for that specific purpose. One hole was reported drilled to a depth of 90 feet; a second was begun. Materials encount were sands and gravels, as predicted.

The log sheets of the airborne magnetometer survey of the Hanford Works and vicinity made in 1959 by the U.S. Geological Survey were received. Preliminary interpretation confirmed the southeastward extension of the Gable Mountain anticline to about a mile south of Ringold. The deep basins in the basalt southeast of 200 East Area and beneath 100-B Area were further confirmed and profiles obtained. An anticline, previously unsuspected, evidently lies beneath 100-F Area and 100-N Area and passes south of 100-D Area. It dies out to east and west without achieving surface expression. The depth of its crest is not known. The anticline is believed, however, to have folded the overlying Ringold beds sufficiently to have influenced the location of one or more old river channels in the Ringold formation surface north of Gable Mountain. It also may have thereby influenced the location of today's river channel near 100-D and 100-H Areas and probably affects ground water movement in the area bordered by 100-K, D, H and F Areas.

Methods were sought and studied for reducing the computation time required for numerical solution of non-linear differential equations. Much of the theoretical development of ground water flow results in models of this form, which are prohibitively expensive to solve by conventional methods. Procedures for reducing three-dimensional problems to two dimensions were tested and methods for speeding up iteration convergence were investigated. None of these tested showed obvious superiority for application to ground water problems. Among the methods studied for improving iteration convergence were the Shortley-Weller 4-point, 9-point, and 15-point methods; the boundary contraction method; and several matrix methods.

The computer program for numerical solution of unsaturated flow problems successfully computed the incremental development of a wetted soil volume beneath an

axial leak in a waste tank for the case of porous, homogeneous soil to the point at which 15,000 gallons of liquid had entered the soil. After the program has been successfully tested for the homogeneous soil case to a point of somewhat greater liquid release it can be applied to more realistic heterogeneous soil cases. The continued development and testing of this computer program was curtailed for budget reasons, but work has continued at a reduced rate with preparation of a program for steady flow systems.

A temperature probe capable of measuring to 0.1 F was obtained to permit a temperature survey of the ground water underlying Hanford Works. The distribution of temperatures may well provide additional information regarding the movement of ground water.

Soil Chemistry and Geochemistry

The polymerization which occurs in litharge and glycerol mixtures was utilized in the laboratory as a bonding agent for powdered zeolites. A method was sought for preparing these materials for application to laboratory column experiments. Several other bonding agents were examined, including sodium silicate, ethyl orthosilicate, and a number of gels. All of these were found to have some unsatisfactory characteristic for laboratory application, such as undesirable wetting properties, instability in hot water, or lack of chemical resistance. The glycerol-litharge cement is stable in cold to boiling water, ten percent mineral acids, and mildly alkaline solutions. Prolonged contact with strongly alkaline solutions eventually depolymerizes the cement.

On the basis of equal weights of zeolite, the exchange kinetics of powdered clinoptilolite cemented with glycerol-litharge was found to be the same as that of the uncemented powder or naturally cemented material. It is expected that this cement will permit the study of exchange properties of several zeolites that can be obtained only as powders.

Laboratory experiments indicated that pyrite (FeS_2) is apparently replaced by sphalerite (ZnS) in solutions of Zn^{+2} as low as 10^{-4} to 10^{-3} M. A statistical experimental design was followed to explore the importance of several system variables in the replacement reaction. Of those studied, temperature and solution pH were indicated to be of most significance. Within the experimental limits, the oxygen concentration was found to be of minor significance, indicating that the replacement reaction is not dependent upon oxidation of the pyrite. This is not felt to be generally applicable to replacement or adsorption reactions of sulfides.

Field Apparatus Development

Components for the orifice-type flowmeter designed for very low vertical flows in wells were received and preparations were made for assembly and testing. The control circuit for the flow meter and packing element was designed. It incorporates voltage and polarity-sensitive relays to provide the necessary functions of inflation and deflation of the packer, and for transmitting signals indicating direction and rate of water flow.

Micromeritics

Design changes required a revaluation of a proposed aerosol sampling probe and delivery line for a chemical process air stream. In the 20-foot long 1/2-inch line, the retention of 20 μ and smaller particles of density 2 was estimated to be negligible for the flow rates anticipated.

Beta-Coincidence Gamma-Ray Spectrometry

A beta-coincidence gamma-ray spectrometry technique was developed which allows improved analysis of certain radioisotopes in aqueous solution. Although the method has not been completely optimized as yet, a background reduction of a factor of 40 can be obtained with only a 50 percent loss in efficiency. This results in increased sensitivity. The degree of selectivity is also improved since only beta-gamma emitters are counted, thus eliminating interferences from K-capture radioisotopes such as Cr-51 and Zn-65. Relatively large (about 100 ml) liquid samples are introduced into a liquid scintillation beta counter which is operated inside a large well crystal gamma-ray detector. Only the spectra from gamma-rays which appear in coincidence with beta particles are observed. This technique will have special application to river water samples.

Silicon Surface Barrier Alpha Detectors

Silicon surface barrier alpha detectors have been found to be superior to Frisch Grid Ion Chambers for the determination of alpha emitters in certain plant streams. The surface barrier detector has a tolerance to beta activity which is about 100 times greater than for the ion chamber and also has a reduced "low energy alpha tail." This makes possible analysis of samples by direct plating instead of requiring chemical reduction of the beta activity, and a greater sensitivity due to less interference from higher energy alpha emitters. A further advantage is the much lower cost of a surface barrier alpha counting system.

Reaction Kinetics of Paramagnetic Centers in Irradiated Seeds

Investigation of the formation and decay of paramagnetic centers in radish seeds during and after gamma-irradiation was continued. Relative concentrations of centers were followed as functions of time by EPR measurements. The peak-to-peak heights on the recorded first-derivative curves for each sample were measured and divided by the analogous quantity from a standard diphenyldipicryhydrazyl sample measured on the same day with similar instrument settings. In this way, relative concentrations were evaluated which should be independent of day-to-day variations in the sensitivity of the EPR spectrometer. Absolute concentrations will be evaluated as time permits, but relative values are sufficient for many purposes.

Prior to irradiation, dormant radish seeds were found to give a small signal at the magnetic field strength characteristic of organic free radicals. The signal intensity at this field strength increased by a factor of 100 after the seeds absorbed 1.0×10^5 rads of Co-60 gamma-radiation in the presence of air. Duplicate samples differed by less than ten percent in signal intensity after the same absorbed dose and a better time schedule for irradiation and measurement will improve this precision. In the presence of air at 298 K (25 C), concentrations of paramagnetic centers in seeds have been followed for two months. The decay is not a simple zero or first order reaction in terms of center concentration. The decay curves can, of course, be expressed as a sum of exponential terms in which certain fractions of the total center concentration can be regarded as decreasing with different half-lives. Although this representation has no theoretical support, it does give an expression of the magnitudes of the time intervals involved.

Thus, roughly half of the centers present one hour after irradiation apparently decay with a half-life of 40 days while the remainder exhibit a half-life of less than 8 days. Similar measurements at 310 K (37 C) in air indicate half the centers present one hour after irradiation decay with a half-life of 16 days while the remainder exhibit a half-life of 0.75 days.

A tentative activation energy for the long-lived component can be calculated to be 14 kcal$\cdot$mole$^{-1}\cdot$deg^{-1} which may be compared with values of 9-12 kcal$\cdot$mole$^{-1}\cdot$deg^{-1} for the diffusion of other neutral species such as gases dissolved in solid polymers. As more data become available a better comparison of the activation energies for these reactions and typical diffusion-controlled chemical reactions will be made. In this way, the hypothesis of free-radicals diffusing and combining with each other in this living tissue can be tested.

This investigation has shown that radish seeds provide a convenient medium for the investigation of chemical reactions produced by irradiation in living tissue. Not only are the seeds of an ideal size for EPR studies, but their metabolic rate is low and the paramagnetic centers formed in them during irradiation are long-lived. These latter features allow adequate time for treatment of the seeds with various radical-scavenging reagents, followed by a kinetic study of the EPR signals from the seeds after irradiation. Comparisons can then be made between the ability of a reagent to depress the signal intensity in seeds and its ability to protect them from lethal or genetic damage.

O. F. Hill
for Manager
Chemical Research and Development

LP Bupp:cf

A. ORGANIZATION AND PERSONNEL

On March 1, 1961, Dr. R. F. Foster, Manager, Aquatic Biology, transferred to the Radiation Protection Operation as Manager of Environmental Studies and Evaluation Operation. P. A. Olson is Acting Manager, Aquatic Biology.

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 dilute untreated effluent and to like concentrations of effluent passed through a bed of aluminum turnings. Fish exposed to the effluent passed through the aluminum (4 per cent strength) show a slight increased mortality over those of the control and untreated effluent, but any significance is still questionable.

I^{131} in Rabbits

Fifty samples of sagebrush and thyroid glands and stomach contents from 25 jack rabbits were collected and analyzed for radioiodine. Results will compare concentrations of I^{131} in the thyroids of the animals to that in food and will establish the range of variation. This special study will conclude the rabbit sampling program of the past several years.

C. columnaris

From the strains of columnaris obtained last summer, it is clear that there is a wide variation in virulence, even of strains taken at the same time and in the same location. As an example, one strain was obtained from river water at 62 F. It caused no kill of fish within three days after exposure. Another strain, taken on the same day and in the same location, caused 100 per cent kill of 50 fish within the three-day period.

Possession of an essentially avirulent strain will be useful in projected tests for the induction of virulence.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Strontium and Calcium

Radioanalysis of two survivors of the medium-treatment (5×10^{-2} μc Sr^{90}-Y^{90}/g/day for 21 weeks) fish seven months after ending isotope feeding showed little difference in total beta activity in compact tissues (e.g., scales, otoliths, operculum) when compared to samples taken from fish sacrificed at the end of feeding. On the other hand, the soft tissues, such as the liver, spleen, G.I. tract, showed only about 5 per cent of the total activity observed at the close of chronic feeding.

A study on the transport of Sr^{90}-Y^{90} through the gastrointestinal tract in trout showed, six hours after single oral administration, that about 60 per cent of the isotope was still retained in the fish and about 20 per cent at 18 hours. The total beta activity in the fish, exclusive of the G.I. tract, represented about 2 to 4 per cent of the given administration at six hours.

Study of the excretion of intravenously injected Sr^{85} and Ca^{45} into the small intestine was completed. In these experiments the small intestine of an anesthetized rat was perfused in situ with solutions of varying calcium content. The radioisotopes were injected intravenously and their subsequent appearance in the perfusate measured. Maximal excretion during a 30-minute period following injection amounted to five per cent of the injected radioisotope. There was no discrimination between strontium and calcium. There appeared to be no effect of perfusate-calcium level except possibly at the highest (25 mM) calcium level where excretion appeared to be somewhat reduced. These results indicate that conclusions drawn from previous studies of calcium and strontium absorption from the intestine could not have been significantly influenced by re-excretion of the absorbed radioisotopes.

Limited studies of Sr^{85} and Ca^{45} excretion into the large intestine indicate that this route of excretion is less significant than that via the small intestine by a factor of approximately ten.

Carbon-14 labeled dinitrophenol (DNP) was used to determine why the effect of DNP on water and calcium uptake was pH dependent. It was found that the DNP was rapidly absorbed and translocated when the nutrient solution was held at pH 4, but slowly taken up when held at pH 6. It appears that this difference is due to the more rapid uptake of the un-ionized DNP molecule.

[redacted]

Iodine

Lambing is about 50 per cent complete. Thyroid uptake studies on new-born lambs, an area not previously investigated, are being performed. (In addition to the regular thyroid monitoring, the whole-body monitor is being used to obtain thyroid and whole-body counts.)

Cesium and Potassium

The experiments on moisture stress previously conducted with Cinebar soil were repeated using Millville soil, with an appreciably lower uptake of Cs^{137} noted. However, the effects of moisture stress on the cesium and potassium concentrations in plants were similar to those observed on Cinebar soil. Cesium concentration in stem and petiole tissue, and other plant parts, was increased as moisture tension (drying) in the soil was increased. Relatively little effect on potassium concentration in the plant was noted.

Comparative Toxicity of Strontium, Plutonium and Radium

Radiographs were taken of the right forelimb and hind limb of all miniature swine on this study. A progression of earlier bone damage was noted with the most severe changes seen in animals injected with Pu^{239} (1.3 μc/kg body weight) at six weeks of age.

The forelimbs are showing considerably more damage than the hind limbs. This may be related to the greater weight supported by the fore limbs or to trauma to the front legs in jumping against objects and dropping to the floor with considerable force.

All animals appear grossly normal although there is a great deal of variation in individual condition -- a reflection of their communal feeding. Utilizing the whole-body monitor, estimates of the body burden were obtained. Reasonable counts were obtained in radium and strontium animals but not in the animals injected with plutonium.

Hazard Evaluation of Sr^{90}, Cs^{137} and I^{131}

Based upon available large-animal data on the metabolism of Sr^{90}, Cs^{137} and I^{131}, the levels of contamination in edible animal products following both chronic and single exposure of the animals to these radionuclides in air or vegetation were evaluated. This was accomplished by determining for each radionuclide a theoretical MPC relative to the MPC for air and water for man that would result in the edible products containing contamination levels equal to the MPC (water) for man. These values may then be multiplied by the acceptable MPC's for man to determine the maximum permissible concentrations of the radionuclide to which the animals may be exposed. The relative MPC's were determined for milk, meat, kidney and liver for the dairy cow, beef cattle, sheep and swine. The advantage of the relative MPC's is that a standard procedure may be used for all radionuclides and the ratios of ion pairs would therefore not be needed.

Plutonium

A new chelating agent 2-(B-Aminoethoxy) cyclohexylamine-N,N,N',N'-tetraacetic acid was tested for its ability to promote the excretion of plutonium from the rat. When administered one hour following intravenous plutonium citrate this new agent stimulated the urinary excretion, during the following four days, of 64 per cent of the injected dose. Untreated control animals excreted less than five per cent. Animals treated with DTPA excreted 72 per cent. The new agent, therefore, would appear to be less effective than DTPA. However, its effect on fecal excretion of plutonium and tissue distribution remain to be evaluated. Test are also being made of its effectiveness when administered orally.

Some preliminary experiments have been directed toward the identification of pluto binding sites in soft tissues. Plutonium in adrenals was not removed with phospholipid or steroid fractions but remained in the protein residue. Approximately one-third of plutonium remaining in liver 90 days after injection was extracted wi water and two-thirds with 0.1 n NaOH. The NaOH treatment removed plutonium which could not be removed by DTPA treatment of the tissue.

Cerium, Neptunium, Americium, and Strontium

Available literature on the metabolism of Ce^{144}, Np^{239}, Am^{241} and Sr^{90} was surveyed. Based on the information obtained, equations were developed for estimating the body burdens of the above radionuclides by analysis of urine of man. This material was submitted to and discussed with the Intenral Dosimetry Group. Data on cerium, neptunium and americium was very inadequate and restricted principally to small animals. Estimates for these radionuclides could easily be in error by a factor of 10. Studies are being planned to determine the excretion patterns and toxicity of these radionuclides in miniature swine. The animals would be injected in groups of three and added to the groups already injected with Sr^{90}, Ra^{226} and Pu^{239}.

Radioactive Particles

Three groups of rats were exposed to $Ce^{144}Pr^{144}O_2$ aerosols for retention and translocation studies, and for testing therapy agents. Carbon black and negative ion inhalation were tested for possible effects on pulmonary clearance of radioactive particles. (A negative ion generator was provided by General Engineering Laboratory, Schenectady, New York.) Results of the tests are not complete.

Gastrointestinal Irradiation Injury

Continuation of studies on repeated irradiation of the abdominal area, with and without cysteine protection, indicate that bi-weekly doses of 500 r can be tolerated, without protection, up to a total dose of about 10,000 r. With this accumulated dose, animals die of what appears to be starvation, after a decrease of approximately 50 per cent in body weight. Protection with cysteine prevents the weight loss and mortality. Bi-weekly doses of 1,000 r are tolerated for extended periods with cysteine protection. At 1,500 r, bi-weekly, cysteine protection has little effect and animals die after an accumulated dose of about 6,000 r.

Microbiological Studies

Experiments on radiation effects on the cation binding properties of yeast cells were extended to calcium ions. Two to three times more calcium was adsorbed to irradiated cells as compared to non-irradiated cells. It is not clear whether this binding was limited to cell surface or may have resulted from a change in permeability. The latter seems quite possible since high calcium concentrations in the medium effect a reduction in leakage of cellular components from irradiated cells. Further studies are in progress to determine whether this reduction constituted a repair of damaged membranes.

Plant Ecology

It was found that chlorophyll production of terrestrial algae can be estimated by acetone extractions without separating the algal filaments from the soil matrix. The absorption spectra obtained show that the green pigment extracted is largely chlorophyll "a". Methods are being investigated to report the chlorophyll "a" content in terms of milligrams of chlorophyll per gram of soil.

Cultures of the algae (Microcoleus vaginatus) which were exposed to X-radiation dosages of about 145,000 r did not show any reduction in chlorophyll production.

Project Chariot

Sorting of samples for ecological analyses of the invertebrate communities of the Cape Thompson, Alaska region was continued. Collections of mollusks and annelids were prepared and sent to taxonomic specialists for determinations.

Development of a program was completed for IBM analyses of specific gamma emitters from fallout in the plants and animals collected from Chariot field studies.

A H Kornberg

Manager
BIOLOGY LABORATORY

HA Kornberg:es

PAGE D-6

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c. Biology Seminars

Daubenmire, R. G., Department of Botany, Washington State University, Pullman, Washington, "Ecologic problems of the sagebrush vegetation in Washington," March 8, 1961.

Sullivan, M. G., "Gastrointestinal tract function following exposure to radiation," March 22, 1961.

Palmer, R. F., "Facilities at HAPO available for biological research," March 22, 1961.

D. Publications

a. HW Documents

Staff of the Biology Laboratory, "Biology Research Annual Report for 1960," Document HW-69500 (in press).

b. Open Literature

None

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - MARCH, 1961

ORGANIZATION AND PERSONNEL

J. H. Wujek joined the operation on March 1 as a technical graduate on a 3-month rotational training program assignment.

OPERATIONS ANALYSIS STUDIES

Fuel Element Performance

Data from the complete file of about 6650 fuel elements thus far irradiated and measured under the Quality Certification Program are being used to obtain revised estimates for the coefficients of the models expressing warp, tube filling capacity, and diameter change as a function of reactor operating conditions. These models are useful in predicting fuel element behavior under various sets of conditions, and in removing the effects of reactor conditions when evaluating fuel element quality as such. The new estimates will be completed in April.

These data are also being used to investigate fuel element distortion as a function of canning date, and the effect of this on the incidence of observed hot spots. It has been established that plotting such quantities as a function of canning date is essentially the same as plotting as a function of Fernald shipping date, so that variations observed may be related to core quality.

A report was written recommending methods of describing fuel element distortion for irradiated NPR fuel elements. The method uses polynomials, which are easily fit using orthogonal polynomials, to describe the fuel element profile. It was also pointed out that similar methods can be used on present fuel elements in order to better describe the types of distortion present. The technique will be used on a sample basis in the near future.

Assistance of a consulting nature was provided in connection with developing a rupture model for hole failures.

Optimization of Reactor Operations

A model was developed which gives fuel element clip requirements, assuming various alternate courses of action with respect to procedures in handling clips. These clips will be used in charging bumper fuel elements. The number required depends on their cost, the economic consequence of running short, and the physical flow of clips.

Z-Plant Information Systems Study

Process technology continues to be modified in preparation for full process line operation. The best logical definition for future operation of the final machining step and the new ingotting furnace and break-out facility has been obtained, and these sections have been coded into the over-all computer program.

Four days of machine debugging were accomplished before the memory drum was removed for modification. Several areas of the program benefited from this activity. It was also discovered that the high speed output punch was not functioning properly. This is to be corrected during diagnostics following reinstallation of the memory drum unit.

A meeting with the Manager, Research and Engineering, CPD, was held to re-establish the computer study continuity with newly appointed CPD managers and discuss personnel requirements to facilitate a successful computer demonstration.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Pre-irradiation warp data from NPR co-extruded fuel elements were analyzed in order to assist in determining how the number of rejects due to excessive warp might be reduced. Of primary interest was an evaluation of the effects on warp of successive Beta-heat treatments. Vector quantities were used to estimate these effects. The possibility of pre-straightening before Beta-heat treating was evaluated. It was also suggested that if shorter fuel elements are used, the warp is reduced by a considerable amount.

A sequential sampling plan had previously been developed for use in the acceptance sampling of lots of aluminum components with respect to wettability characteristics. Further work was done this month in describing the results to be expected when within lot variation is changed.

Irradiation Processing Department

A study of uniform corrosion models is continuing.

A theoretical model is being fitted to some points which describe fission decay in a reactor.

A study was made to determine whether the recent failures of rear cross-header fittings are indicative of an increasingly severe problem. Sample size requirements for examining fittings for near failures were also computed.

The problem of determining the symmetric interconnection of contacts from nine identical relays was solved by the use of symbolic logic. Requirements for the circuit were:

(a) Each relay should have the same number of contacts.
(b) The number of contacts per relay should be a minimum, and
(c) The circuit of contacts should be nonconducting whenever any seven of the nine relays were de-energized.

This analysis arose in connection with the design of a safety circuit.

Chemical Processing Department

Consultations and computations were continued for Finished Products Technology in connection with the design and use of equipment, fixtures, and gauging mechanisms necessary to accurately fabricate and inspect proposed weapon components.

Comments were given in connection with potential hazards involved in the shipping of cesium and strontium to Oak Ridge.

Assistance was given in preparing for a study concerning assigned automobile utilization. Results from queuing theory will be applied.

The number of measurements required per part in the acceptance inspection of final product has been reduced due to improved analytical and process control. One analytical determination suffices for most parts.

In connection with determining the Pu-240 content of final product, an evaluation was made of the accuracy of the mass spectrometer, which is used on a sample basis in conjunction with the part-by-part measurement done by neutron counting. Questionable parts located by neutron counting are also re-measured by the mass spectrometer.

Steps are being taken to use evolutionary operation techniques in connection with the production of buttons. Several variables associated with the reduction of the fluoride will be controlled. It is tentatively planned to try and optimize yield, keeping purity above a specified level.

Relations Operation

Three additional salary curves were fitted at the request of Relations personnel.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Chemical Development

Consultations continued with Process Development Operation in the general area of instrument calibration for the pending pulse column test facility experiments. Additional mid-column photometer pilot study data are being analyzed to determine the effect of the temperature differential between calibration temperature and the temperature during experimental runs. An appropriate temperature correction factor will be derived from this data. An experiment was designed to calibrate the rotometer which will be used to measure flow rate of the pulse column feed stream. Since the relationship between bulb displacement and flow rate is influenced by solution density, the calibration is being done for a range of uranium concentrations from 50 to 120 g/l.

Work continued on a mathematical problem associated with ion exchange phenomena reported in January. Further meetings were held with interested personnel of the Chemical Research and Development Operation of Hanford Laboratories for the purpose of mutual clarification of the chemical and mathematical concepts involved.

Materials Development

Components of variance calculations were performed on graphite physical properties test data for Materials Development Operation. Tensile strength

measures, load and deflection, electrical resistivity, thermal conductivity and coefficient of thermal expansion data were analyzed to determine the variability of the properties within a graphite block and between several such blocks. The effect on the average value of these properties of crystal orientation, resulting from extrusion of the blocks during fabrication, was also estimated.

4000 Program

Swelling Studies

Analysis of pore size distributions for irradiated uranium samples, pre- and post-anneal, continued in order to determine the heterogeneity of such distributions within a single uranium sample.

Plutonium Recycle

Several minor modifications were made in the experiment previously designed for Structural Material Development Operation to investigate the reliability of a fluorescent penetrant nondestructive test used to detect surface defects on zirconium tubes. It was not possible to procure sufficient tubes with roughly the same number of defects to handle the experiment as initially designed. The modified experiment uses 32 tubes - 18 are now available and an additional 14 should be in another month.

An experimental program was designed for Ceramic Fuels personnel to investigate high energy uranium oxide impacting as a function of the independent variables, oxygen uranium ratio, Dynapak piston pressure, and oxide temperature. The primary function of the experiment is to determine how these variables interact so that maximum density impacting can be realized as a function of oxygen uranium ratio with piston pressure and oxide temperature kept as low as possible.

Further progress has been made on the problem of achieving dense packings with mixtures of three fixed sizes of spherical particles. Three sizes and the relative proportions of each have been discovered that yield a volume packing factor in excess of .9. It can be shown that an absolute upper bound for the packing density of three sizes of spheres is .9825.

6000 Program

Biology

The linear kinetic multicompartment biology model is in the process of being generalized. In particular the entire model is being rewritten in terms of a multivariate diffusion partial differential equation. It is expected that the solution, when obtained, will bring the present estimation technique within the purview of classical statistical estimation theory.

General

Instrumentation

A statistical analysis of data from a recent calibration study by Instrument Research and Development Operation was initiated. The results will provide a

reference system for the calibration of linear differential transducers for use in in-reactor creep testing of zirconium alloys.

Work Sampling Study

A statistical analysis of data from the work sampling study recently conducted by Analytical Laboratories Operation has been completed and the results reported to interested persons.

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. Statistical analysis was performed of mass spectrometer standards data and estimates of the precision and accuracy of the instrument were provided to interested persons.

The study to determine the possibility of using isotopic concentrations of plutonium to make inferences about the reactor conditions under which it was produced is continuing.

MISCELLANEOUS

Methodology

Several discussions were held with personnel of Nuclear Physics Research Operation and some mathematical calculations were done in connection with the use and interpretation of a computer code for generalized least squares analysis recently obtained from the Los Alamos Scientific Laboratory.

A table of the function $2N \log N$ for $N = 1(1)5000$ has been calculated and a foreward to explain its use has been written. This material is being prepared as a formal statistics and mathematics distribution Hanford report.

A table and accompanying nomogram for the calculation of sample-background ratio confidence limits from low level counting statistic data has been prepared. A formal report for mathematics and statistics distribution is currently being written to circulate this material to HAPO research personnel.

Carl A. Bennett, Manager
Operations Research & Synthesis

CAB:kss

PROGRAMMING OPERATION
MARCH 1961

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Computer Code Development. Microscopic debugging of the fuel cost portion of the PUCK code is nearly finished. Fuel costs for the recycled plutonium mode are checking in all four fuel cost components and in total fuel cost, but some further debugging will be necessary because some intermediate values do not agree with the standard. Results for the uranium mode still differ slightly due to variations in a minor term. The equations to be used in subroutine Rx have been coded as a main program for testing purposes. Resulting compositions of the plutonium isotopes appear correct; but as yet, cannot be considered authoritative. Rx will be the master minding routine for PUCK and will prescribe the equilibrium and near equilibrium plutonium compositions for analysis. Currently, the PUCK code analyzes only the secular equilibrium case which may, in fact, take hundreds of years to attain.

The supercritical reactor design has progressed to the point where more precise fuel costs are needed than were supplied earlier with the PUCK code. Programming has been supplying such data to the Reactor and Fuels Operation of the Hanford Laboratories. MELEAGER, a physics burnup code, will be utilized to give exposure vs. enrichment for both batch and graded fuel discharge schemes. These bracket the operating case of primary interest since the Supercritical Reactor would likely be operated in a compromise mode. These exposure data will be supplied to the QUICK fuel cost code with a wide range of the input economic parameters. Preliminary debugging demonstrated the feasibility of the method, and the necessary cases are being set up.

Work continues on an interim topical report dealing with the effect on fuel cost of using various different fuel claddings, including comparisons between zircaloy and stainless steel. This first report covers uranium enrichment, but the study will be extended to include the ramifications of plutonium enrichment. The larger neutron cross sections of plutonium generally allow the use of more parasitic material in a reactor. To fully evaluate the possible optimum fuel element designs using plutonium enrichment, more care must be given the actual fuel geometry by virtue of plutonium self-shielding in the thermal spectrum and significant epithermal absorptions which, in turn, require self-shielding treatment. As a consequence, this work is being treated as a fuel geometry study for which generalized high speed codes are being developed. If blind use is made of codes to determine the necessary parameters, a ridiculously large number of computations appear necessary. However, inspection of the basic relationships within the codes and the actual available knowledge indicates that a manageable computation load should be possible. As a consequence, a simple code is being prepared to select the computations

to be made in view of the actual possible significance, and then to define the limits of the results. While this work is under way, the plutonium-enriched burnup studies are being organized. Much of this work can be made available to this study be editing reactor fuel burnup data from specific cycle analyses. These data will be tabulated so that reactor designs maximizing the value of plutonium can be qualitatively defined.

Plutonium Recycle Program Planning Activities. The long range schedule for fueling the PRTR is being revised and up-dated, taking into account changes in delivery dates for high-exposure plutonium, revised neutron yields from plutonium based on the PRTR critical tests, and other changes which have occurred since the previous schedule was issued.

A study has been started to identify the conditions for economical application of partial-decontamination separations techniques, such as the "Salt Cycle" process, to over-all fuel cycles for the utilization of plutonium in power reactors (plutonium recycle). Initial efforts are being directed at determining the types of fuels and reactor feed and burnup conditions under which partial-decontamination type processes such as "Salt Cycle" appear attractive. One of the major considerations will be determination of the cost of remote, heavily shielded refabrication of partially-decontaminated, plutonium-bearing, fuel elements.

One member of Programming has provided consultation on design scoping of the Fuels Recycle Pilot Plant, and participated in a visit to six sites to discuss the latest operating philosophy and design considerations for "hot" laboratories. Of interest from these contacts is the continuing shift of the meaning of "containment" from "containment as a personnel protection device" to "contamination control and easy disposal".

2. SPECIFIC CYCLE ANALYSES

Code Development. The first working version of a computer program designed to generalize the MELEAGER burnup calculations has been completed. The code converts batch irradiation data to uninteracted graded data and will provide shut off data for either mode at any desired final reactivity. Thus, a single MELEAGER physics calculation represents both batch and uninteracted graded cases at any number of final k_{∞} values, which constitutes a gross saving of computer time. Concurrently, the MELEAGER physics code has been changed to allow fully-interacted, graded burnup calculations to be made in addition to the uninteracted computations mentioned above. These two forms of graded irradiation bracket the possible lattice arrangements that may be encountered in a reactor. Computation of fully interacted cases can be rapidly completed since over-all reactor conditions apply, which eliminates the necessity of altering the nuclear cross sections as the burnup proceeds. The MELEAGER generalization code has been written so that it can also process the fully interacted graded discharge data, although slightly different relationships are used. The code curve-fits the isotopic compositions, the exposure, and the instantaneous and average k_{∞}'s as a function of time. The isotopic density fit is accomplished by approximating the data with an exponential function, and then fitting the difference by two third-order polynomial functions. The time scale is then normalized to a constant flux and

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selected specific power case to represent graded irradiation. Third-order polynomials are also used to fit the data as a function of k_{∞}. This provides "shutoff" data at a number of limiting k_{∞} values so that a single MELEAGER calculation can be converted into any number of cases at a great savings in computer time. A complete calculation with an unlimited number of final k_{∞} values requires about one minute compared with approximately three minutes for a single MELEAGER case which produces only one k_{∞} value.

A revision of the QUICK economics code was prompted by the necessity for refining the incremental fuel element fabricating and jacketing cost (FEFJ) calculation for simple plutonium recycle. This incremental additional cost is required for jacketing plutonium bearing fuel elements over the cost of jacketing uranium-only fuel elements. In this revision, the available plutonium is considered to be mixed with tails composition uranium while the fraction of the fuel elements in the reactor that contain plutonium is determined by the criterion that the enrichment (atomic fraction) of each element in the reactor be the same. The FEFJ cost for the reactor is calculated by adding the basic FEFJ cost to the delta cost and multiplying by the fraction of the elements that contain plutonium. This revision permits evaluation of a zoned reactor in which the concentration of recycled plutonium is maximized so that the over-all cost of the incremental fabrication charges, delta, is minimized. The impact of this is most impressive. For example, in a typical thermal reactor, by confining the plutonium enrichment to depleted uranium, 10 to 20 grams of fissionable plutonium are used in each pound of fuel which spreads a delta value of $20/lb of fuel such that the plutonium value is decreased only one to two dollars per gram. If, on the other hand, the recycled plutonium is used to enrich every fuel element in the reactor, then, the recycled plutonium is in two to three gram quantities in each pound of fuel and the associated plutonium value reduction is $10 to $20/gram for an incremental charge of $20/lb of fuel. There is a cost involved with zoning since higher-enriched uranium must be purchased for the uranium-enriched zone at a slightly higher cost. Accordingly, this section of the code is arranged so that:

1. The plutonium can be mixed with any desired uranium composition, or the computer can be instructed to select the minimum cost mixture.

2. The enrichment of the plutonium bearing fuel elements can be adjusted to obtain the same heat rate (i.e., fission rate), the same initial k_{∞}, or the same enrichment as the uranium-only fuel elements.

Specific Studies. Final normalization studies are nearing completion that reconcile the MELEAGER burnup analysis with the methods employed for analyzing the APWR (TID-8502). With completion, an extensive analysis of plutonium value in the APWR will begin. The analysis will be for batch and graded operation, with zoned and unzoned plutonium enrichment for simple recycle, and for full plutonium enrichment without zoning. In addition, thorium with U-233, U-235, and plutonium as alternative enrichments will be examined.

The report of plutonium value in the Beloyarsk, Russia, superheating reactor is in final rough draft form and will be published as HW-68479. Generally speaking, plutonium has a high value in this machine due to the improvement in thermal utilization afforded by the high neutron cross section of plutonium. Values of $14 to $16/gram of fissionable plutonium as nitrate are typical results of the computations. These values are reduced to $12 to $14/gram as metallic buttons, which is the form currently stipulated by the AEC for comparisons.

Details of this and other studies were presented at the DRD Evaluation and Planning Branch (EPB) program review in Washington on March 21 and 22. In addition, a paper was accepted for the ANS June meeting entitled, "A Comparison of Key Nuclear and Economics Factors for Thermal Reactor Fuels". The paper is based upon error analysis studies made for the APWR study. Measurements of the productivity of varying only eta for U-235, U-233, Pu-239, and Pu-241 were made by altering nu for each and computing the resulting change in value. Corresponding computations were also made for the key cross sections. The relative dollar value of the nuclear fuel is taken into account by parameterizing the price schedule for U-235 at fifty, one hundred, and two hundred percent of the present schedule, and by including the relative non-nuclear charges for three fuel element fabricating charges. The data clearly show that the value of Pu-239, when compared to U-235, would be confounded because the slightly reduced Pu-239 eta value effect would be obscured by the greater absorption cross section of Pu-239. In addition, plutonium-239 fissions less often than U-235. It now appears that additional correlations may be possible by considering the fissionable-to-fertile cross section ratios, from which some generalization may be possible about the value of various plutonium batches.

B. OTHER ACTIVITIES

A document was issued (HW-68922) which proposes consideration of research and development activity on a means of coupling an aqueous process for primary decontamination with a fused-salt, fluoride-volatility process for final uranium decontamination. Plutonium would be isolated by conventional ion exchange methods. In the most advanced alternative of this proposal partially-decontaminated uranyl nitrate solution would be delivered into a cell in which hydrogen and elemental fluorine are produced by electrolysis of a fused salt. By establishment of a suitable pattern of flow it is hoped that the nitrate could be successively dehydrated, denitrated, reduced with hydrogen, and converted to UF_4 at the cathode and finally to UF_6 at the anode. In a situation requiring new separations facilities such a combined process may afford major economies. It could also be potentially attractive in the processing of non-production fuels and in uranium ore milling.

The risks associated with shipment of large quantities of radioisotopes are being evaluated, and requests have been initiated for additional data to improve the confidence in such estimates. This work is in support of projected shipments of tens of thousands of curies of materials such as Sr-90, Cs-137, and Ce-144.

Hanford waste disposal practices, environmental monitoring, and appropriate related research were reviewed with S. H. Small of the International Atomic Energy Agency, Vienna, Austria. Also, similar topics plus the proposed ecological studies in the Columbia River system including the estuary and oceanographic studies were discussed with Dr. I. H. Wallen, AEC-Wash., Division of Biology and Medicine. A report was compiled and transmitted to AEC-HOO for the use of AEC-Wash., Division of Biology and Medicine, in the Special Report to Congress on Life and Physical Sciences.

HAPO-wide irradiation units requirements were reviewed and compiled by programs for Fiscal Years 1961, 1962, and 1963, and transmitted to HOO. The tabulation included the needs for each program by capsule irradiations and loop irradiations in sufficient detail for Commission planning purposes.

Assistance was provided in arranging for visits and tours by 209 visitors during the month. This number included 99 visitors on 39 official visits, plus 110 students and school administrators on four separate tours. It also included one Austrian, one Swede, and 11 Japanese nationals of the Japanese nuclear material test reactor team.

Study is being given to the possibility of having one day a month set aside as "tour day" at Hanford, and to publicizing this procedure, in order that all but official visits would be held on this day. The maximum capacity for handling tour visitors under such a plan is estimated at about 1200 visitors in one day.

F. W. Woodfield
Acting Manager,
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FW Woodfield:rd

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF MARCH, 1961

A. ORGANIZATION AND PERSONNEL

The internal re-alignment of the Radiation Protection Operation became effective March 1. The Section is now composed of six Subsections and two individual contributor positions reporting to the Manager - Radiation Protection. In conjunction with the staffing of the new Subsections, R. F. Foster joined the Radiation Protection Operation as Manager, Environmental Studies and Evaluation and H. V. Larson joined the Radiation Protection Operation as Manager, External Dosimetry. John M. Selby, Engineer, was rehired into the Radiological Development and Calibrations Operation on March 13. Alice L. Didier, Secretary, was hired into the Internal Dosimetry Operation on March 7. Effective March 20, Melvin L. Brinkerhoff, Chemical Analyst, was transferred to the Fuels Preparation Department as a Metal Handler. The total force in the Radiation Protection Operation on March 1 was 138; 39 exempt and 99 non-exempt.

B. ACTIVITIES

An HLO employee, assigned to the 325-A High Level Cell Facility, received an exposure of 6.3 rads beta and .19 r gamma, as measured by his film dosimeter. The source of this excessive exposure to the skin was believed to be a highly contaminated metal bar or contaminated protective clothing. The metal bar which was handled was subsequently found to have surface contamination of 150 rads/hour at two inches. The dose to the skin exceeded the maximum permissible dose of 6 rads recommended by the NCRP for a 13-week period.

Four IPD employees received transient internal deposition when an unknown gas under pressure was released from a sample tube in the inner rod room of the 105-KE Building. Whole Body Counter measurements indicated 6 - 100 nc of Na^{24} and from 30 to 180 nanocuries (nc) of Zn^{65}, representing respective maxima of 2% and 0.3% of the maximum permissible body burden (mpbb). Three other IPD employees received transient internal deposition of Mo^{99} while lubricating the reactor control rods at the 105-DR Building. Examination in the Whole Body Counter indicated from 125 - 280 nc of Mo^{99} (1.6% - 3.6% of the mpbb) with traces of Na^{24} and Zn^{65}.

A localized exposure from a radioactive particle on the face of an IPD employee resulted in an estimated maximum dose of 4.6 rads, including .05 r to a small skin area.

Particulate fission product contamination occurred throughout the 105-KW Building during the removal of the ruptured fuel element and process tube from the reactor front face. The contamination, which was believed to result from removal and disposal of contaminated protective clothing, was confined to the building.

There were no new cases of plutonium deposition confirmed during the month. The total number of plutonium cases that have occurred is 265, of which 193 are currently employed.

A faulty seal on a tank containing plutonium nitrate solution resulted in widespread contamination of equipment, floor areas as well as to three employees at the Physical Constants Test Reactor in the 305 Building. Decontamination and resurfacing of floor areas proceeded throughout the month in contaminated air up to 1.5×10^{-9} μc Pu/cc. Microcurie amounts of plutonium were measured on the hands of one employee and on other surfaces in the reactor room. Preliminary bioassay samples of involved employees indicated little, if any, deposition of plutonium.

The floor and bench in Room 42 in the 231-Z Building were contaminated up to 40,000 d/m from the radium on the dials of an aircraft bomb site that had been dismantled to obtain some gears and shafts. Several improvements have been incorporated into the new Physical Testing Mobile Laboratory which will result in improved radiation control. Included are a generator for operation of additional lights and radiation instrument alarms, a flashing red light on the truck, improved shielding during transport, and greater security of the sources when the truck is unattended.

The criticality meters alarmed in the 325 Building and in the 305-B Building at unrelated times during the month. Immediate followup surveys and processing of the disaster film kits confirmed that no abnormal radiation event had occurred. The cause of the alarm in the 325 Building was not determined. In the 305-B Building, the alarming level had been established too low for operating the Physical Constants Test Reactor at a power level of 100 watts.

A program to obtain background bioassay and Whole Body Counter measurements for Sr^{90} on all Maintenance Laboratories and service personnel at the Hot Semi-Works was initiated. Background sampling of the Hot Semi-Works stack was initiated during the month. The following average activities were discharged:

gamma emitters	negligible
beta emitters	1×10^{-5} curies/day
alpha emitters	1×10^{-6} curies/day

Laboratory sensitivity for measuring Sr^{90} on the integrated filter sample is 9×10^{-7} curies/day. This represents approximately 1% of the release limit for this isotope.

Equipment revisions and recalibration of the Redox stack 50' level sampling equipment was accomplished. A 3/4" orifice was installed to provide the isokinetic sample flow through the manifold while allowing a volume of 2.4 cfm through the sampler. Additional revisions remaining are: 1) diversion of steam jet discharge from the stairs and back into stack to prevent contamination of stairways and icing in winter months, and 2) relocation of the steam trap at the top of the stairs to prevent icing.

Field testing of the charcoal adsorber cartridges for I^{131} monitoring continued. Data to date indicates that additional development work on design is required.

Calibration of the modified sodium iodide scintillation equipment for aerial monitoring was reinstituted. Flights were made at varying altitudes and at different time constants over a 2 curie cobalt source. The results were in fair agreement with calculated values. Measurements were made over land and an infinite water source to determine the capabilities of detecting an increase in background due to contamination. A reduction by a factor of two was observed from land to water at 500'. Since the background over the water was essentially the same at lower altitudes as at 500', this indicates that it should be possible to detect an increase in ground radiation levels of about 25% for an infinite source size. Five flights were made during the month for a total of 26 manhours of flying time for environmental monitoring personnel.

The Automatic Columbia River Monitoring Station (ACRMS) continued to operate sporadically due to previously reported amplifier troubles. Two new solid state amplifiers were ordered on an emergency basis and installation of the new amplifiers was planned during the second week of April.

The ACRMS was in operation part time during the down period of the reactors on March 13th and 14th. A definite trend in the measured activity of the river was noted. In addition, several radiation traverses and temperature measurements were made on the Columbia River. Results of these studies will be reported separately.

Sampling of Columbia River fish was started by the Environmental Studies and Evaluation Operation on March 29, 1961. All equipment ordered for fish and waterfowl sampling was received. Modification of the laboratory is currently in process and should be completed during the first week of April. Discussions were held with Dr. Eagan and others of the State Agriculture Department relative to obtaining bovine thyroids. Favorable cooperation was indicated and the details are currently being worked out. Twenty-four crop samples were obtained during the month. Routine surveys of the ground of control plots in the 200 Areas indicated no unusual conditions that were not previously noted.

Compilation of information relating to reactor effluent and the measurement of radionuclides in the Columbia River was begun for use in an audit of the monitoring and evaluation of this source of environmental exposure.

The State of Washington Department of Game was re-contacted to encourage initiation of a survey of the kinds and numbers of fish and waterfowl harvested from this area and the quantities eaten by local residents. Formal contract arrangements for the surveys are nearing completion.

Waste disposal policies for the Fuel Recycle Pilot Plant are in the process of being formulated. The majority of effort has been concentrated on establishing gaseous exhaust limits. Those radionuclides which are being investigated are Pu^{239}, U (natural), I^{131}, Sr^{90}, and Sr^{89}.

A study was initiated of the potential need for restricting use of land south of the 300 Area, considering planned additions to plant facilities and the northward growth of the City of Richland.

Assessment of the maximum consequences of an accidental release of selected radionuclides during shipment was completed during the month. Two cases were considered. The first case involved the shipment of 90,000 curies of Ce^{137} in an Oak Ridge designed cask (STT). The second case involved the shipment of 80,000 curies of Sr^{90} in a HAPO designed cask (HAPO 1A). The results of these analyses were documented in HW-68899 with L. L. Zahn as co-author.

The Radiological Design Criteria for the Fuel Recycle Pilot Plant were completed and distributed. The feasibility of moving Burial Ground #6 to permit the location of the FRPP facility due east of the 308 Building was studied.

Landsverk Instrument Company indicated that the one hundred prototype ionization chamber finger ring dosimeters, being obtained for final evaluation, will be shipped by the end of March.

Development work on the new film badge dosimeter continued. Film shielded with 25 mils of tungsten and exposed to equal doses of filtered X-rays with energies from 52 to 170 Kev exhibited a density range of 10%. At higher energies, the density increased by about 60% indicating that a thinner tungsten filter is required to normalize the film response from 0.05 to 1 Mev. Tungsten filters, 20.8 mils in thickness, have reduced the density variation, at constant dose, to about 10% over the energy range from 0.05 to 1 Mev.

X-ray templates to code dosimeter film with the area as well as the week and year in which it was worn are being fabricated for use in the badge processing machine.

The design of the new automatic densitometer has required considerable rework by the Nucleonic Instrumentation Operation. The design is now 70% recompleted and the equipment about 40% fabricated. Necessary parts for all alterations have been obtained and final completion of this project is predicted for April.

The 9" diameter double moderator criticality dosimeter received additional performance evaluation testing. The foil system similar to the Savannah River criticality dosimeter has been added to provide the division of the neutron spectrum into five energy groups. Test performance to date indicates that the total single collision theory dose in rads can be evaluated with an accuracy of $\pm$ 15%. The performance of copper foils irradiated at neutron energies ranging from 0.230 to 0.916 Mev was found to be about a factor of 5 less than the response at 1.8 Mev. These observations indicate that a copper foil will be useful for measuring the total neutron flux below about 1 Mev.

Several threshold foil detectors were exposed to neutrons to investigate the feasibility of counting the foils on a single channel counter. The neptunium fission foil calibration curve was calibrated against an actual neutron exposure. An analysis of the threshold foil detector system and the double moderator criticality system is being prepared. A neutron moderator designed to provide thermal neutrons from the positive ion accelerator has been completed and is ready for installation in the Positive Ion Accelerator Building.

A jig for use in positioning the impactor head on the portable impactor air samplers has been designed. Six units were fabricated. To assure constant efficiency of the impactor air samplers, it is necessary that the distance between the impactor head and the collector plate be maintained at a predetermined value. The jig permits the checking and relocation of this spacing if necessary.

A review of calibration procedures and methods has been initiated in order to define areas in need of improvement, correction, or development attention. An extensive program to provide necessary modifications to procedures and equipment is being initiated. As part of this program, the K-fluorescent source was re-examined and an appropriate new dose rate calibration obtained.

An electrically-driven system for rotating film dosimeters during routine calibration at 16 and 59 Kev was designed to eliminate slight discrepancies in K-fluorescent source beam intensities. Comparisons of dosimeters calibrated on the rotating system and previously calibrated dosimeters show a significant decrease in density variation between dosimeters. All of the initial K-fluorescent X-ray filters have been replaced. Each filter now has the same dimensions and consists of a single sheet of material. The energy and dose rate obtained with each new filter was reviewed prior to its use. Some further studies of the energy spectra remain to be completed.

Routine calibration and special services were provided to customer groups. A total of 39.8 calibration hours were spent on special studies during the month. The year-to-date total for special studies is 160.2 hours. The 220 KVP X-ray unit was recalibrated with the free air chamber. The dose rate had drifted down about 15% since the last calibration.

Safety rules, emergency call list, and evacuation procedures were reviewed and updated. The air conditioner switch was plainly identified, and a klaxon warning horn was installed to signal for building evacuation as necessary. All radium sources stored in the vault were given a leak test. Excess papers were processed for 19 CP meters, 4 Juno meters, 4 GM meters, and other obsolete equipment.

A prototype Scintran instrument was received from General Electric, San Jose, California, and is undergoing preliminary acceptance and calibration test. The Bendix self-reading pencils were received and are being given calibration performance checks. At this time, 28 out of 200 pencils received have failed some portion of the acceptance test.

C. TRIPS AND VISITORS

David Wagstaff from the Oregon State Board of Health visited the Calibration facilities on March 16.

C. M. Unruh attended the Film Dosimetry Performance Criteria Meeting held at Germantown AEC office. L. R. Rogers, Assistant Director, Nuclear Materials Safety for the AEC convened the meeting to discuss personnel dosimeter criteria. The criteria being developed may at a future date be utilized in evaluating the performance of commercial film dosimeter services.

J. W. Novak and W. E Bleiler from Argonne National Laboratory, Lemont, Illinois, visited Radiation Protection facilities to discuss radiation protection procedures and methods used at Hanford.

K. R. Heid attended the Nuclear Weapons Medical Symposium at Albuquerque, New Mexico.

Seven of twelve papers submitted for presentation at the 1961 Annual Meeting of the Health Physics Society have been accepted thus far. The papers accepted were:

1. "Columbia River Continuous Monitoring System" - by T. C. Mehas
2. "Radiological Protective Apparel Program At Hanford" - by T. C. Mehas
3. "A Portable Dose Rate Instrument For Measurement Of Natural Background Radiation Levels" - by F. L. Rising
4. "Experience With An Ionization Chamber Pulse Reader At Hanford" - by F. L. Rising
5. "Radiological Development Within The Hanford Radiation Protection Program" - by C. M. Unruh
6. "Radionuclide Classification: Relative And Absolute Hazard" - by J. W. Vanderbeek
7. "Quantitative Measurements Of Some Gamma Ray Emitting Radionuclides In Nuclear Industrial Workers By Whole Body Counting Techniques" - by F. Swanberg

D. EMPLOYEE RELATIONS

Three suggestions were submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to 8. Three suggestions were adopted and one rejected. Three suggestions submitted by RPO personnel are pending evaluation.

Three were three medical treatment injuries during the month for a frequency of 1.20 No security violations occurred during March.

Radiation protection training included: three 1-hour demonstrations of protective equipment and their use were presented by radiation monitors to 90 members of Design Engineering Operations; four 2-hour training sessions on radiological problems at the Biology Facility were held with all 100 Area Firemen; and one 2-hour talk on radiation protection was presented to all Hot Semiworks personnel.

E. SIGNIFICANT REPORTS

HW-66954 "Radiological Design Criteria For The Fuel Recycle Pilot Plant" by L. G. Faust and C. M. Unruh

HW-68751 "Control Limits For Concentration Of Radioactive Materials In Aqueous And Gaseous Effluents From The Plutonium Recycle Test Reactor" by G. E. Backman

HW-68851 "Analysis Of Radiological Data For The Month Of February, 1961" by R. F. Foster

HW-68899 "Maximum Liability Evaluation, Strontium And Cesium Shipments Decalso Media" by E. C. Watson and L. L. Zahn

HW-69039 "Monthly Report - March, 1961, Radiation Monitoring Operation" by A. J. Stevens

L. C. Rouse presented a lecture entitled, "Some Health Physics Aspects Of PRTR" to the Columbia Chapter of the Health Physics Society.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-February 1961 - Mid-March 1961)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.7	% MPC_w-GI*
Separations Areas	Gross Beta	2.3×10^{-7}	µc/cc
Pasco	Isotopic	9.1	% MPC_w-GI**
Kennewick	Isotopic	< 1.0	% 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	3.0	% MPC_w-GI*
Hanford	Isotopic	2.5	% MPC_w-GI*
Pasco	Isotopic	18	% MPC_w-GI**
McNary Dam	Gross Beta	No Sample	µc/cc
Vancouver, Washington	Isotopic	0.5	% MPC_w-GI**
Atmosphere			
I^{131} Separations Areas	I^{131}	6.8×10^{-14}	µc/cc
I^{131} Separations Stacks	I^{131}	0.8	Combined cur. c
Active Particles - Project	--	1.0	ptle/100 m^3
Active Particles - Environs	--	0.1	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	2.1×10^{-6}	µc/g
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Eastern Washington and Oregon	I^{131}	No Sample	

* 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.

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
March	1	1
1961 to Date	1	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
March	5,324	67	3	0
1961 to Date	14,742	213	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)
March	11,128	963	136	43	30	9.87	23.50
1961 to Date	30,503	2,640	266	78	78	9.02	20.38

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
March	2,320	0	0	0	10
1961 to Date	5,232	0	0	0	25
Fast Neutron					
March	777	79	10	0	10
1961 to Date	1,596	218	53	0	25

Whole Body Counter

	Male	Female	March	1961 to Date
GE Employees				
Routine	41	2	43	148
Special	10	0	10	27
Terminal	0	0	0	1
Nonemployees	3	0	3	9
Pre-employment	0	0	0	0
Total	54	2	56	185

Bioassay

	March	1961 to Date
Confirmed Plutonium Deposition Cases	0	2*
Plutonium: Samples Assayed	518	1,933
Results above 2.2×10^{-8} µc Pu/sample	18	53
Fission Product: Samples Assayed	577	2,062
Results above 3.1×10^{-5} µc FP/sample	0	2
Uranium: Samples Assayed	291	862

*The total number of plutonium deposition cases which have occurred at Hanford remains 265.

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples	Following Period of No Expos Units of 10^{-9} µc U/cc Maximum	Average	Number Samples
Fuels Preparation	80.3	3.2	74	436.0	10.6	62
Fuels Preparation*	1.7	1.7	1	0	0	0
Hanford Laboratories	19.9	3.1	32	6.5	2.1	27
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	58.0	7.2	32	41.7	6.2	38
Chemical Processing*	81.4	47.1	2	16.8	8.3	3
Special Incidents	470.0	51.4	18	0	0	0
Random	1.0	1.0	2	0	0	0

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

Thyroid Checks	March	1961 to Date
Checks Taken	0	0
Checks Above Detection Limit	0	0
Hand Checks		
Checks Taken - Alpha	30,682	87,339
- Beta-gamma	42,968	139,998
Skin Contamination		
Plutonium	29	63
Fission Products	46	129
Uranium	1	24

CALIBRATIONS	Number of Units Calibrated March	1961 to Date
Portable Instruments		
CP Meter	852	2,710
Juno	220	703
GM	433	1,782
Other	160	497
Audits	99	312
Total	1,764	6,004
Personnel Meters		
Badge Film	1,623	4,263
Pencils	-	-
Other	309	1,198
Total	1,932	5,461
Miscellaneous Special Services	1,181	2,142
Total Number of Calibrations	4,877	13,607

A. L. Keene
Manager
Radiation Protection

1230075

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - MARCH, 1961

GENERAL

There was one security violation charged to the Operation.

There were no major injuries; the minor injury frequency rate was 2.29, which is considered below average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 19,837 hours. This includes 14,721 hours performed in the Technical Shops, 3,621 hours assigned to Minor Construction, 259 hours assigned to other project shops and 1,236 hours assigned to off-site vendors. Total shop backlog is 21,651 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 8.3% (1,457.9 hours) of the total available hours.

Distribution of time was as follows:

	Man-Hours	% of Total
Fuels Preparation Department	4,957	25.0%
Irradiation Processing Department	739	3.7%
Chemical Processing Department	646	3.3%
Hanford Laboratories Operation	13,298	67.0%
Construction Engineering & Utilities	17	0.1%
Miscellaneous	180	0.9%

Requests for emergency service increased sharply, requiring an overtime rate of 8.3%, compared to 5.4%, the previous period. A majority of the requests originated from the Weapons Component Operation in CPD and the PRTR Operation in HLO.

At the close of the reporting period, there were two open requisitions for Machinists and one for a qualified Instrument Technician. Candidates for these positions have been processed and final call-in issued. Two Machinists were added to the roll during the reporting period. A Junior Engineer associated with the Manufacturing Training Program was assigned to the Technical Shops for a six-month training period. Exposure to all phases of shop operation is planned, with vacation relief duties furnishing the majority of the experience.

Security performance was considered satisfactory, with no violations. There were nine medical treatment injuries, which is considered within the normal control level in an operation of this type.

CONSTRUCTION OPERATION

There were 65 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $110,743. One hundred and fourteen new orders, 2 supplements and adjustments for underruns amounted to $78,072. Expenditures during the month on HLO work were $117,723. Total J. A. Jones backlog at month's end was $75,232.

Summary

	HL		CE&UO	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	64	$ 106,238	1	$ 4,505
Issued during the mo.(Inc.Sup.& Adj.)	114	73,072	1	8,524
J.A. Jones Expenditures during mo. (Inc. C.O. Costs)		$ 106,148		$ 11,575
Balance at month's end	69	73,162	1	1,454
Orders closed during month	109	227,211	0	0

FACILITIES ENGINEERING OPERATION

Projects

There were 12 authorized projects at month's end with total authorized funds of $1,942,000. The total estimated cost of these projects is $8,812,000. The difference between expenditures and estimated cost was $7,569,000, as of February 28, 1961.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end 12

Number of new projects authorized during the month: 2
- CGH-923 - Spectroscopy Laboratory - 325 Building
- CAH-921 - Geological & Hydrological Wells - FY-61

Projects completed during the month: 3
- CG-785 - In-Reactor Studies Equipment - 105 KW
- CGH-805 - High Temperature Tensile Testing Cell - 327 Bldg
- CGH-907 - Strontium-90 Interim Program

New project proposals submitted to AEC during month: 2
- CGH-922 - Burst Test Facility for Irradiated Zr Tubes
- CGH-927 - Additions to 271-CR Building Waste Treatment Demonstration Facility

New projects awaiting AEC approval:
- CGH-902 - Uranium Scrap Burning Facility
- CAH-917 - Field Service Center
- CGH-918 - Second Whole Body Counter Cell Addition - 747 Building
- CGH-919 - 314 Building Ventilation System
- CGH-922 - Burst Test Facility for Irradiation Zr Tubes
- CGH-924 - 200 KW Induction Heating System - 306 Building
- CGH-927 - Additions to 271-CR Building Waste Treatment Demonstration Facility

Project Proposals complete or nearing completion:
- Coolant Systems Development Laboratory
- Laboratory Waste Retention Facilities Expansion
- Safety and Operating Improvements - 231-Z Building

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) HLO PAC & 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.
Control and Safety Rods for Tamper Tank (Critical Mass)	Design work is nearing completion. Development work is required prior to completion of design.
Beryllium Dust Filters - 306 Bldg.	Fabrication and installation work is complete.
Electrical Modifications - 3702 Building	Field work is delayed pending availability of craftsmen.

1230078

Title	Status
Filter Changer - CWS	Drawings are being prepared of the proposed design involving a technique using plastic bags and shielded cart.
327 Water Basin - Clean-up System	A study is being made of a recirculating filter system for removing radioactive contaminates from storage basin water.
Cask Storage - 327 Building	A study is being started.
Material Handling System and Other Shop Improvements - 328 Building	Engineering work is in progress.
Motorized Door Opening Device - 327 Building	Design complete. Installation work is in progress and will be complete about April 15, 1961.
Modifications to H-1 Loop - 105-H Building	Conceptual work is in progress.
Arrange space and install utilities for business machines - 3760 Bldg.	Design work in progress.
Source Positioner - 3745 Building	Design complete. Material on hand. Installation depends on craft forces.
Special Air Conditioning - Laboratory in 222-U Building	Installation work is essentially complete.
Zone Modifications - 325 Building Air Conditioning System	Design is progressing on the addition of reheat coils and associated controls to the air conditioned space of 325 Building.

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 185 design drawings were completed this month.

Major design and drafting work in progress includes the following:

1. Structural Materials Irradiation Test Facility - design - 43 dwgs. required - 95% complete.
2. Thermal Precipitator - 5 dwgs. required - 40% complete.

3. Critical Facility - approx. 20 dwgs. required - 95% complete.

4. Process Calciner - 25 dwgs. estimated - 80% complete.

5. Transfer Cask - 327 Building - 7 dwgs. - complete.

6. Rupture Loop Mock-up Facility - 15 dwgs. required - work started.

7. Process Tube Monitor Mark III - 6 dwgs. required - work started.

Plant Maintenance and Operation

February costs were $136,309 which is 97.2% of forecasted expenditures.

Analysis of Costs

The cumulative expenditures continue about 2.8% below forecast to date. The emphasis on PRTR work has curtailed other maintenance because of craftsmen availability. The weather remains milder than normal with reduced steam consumption.

Improvement Maintenance

Item	February
Relocation and alteration	$ 920
Repainting	6986
Reroofing	0
Electrical Modifications	383
Piping Modifications	1191
H & V Modifications	(854)
	$ 8626

Waste Disposal and Decontamination Service

New lead casks were received during the month for waste disposal. These are being used on a trial basis and will be evaluated. The latent radiation in the liquid waste handling trailers appears on the increase. This is noted even shortly after decontamination of the trailers. The first step to be taken is to place a layer of lead over the front ends of the trailer thus protecting the tractor driver. Concurrently, a long range study is being initiated of liquid waste handling procedures for HLO.

Plant Engineering

Approximately 24,700 square feet of prints were reproduced during the month.

The total estimated value of the 20 requisitions issued during the month was $40,000. The majority of this procurement activity is for approved HLO projects.

Painting continued in 325 Building.

Interior painting was completed in 3707-C Building.

Painting of certain rooms in 231-Z Building continued.

Painting was started in 3745 Building.

The replacement, rerouting, and shielding of the crib waste line in 327 Building is being performed by J. A. Jones Construction forces.

A new type of sump pump was installed in basement of 326 Building to solve flooding problem; however, misoperation of controls allowed flooding to occur. These controls (float and guide) have been adjusted and the pumps are now being checked by the operators on each shift for proper operation.

Electrical Load Studies are being made in 325 and 3760 Buildings.

A drain line of adequate size connected to the 328 Building air washer was installed. This should minimize overflow problems and resultant damage to occupied space.

The crane in 314 Building is out of service until repairs are made. Material is on hand. Motors have been overhauled. Work will be complete about mid-April.

Improvements to safety features of 325-A Building ventilation system will be installed during April.

The crane in 321 Building is being readied for inspection and repairs.

Estimates have been obtained for redressing crane rails in 327 Building.

Criticality alarm systems installed in the Hot Semi-Works and Critical Mass Laboratory are being interconnected.

TECHNICAL INFORMATION OPERATION

James Cape, of the AEC Technical Book Section, visited Technical Information on March 20 - 21 in connection with the Commission's book publishing program. Hanford books on Graphite, Plutonium, Radioactive Waste Disposal and on Environmental Radiation Biology were discussed. The discussions also brought out the fact that a Hanford book on Radioactive Waste Monitoring might fill a definite need. An outline is being prepared.

Word was received late in the month that the Division of Classification has reinstated previous instructions on classifying plutonium. These instructions permitted certain limited quantities of plutonium, for use in unclassified projects, to be handled as unclassified.

A major bibliography "Review of Power and Heat Reactor Designs -- Domestic and Foreign" was completed during the month. Fifteen copies were prepared for internal HAPO use. The multilith masters are being forwarded to the Office of Technical Information Extension, Oak Ridge, from which they will be able to reproduce additional copies as off-site demand warrants.

A comprehensive bibliography on the Columbia River has been started. It will consist of about 400 Hanford reports, a few from the Public Health Service and other sources, and also selected references from the open literature of the last several years.

The Classified Files microfilming program is proceeding steadily, with 22,800 documents microfilmed to date. Considering the age of most of the documents being microfilmed, there is a surprising amount of use of the microfilm files. Classified Files is averaging 250 - 300 requests per month for the films.

The review for "Limited Circulation" and "Atomic Weapon Data" markings on all documents microfilmed to date has been completed. All documents presently being prepared for microfilming are being screened and marked by the Inventory Clerks. Some thought has been given toward providing title information for future microfilmed documents. It appears that this information could be obtained from an additional catalog card produced by the Flexowriter after the installation of the Card-a-type system. The title could be clipped from the card and inserted in the microfilm jacket.

Work Volume Statistics

	February	March
Document Distribution and Files		
Documents routed and discharded (copies)	22,215	19,763
Documents issued (copies)	14,361	11,466
Documents sent off-site (copies)	8,182	5,700
Document reserves filled (copies)	617	671
Documents picked up and delivered	20,827	19,114
Document Accountability		
Holders of classified documents whose files were inventoried	284	411
Documents inventoried in Files (copies)	--	--
Documents destroyed or retired (copies)	15,344	13,475
Documents revised (copies)	1,196	1,181
Documents pulled and documents filed (copies)	21,465	18,391
Documents reclassified	651	602
Documents microfilmed	4,843	4,220
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	207,343	204,941

	February	March
Reference and Publication		
Books cataloged (new titles)	146	88
Books added to the collection (volumes)	327	302
Ready reference questions answered by professional staff	200	223
Literature searches by professional staff	90	71
Reports abstracted (titles)	261	287
Formal reports prepared (titles)	16	9
Off-site requests for HAPO reports (copies)	231	181
Reports released to CAP (titles)	48	17
Library Acquisitions and Circulation		
Books ordered (volumes)	470	377
Periodicals ordered	172	208
Books circulated (volumes)	1,935	2,519
Periodicals circulated (issues)	3,201	4,144
Inter-Library Loans	83	81
Films borrowed or rented	20	10
Industrial film showings	77	53
Bound periodicals added to the collection	133	172
Bound periodicals discarded	35	1

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	31,138	8,603	1,757	2,046	43,544
No. of bound periodicals	14,418	14	1,891	6	16,294
	45,556	8,617	3,648	2,052	59,838

Classification and Declassification	February	March
Documents, including drawings and photographs reviewed for downgrading or declassification	246	351
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	45	26
Documents submitted to Declassification Branch, Oak Ridge	57	64

J L Boyd
Manager,
Laboratory Auxiliaries

JL Boyd:jw

1230083

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CG-785	In-Reactor Studies Equipment - 105 KW	0290

AUTHORIZED FUNDS				COST & COMM. TO 3-19-61	$ 283,257
$ 325,000	DESIGN $ 47,000	AEC $		ESTIMATED TOTAL COST	$ 305,000
	CONST. $ 278,000	GE $ 325,000			

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	1-5-59	9-9-60	DESIGN	12-30-60
CONST.	3-22-60	DIR. COMP. DATE 3-1-61	CONST.	3-1-61

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES	2	1250
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	0	710
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II		100	100
AE-TIT. II			
CONST.	100	100	100
PF	100	100	100
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a research and development facility to permit instantaneous measurement of physical properties of materials under dynamic in-reactor and simultaneous ex-reactor conditions.

Work on the exceptions is continuing, but is being held up pending receipt of the remaining procurement items. Since this project has been completed, with minor exceptions, it will no longer be reported.

PROJ. NO.	TITLE	FUNDING
CGH-805	High Temperature Tensile Testing Cell - 327 Building	0290

AUTHORIZED FUNDS				COST & COMM. TO 3-19-61	$ 164,867
$ 170,000	DESIGN $ 20,000	AEC $		ESTIMATED TOTAL COST	$ 168,000
	CONST. $ 150,000	GE $ 170,000			

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	8-26-58	9-9-60	DESIGN	6-15-59
CONST.	9-14-60	DIR. COMP. DATE 4-1-61	CONST.	4-1-61

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		740
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		285
GE FIELD ENGINEERING		50

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I		100	100
GE-TIT. II		100	100
AE-TIT. II			
CONST.	100	100	100
PF	2	100	100
CPFF	35	100	100
FP			
Mat'l	63	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides equipment for performing room and high temperature tensile tests on highly irradiated materials and involves the installation of a cell in the 327 Building.

The project is complete with the exception of installation of the in-cell tray to be fitted tightly around operating equipment and the normal start-up adjustments and modifications. The Physical Completion Notice is being prepared. No further reporting will be made.

1230084

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- [illegible]

DATE 3/31/61

PROJ. NO.	TITLE	FUNDING
CAE-822	Pressurized Gas Cooled Facility	4141-Opera

AUTHORIZED FUNDS				COST & COMM. TO	
$ 995,000	DESIGN $ 40,000 / CONST. $ 995,000	AEC $ / GE $ 995,000		ESTIMATED TOTAL COST	$ 1,120,000

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 8-19-59 / CONST. 10-17-60	DIR. COMP. DATE	6-30-61		DESIGN 4-29-60 / CONST. 9-30-61

ENGINEER

REDO - DP Schively

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.	ACT
DESIGN	100	100	
TITLE I			
GE-TIT. II	100	100	
AE-TIT. II			
CONST.	100	71	
PF			
CPFF	92	50	
FP	8	9=	

SCOPE, PURPOSE, STATUS & PROGRESS

The NaK heater is being prepared for return to Struthers-Wells for alteration.

A contract for $8,400 was awarded to Struthers-Wells for detail design of the Gas-Loop Shielding.

PROJ. NO.	TITLE	FUNDING
CGH-834	Modifications & Additions to High Pressure Heat Transfer Apparatus - 189-D Building	0290

AUTHORIZED FUNDS				COST & COMM. TO	
$ 700,000	DESIGN $ 66,000 / CONST. $ 634,000	AEC $ / GE $ 700,000		ESTIMATED TOTAL COST	$ 597,645 / $ 745,000

STARTING DATES		DATE AUTHORIZED		EST'D. COMPL. DATES	
	DESIGN 4-20-59 / CONST. 4-22-59	DIR. COMP. DATE	4-1-61		DESIGN 2-15-61 / CONST. 6-15-61*

ENGINEER

DEO - E. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	10	3700
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION	[illegible]	960
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACT
DESIGN	100	100	
TITLE I			
GE-TIT. II	100	100	
AE-TIT. II			
CONST.	100	100	
PF			
CPFF	100	100	
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 revised project proposal requesting additional funds and extension of the completion date is being routed for signatures. Construction has been stopped pending authorization of this revision.

* Based on the revised estimated cost of $745,000

1230085

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CAF-842	Critical Reactivity Measuring Facility	58-e-15

AUTHORIZED FUNDS				COST & COMM. TO 3-19-61	$ 114,934
$ 360,000	DESIGN $ 45,000	AEC $ 148,000		ESTIMATED TOTAL COST	$ 360,000
	CONST. $ 315,000	GE $ 212,000			

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 11-17-59			DESIGN 2-1-61
	CONST. 10-3-60	DIR. COMP. DATE 4-30-61		CONST. 4-30-61

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	32
PF			
CPFF			
FP	40	80*	80

SCOPE, PURPOSE, STATUS & PROGRESS

Contractor has the lock in position and grouted. Operating mechanism is still to be installed.

All concrete work is complete and installation of the structural steel has started.

* Revised schedule. The contractor was granted a 48-day extension due to late delivery of the lock.

PROJ. NO.	TITLE	FUNDING
CCH-858	High Level Utility Cell - 327 Building	0290

AUTHORIZED FUNDS				COST & COMM. TO 3-19-61	$ 70,000
$ 70,000	DESIGN $ 70,000	AEC $		ESTIMATED TOTAL COST	$ 400,000
	CONST. $	GE $ 70,000			

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 11-2-59	10-1-59		DESIGN 3-1-61
	CONST. 8-1-61*	DIR. COMP. DATE		CONST. 2-1-62*

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.

The project design is complete except for the incorporation of comments. A revised project proposal for total construction funds was transmitted to RCO-AEC on 3-8-61.

* Based on authorization of construction funds by 4-1-61.

1230086

SEMI – MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ.NO. CAE-866

TITLE Shielded Analytical Laboratory - 325 B Building

FUNDING 61-a-1

AUTHORIZED FUNDS					
$ 60,000	DESIGN $ 60,000	AEC $ 45,000	COST & COMM. TO 3-19-61	$ 15,000
	CONST. $	GE $ 15,000	ESTIMATED TOTAL COST	$ 700,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE			
DESIGN 9-5-59	DATE AUTHORIZED 5-31-60	DESIGN 12-14-60		WT'D.	SCHED.	AC
CONST.	DIR. COMP. DATE	CONST. 3-1-62	DESIGN	100	100	1
			TITLE I			
			GE-TIT. II	10	100	1
			AE-TIT. II	90	100	1
			CONST.	100	NS	
			PF			
			CPFF			
			FP			

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

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.

A reply was given to AEC on March 8, 1961, to their inquiries concerning the site for this facility.

PROJ. NO. CAE-867

TITLE Fuel Element Rupture Test Loop

FUNDING 58-a-15

AUTHORIZED FUNDS					
$ 1,500,000	DESIGN $ 130,000	AEC $ 770,000	COST & COMM. TO 3-19-61	$ 281,365
	CONST. $ 1,270,000	GE $ 730,000	ESTIMATED TOTAL COST	$ 1,500,000

STARTING DATES			EST'D. COMPL. DATES		PERCENT COMPLETE		
DESIGN 8-1-60*	DATE AUTHORIZED	DESIGN 2-15-61		WT'D.	SCHED.	AC
CONST. 11-2-60	DIR. COMP. DATE 10-31-61	CONST. 11-31-61	DESIGN	100	100	1
			TITLE I			
			GE-TIT. II	92	100	1
			AE-TIT. II	9	100	1
			CONST.	100	10	
			PF			
			CPFF	4		
			FP			
				2	13	
				3	1	

ENGINEER

REDO - PC Walkup

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Co.

All design drawings and construction specifications have been approved.

* Detail Design. Scope design started 12/4/59 and completed 1/15/61.

** Water plant construction scheduled for starting 3/1/61. Letting out for bid has been delayed by AEC.

1230087

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CAH-870	Facility for Recovery of Radioactive Materials-325 Bldg.	60-a-1

AUTHORIZED FUNDS				COST & COMM. TO	
$ 486,000	DESIGN $ 46,000	AEC $ 446,000		3-19-61	$ 39,957 (GE)
	CONST. $ 440,000	GE $ 40,000		ESTIMATED TOTAL COST	$ 486,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 11-20-59	DATE AUTHORIZED 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	98
PF	1	100	100
CPFF			
FP	99	99	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.

Work completed the last two weeks is as follows:

1. Due to a design change modifying Vault "A" tank nozzles the fixed price contractor's completion date was extended 14 days to 4/8/61.
2. All testing of mechanical and electrical work is completed.
3. A second punch list has been made and items of work are being completed.
4. All cover slabs have been placed on Vaults "B","C" and trench. The bottoms of these slabs and the main floor remain to be painted. The other large remaining item of work is polishing of all S/S liners.
5. The temporary wood in exhaust duct was removed and the permanent duct installed.
6. All doors have been hung and hardware installed.
7. The last remaining section of main floor slab was poured.

PROJ. NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-h-1

AUTHORIZED FUNDS				COST & COMM. TO	
$ 40,000	DESIGN $ 40,000	AEC $ 30,000		3-19-61	$ 9,998
	CONST. $	GE $ 10,000		ESTIMATED TOTAL COST	$ 420,000

STARTING DATES			EST'D. COMPL. DATES	
DESIGN 8-8-60	DATE AUTHORIZED 9-2-60		DESIGN 3-31-61	
CONST. 6-1-61*	DIR. COMP. DATE		CONST 2-15-62	

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.

B. D. Bohna revised the 40 tracings and 16 specifications and at Bohna's suggestion, a trip was made by G. E. personnel to resolve any problems that may be known prior to their sending all drawings and specifications to Hanford for approval.

* Based upon award of Contract by 5-15-61.

1230088

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CAE-896	Stress Rupture Test Facility	60-1

AUTHORIZED FUNDS				
$ 90,000	DESIGN $ 7,500 / CONST. $ 82,500	AEC $ 78,500 / GE $ 11,500	COST & COMM. TO 3-19-61	$ 9,131
			ESTIMATED TOTAL COST	$ 90,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN 7-29-60	CONST. 3-6-61	3-6-61	DESIGN 12-1-60	CONST. 10-15-61
DIR. COMP. DATE 10-15-61				

ENGINEER

FEO - E. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE Geo. A. Grant, Inc.		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.
DESIGN	100	100
TITLE I		
GE-TIT. II	100	100
AE-TIT. II		
CONST.	100	2
PF		
CPFF		
FP		

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

Construction has started as of 3/20/61. Contractor has moved his office on-site and has made preliminary checks prior to getting underway.

PROJ. NO.	TITLE	FUNDING
CAE-901	Structural Material Irradiation Test Equipment - ETR	1290

AUTHORIZED FUNDS				
$ 125,000	DESIGN $ 12,000 / CONST. $ 113,000	AEC $ / GE $ 125,000	COST & COMM. TO 3-19-61	$ 52,362
			ESTIMATED TOTAL COST	$ 125,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN 9-15-60	CONST. 4-15-61	9-2-60	DESIGN 4-1-61	CONST. 10-15-61
DIR. COMP. DATE 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	65
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.
DESIGN	100	100
TITLE I		
GE-TIT. II	100	100
AE-TIT. II		
CONST.	100	
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.

Design is complete.

A conference with the Phillips Petroleum Company project engineer is scheduled for 3-29-61, to plan the installation of the equipment. A schedule for this portion of the work will be developed.

1230089

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/22/61

PROJ.NO.	TITLE	FUNDING
CPF-902	Uranium Scrap Burning Facility	61-J

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$ 36,000	CONST. $	GE $	ESTIMATED TOTAL COST	$ 36,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	5-15-61*	DIR. COMP. DATE	DESIGN	7-1-61*
CONST.	7-1-61*		CONST.	

ENGINEER

FEC - 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		
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 but no work was started until review by General Electric Company has been made regarding AEC's proposed changed Methods of Performing Work.

* Based on acceptance of a directive and work authority by May 1, 1961.

PROJ. NO.	TITLE	FUNDING 25% GE 75% Operating
CPF-907	Strontium-90 Interim Program	

AUTHORIZED FUNDS	DESIGN $ 35,000	AEC $	COST & COMM. TO 3-10-61	$ 393,289
$ 420,000	CONST. $ 385,000	GE $ 420,000	ESTIMATED TOTAL COST	$ 420,000

STARTING DATES		DATE AUTHORIZED 9-6-60	EST'D. COMPL. DATES	
DESIGN	9-8-60	DIR. COMP. DATE 3-1-61	DESIGN	3-1-61
CONST.	9-8-60		CONST.	3-1-61

ENGINEER

FEC - E. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	12	4050
PLANT FORCES	1	260
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
AE-TIT. II			
CONST.	100	100	100
PF	100	100	100
CPFF	99	100	100
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow the separation of Strontium-90 material from Separations Plant waste streams on an interim basis, and involves the conversion of the ECT Semi-Works Plant for this purpose.

It is anticipated that the work on the exceptions will be completed by the end of this reporting period. This project will no longer be required.

1230090

SEMI-MONTHLY PROJECT STATUS REPORT

HW- 69062

GENERAL ELECTRIC CO. — Hanford Laboratories

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CAE-914	Rattlesnake Springs Radioecology Facility	61-3

AUTHORIZED FUNDS					
$ 72,000	DESIGN $ 3,400*	AEC $ 53,700	COST & COMM. TO 3-19-61	$ 6,050
	CONST. $ 68,600	GE $ 18,300	ESTIMATED TOTAL COST	$ 72,000

STARTING DATES			ESTD. COMPL. DATES		PERCENT COMPLETE			
DESIGN	3-1-61	DATE AUTHORIZED 12-22-60	DESIGN	6-1-61		WT'D.	SCHED.	AC
CONST.	7-15-61	DIR. COMP. DATE 10-31-61	CONST.	12-1-61	DESIGN	100	NS	
					TITLE I			
					GE-TIT. II	100	NS	
					AE-TIT. II			
					CONST.	100		
					PF			
					CPFF			
					FP			

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

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 98% complete.

Requisitions have been issued for equipment being purchased by G. E.

* Bovay Engineers.

PROJ. NO.	TITLE	FUNDING
CAE-916	Fuels Recycle Pilot Plant	Funds Avail. to Cor

AUTHORIZED FUNDS				
$ 50,000	DESIGN $	AEC $	COST & COMM. TO 3-19-61	$ 43,000
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 5,000,000

STARTING DATES			ESTD. COMPL. DATES		PERCENT COMPLETE			
DESIGN	3-1-61	DATE AUTHORIZED 2-9-61	DESIGN	7-1-62		WT'D.	SCHED.	AC
CONST.		DIR. COMP. DATE	CONST.	2-1-63	DESIGN	100	NS	
					TITLE I		NS	
					GE-TIT. II			
					AE-TIT. II			
					CONST.	100		
					PF			
					CPFF			
					FP			

ENGINEER

FEO - RW Dasbenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

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.

Scoping design is progressing on this facility.

1230091

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CAE-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 5-15-61*	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN 9-1-61*
	CONST. 10-15-61*	DIR. COMP. DATE		CONST. 2-1-62*

ENGINEER

FEC - 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 project proposal was transmitted to the AEC on 1/23/61. The proposal has been sent to Washington for approval.

A number of estimates of cost have been prepared for locating the structure at various sites. Fall-out shelter and bomb-proof structures have been considered. A recommendation will be presented to the AEC.

* Based on AEC authorization by 4/15/61.

PROJ. NO.	TITLE	FUNDING
CGE-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 6-1-61*	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN 9-1-62*
	CONST. 1-1-62*	DIR. COMP. DATE		CONST. 8-1-62*

ENGINEER

FEO - H. Radcw

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 is being reviewed.

* Assuming AEC authorization by 5-1-61.

1230092

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CAE-919	Air Conditioning - 314 Building	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO	$
$	CONST. $	GE $	ESTIMATED TOTAL COST	$ 35,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 3-2-61		DESIGN 5-5-61	
	CONST. 4-14-61	DIR. COMP. DATE	CONST. 6-30-61	

ENGINEER

FEC - 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.	A
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.

The project proposal was approved by HOO-AEC on 3-2-61.
Directive has been received but no work will be started until review by the GE Co has been made regarding the AEC's proposed change in Methods of Performing Work.

PROJ. NO.	TITLE	FUNDING
CAE-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		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 4-15-61	3-21-61	DESIGN 5-15-61	
	CONST. 5-1-61	DIR. COMP. DATE	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.	A
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of special research, test and monitoring wells.

Directive was issued March 21, 1961.
Work Authority was issued March 24, 1961.

Bid opening scheduled for April 11, 1961

1230093

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW-69062

DATE 3/31/61

PROJ.NO.	TITLE	FUNDING
CGE-922	Burst Test Facility for Zirconium Tubes	61-j

AUTHORIZED FUNDS $	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO $	ESTIMATED TOTAL COST $ 228,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.

ENGINEER

FEC - 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 was submitted to the Commission March 17, 1961, and is being returned unapproved.

PROJ. NO.	TITLE	FUNDING
CGE-923	Spectroscopy Laboratory	0290

AUTHORIZED FUNDS $ 95,000	DESIGN $ 4,500	CONST. $ 90,500	AEC $	GE $ 95,000	COST & COMM. TO 3-19-61 $ 6,300	ESTIMATED TOTAL COST $ 95,000

STARTING DATES	DESIGN 3-21-61	CONST. 6-1-61	DATE AUTHORIZED 3-9-61	DIR. COMP. DATE 11-15-61	EST'D. COMPL. DATES	DESIGN 6-1-61	CONST. 12-15-61

ENGINEER

FEC - 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	1
TITLE I			
GE-TIT. II		NS	1
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This Project will provide a facility for specialized spectroscopy work.

The proposal was approved by the Commission 3-8-61. The Directive was issued 3-9-61.

Work Release Authorization WRA No. 67 was issued 3-14-61. Design was started 3-21-61. Equipment specifications are being prepared.

1230094

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 69062

DATE 3/31/61

PROJ. NO.	TITLE	FUNDING
CGH-924	200 KW Induction Heating System - 306 Building	0290

AUTHORIZED FUNDS $	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO $	ESTIMATED TOTAL COST $
						31,000

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	5-1-61*	6-1-61*				7-1-61*	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.	AC
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
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.

Directive has been received but no work will be started until review by the GE Lo has been made regarding the AEC's proposed change in Methods of Performing Work.

* Based on acceptance of a Directive by 4-15-61.

PROJ. NO.	TITLE	FUNDING
CGH-927	Additions to the 271-TR Building Waste Treatment Demonstration Facility	61-1

AUTHORIZED FUNDS $	DESIGN $	CONST.$	AEC $	GE $	COST & COMM. TO $	ESTIMATED TOTAL COST $

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.
	5-1-61*	8-1-61*				9-1-61*	[illegible]

ENGINEER

FEC - 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.	AC
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 wastes for safe discharge to the plant environs.

The project proposal was submitted to BOO-AET on [illegible].

* Based on authorization by [illegible].

1230095

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

COMMUNICATIONS

Prepared press release on Dr. D. W. Pearce's appointment to IAEA. In addition, participated with Relations Operation in the preparation of four additional releases: 1) Fuels Fabrication Development Addition, 2) Dr. Bennett's ACS speaking tour, 3) River Monitoring Station, and 4) B. Brenden's technical paper.

EMPLOYMENT (Professional)

Advanced Degree - Fourteen Ph.D. candidates visited HAPO for professional employment interviews. Three offers were extended; one acceptance and two rejections were received. Current open offers total three. Recruiting trips to four universities occurred.

BS/MS - Eighty-eight applicants were considered, 51 offers were extended, 8 acceptances and 16 rejections were received. Current open offers total 98.

Technical Graduate Program - Six Technical Graduates were placed on permanent assignment during the month; four others terminated from HAPO rolls. Current program members total 51.

Information meetings were held in each department at HAPO concerning the "A" Course to be held this fall.

EMPLOYMENT (Non-professional)

Nine requisitions were filled during the month with a total of 11 active requisitions remaining to be filled.

O. E. Boston, Manager
Professional Placement
and Relations Practices

OEB:lmh

1230096

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Feb.	Mar.
Requisitions		
Active at end of month	11	23
Cancelled	1	2
Received	9	23
Filled	5	9
Hold	9	9

Nonexempt Transfer Request	Feb.	Mar.
Transfers		
Active cases at end of mo.	75	60
Cancelled	2	21
New	4	9
Effected	6	4

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	Extended	Accepted	Open	On the Roll
PhD	460	133	41	38	20	5	3	2
Exp. BS/MS	325	44	28	-	31	17	8	7
Prog. BS/MS	293	-	-	-	144	24	106	4

B. Technical Recruiting Activity - HL - September 1, 1960 to date

	Visits to Richland				Offers			
	Cases Considered	Invited	Visited	To Visit	Extended	Accepted	Open	On the Roll
PhD	460	133	41	38	15	4	3	2
Exp. BS/MS	-	18	11	-	12	6	-	-

In addition to the above activity, 9 exempt employees have transferred into HL from other HAPO departments and 8 technical graduates have accepted off-program placement in HL to date.

C - Technical Graduate Program
Month ending March 31, 1961

Number Personnel on Assignment	51
(HAPO Tech Grad Program 47	
(Engineering & Science Program 4	

Distribution of Assignments by Departments

IPD	20
HL	21
FPD	6
CPD	1
C&AO	2
CE&UO	1

Distribution of Assignments by Function

Research & Development or Engineering	35
Other	16

FINANCIAL OPERATION MONTHLY REPORT
MARCH 1961

Personnel

Effective March 1, 1961, the six exempt personnel doing technical administration in the research operations were transferred into the Financial Operation. A number of financial positions were revised due to a re-alignment of responsibilities. Mr. E. B. Hutchins was transferred from Contract and Accounting Operation to Hanford Laboratories Financial Operation as Specialist - Auditing and Economic Evaluations.

Activities

GENERAL ACCOUNTING

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-104	Fission Products Dispersal Handbook	Submitted to Commission but not yet approved
AT-105	Symposium on the Biology of the Transuranic Elements	Submitted to Commission but not yet approved
AT-140	National Academy of Sciences - National Research Council - Advisory Committee on Civil Defense	Submitted to Commission but not yet approved
AT-149	Recruiting Practices	In process

Travel activity is now running slightly ahead of last fiscal year with 942 trips started compared with 887 last fiscal year. At the end of March last year, $11,200 had been expended for travel to professional and trade society meetings. This represented 25% of the $44,000 budget for the fiscal year (it should be remembered that $15,000 was added to this budget in March 1960, which accounts for the relatively low percentage expenditure). Fiscal year 1962 to date expenditures total $25,000, or 39% of the yearly budget of $64,500. Travel activity for the balance of the year will probably increase substantially in keeping with seasonal trends.

Project CAH-878 - Additional Facilities for Isotope Study on Animals, 141-C Building Addition valued at $63,767 was unitized and a unitization report will be issued in April.

Preliminary unitization work was performed on the following projects:

CAH-864	Shielded Animal Monitoring Station - 100-F Area
CGH-785	In-Reactor Studies Equipment - 105 KW
CGH-805	High Temperature Tensile Testing Cell - 327 Building
CGH-819	Increased Laboratory Waste Facilities
CGH-864	Shielded Animal Monitoring Station

The physical inventory of movable cataloged equipment in the custody of Reactor and Fuels R&D Operation began March 13, 1961. This inventory, which is proceeding on schedule, will be completed in June 1961.

The field count in connection with the physical inventory of Cold Semi-Works - 321 Facilities is complete and reconciliation by C&AO of the inventory results is in progress.

Letters of instruction were issued to the field regarding the quarterly inventory of Other Special Materials at March 31, 1961, and the new certification type inventory. Comments from the field have been very favorable to this type of inventory and C&AO Property Management is considering adopting our new method HAPO-wide.

Sixty-five new items valued at $24,807 were received at the Laboratory Equipment Pool during the month. Seven items valued at $11,001 were withdrawn by custodians and 17 items valued at $3,866 were disbursed in lieu of placement of requisitions. Four items valued at $2,575 were excessed. There are currently 598 items valued at $224,779 located in the Equipment Pool.

Reactor and Other Special Materials on hand at month end consisted of the following:

Beryllium	1 221 gr.	$ 696
Gold	2 228 gr.	2 987
Palladium	2 377 gr.	2 710
Platinum	5 230 gr.	15 221
Silver	2 413 gr.	97
Zirconium:		
Inventory Stock	3 228 lb.	70 703
R&D Stock	607 lb.	9 114
Scrap	10 127 lb.	-0-
		$101 528

One purchase requisition for 551 gr. of platinum valued at $1,603 was cancelled and the material was furnished from existing stock at the Equipment Pool.

Of the 4,240 gr. of platinum scrap made available to the AEC for shipment off-site 2,312 grs. of uncontaminated platinum valued at $6,681.68 was transferred to the AEC New York Operations Office. The balance of material, which is contaminated, will be held until we receive additional shipping instructions. The local Commission advised this material will not be shipped until approximately September 1961.

Action as indicated occurred on the following projects during the month:

New Funds Authorized to HLO

CGH-858	High Level Utility Cell	$330 000
CAH-896	Stress-Rupture Testing Facility	500
CAH-921	Geological and Hydrological Wells-FY 1961	9 500
CGH-923	Spectroscopy Laboratory	95 000

Physical Completion Notices Issued

CAH-747 Plutonium Fabrication Pilot Plant

Construction Completion and Cost Closing Statements Issued

CA-744 Metallurgical Development Facility - 306 Building

Section Managers have been requested to project their expenditures of funds from Equipment Not Included in Construction Projects Budget for the balance of FY 1961. Information gained will be used to effect a reallocation of available funds where possible in order that HLO may realize maximum utilization of these funds for required equipment.

COST ACCOUNTING

The Hanford Laboratories operating cost control budget was adjusted in March to include additional funds authorized in the recent revision of the AEC Financial Plan dated March 6, 1961, and the revised allocation of funds by the General Manager - HAPO, dated March 28, 1961, as follows:

	Increase (Decrease)
04 Program Research and Development	
Plutonium Recycle Program	$140 000
Swelling Studies	40 000
UO_2 Fuels Research	(40 000)
06 Program Research and Development	
Radiological Physics and Dosimetry	30 000
02 Program Production	
Fabrication of DMA Elements	10 000
Safeguards Design Review	(35 000)
Strontium-90 Purification (from CPD)	100 000
Off-Site Customer Requests	
Fabrication of Birch Elements	60 000
Atmospheric Diffusion Studies (USAF)	27 000
Other Requests (budget reconciliation)	(4 000)

Hanford Laboratories also received an additional $100,000 in 04 Program Equipment funds for FY 1961, thus bringing total 04 Program Equipment authorization to $985,000, including $170,000 for Strontium-90 Program and $7,000 reallocation to the Chemical Processing Department.

Preparation of the Budget for FY 1963 and Revision of Budget for FY 1962 is nearing completion. The most noteworthy accomplishment in March was the review of 04 Program R&D Proposals with Washington-AEC and the subsequent revision of the proposals. Reproduction and assembly of the proposals remains to be completed.

Considerable effort this month was devoted to the recasting of budgets and conversion of codes on outstanding cost documents to reflect organizational changes effective 3/1/61 in the Radiation Protection, Laboratory Auxiliaries, Physics and Instruments R&D and Financial Operations.

Special requests received during the month were as follow:

1. Authorization in the amount of $190,000 from the U.S. Air Force to perform atmospheric diffusion studies at Cape Canaveral, Florida, and Vandenberg AFB, California.

2. Authorization in the amount of $55,000 from the U.S. Air Force to perform atmospheric diffusion studies at Edwards AFB, California.

3. Provide consulting assistance to GE-APED concerning inert welding problems. Estimated costs are $1,000.

4. Authorization in the amount of $3,600 from GE-ANPD to provide for the x-ray diffraction of irradiated materials in the Radiometallurgy Laboratory. This authorization was subsequently cancelled by ANPD. Work had not started on this job nor were any costs incurred.

Instructions were prepared and submitted to the other HAPO components requesting information on professional recruiting activities and related costs. Information will be prepared on a quarterly basis by Hanford Laboratories, covering all HAPO activity.

A new procedure has been established for reproduction and distribution of purchase orders originated by Hanford Laboratories. Vellum masters will be mailed by Purchasing Operation directly to FPD Duplicating who will reproduce copies and distribute them according to instructions. More prompt distribution of purchase order copies will be realized by this method.

Arrangements were finalized with Contract and Accounting Operation to issue reports by data processing techniques concerning the work activity of all Hanford Laboratories personnel.

GENERAL

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 371	648	723
Additions and Transfers In	12	5	7
Removals and Transfers Out	22	12	10
Employees on Payroll at End of Month	1 361	641	720

Overtime Payments During Month	March	February
Exempt	$ 4 622	$ 7 108
Nonexempt	22 004	14 748
Total	$ 26 626	$ 21 856

Gross Payroll Paid During Month		
Exempt	576 812	$567 105
Nonexempt	466 797	367 505
Total	$1 043 609	$934 610

Participation in Employee Benefit Plans at Month End	March		February	
	Number	Percent	Number	Percent
Pension Plan	1 215	99.3	1 217	99.3
Insurance Plan				
Personal Coverage	371	99.9	383	99.8
Dependent Coverage	982		981	
U.S. Savings Bonds				
Stock Bonus Plan	65	32.7	68	34.5
Savings Plan	84	6.2	83	6.1
Savings and Security Plan	1 049	90.3	1 051	89.5

Insurance Claims	March		February	
	Number	Amount	Number	Amount
Employee Benefits				
Life Insurance	0	$ 0	0	$ 0
Weekly Sickness and Accident	7	582	21	1 974
Comprehensive Medical	95	7 089	91	6 256
Dependent Benefits				
Comprehensive Medical	240	14 909	190	9 958
Total	342	$22 580	302	$18 188

Good Neighbor Fund	March	February
Number Participating	929	933
Percent Participating	68.3%	68.1%

W Dale

W Sale
Manager - Finance

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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
E. A. Smith	A Detector for Flaws and Non-Bonds in Zircaloy Fuel Element Closures
T. D. Chikalla	A Method for Evaluating In-Reactor Mass Transfer and Densification of Ceramic Fuels Materials - HW-68787, March 9, 1961
H. L. Libby J. T. Russell	Segmental Time Reversal Device
L. K. Mudge	Electrolytic Preparation of Large UO_2 Crystals
F. A. Scott	Electrolytic Preparation of UO_2 Ceramics
V. P. Kelly	A Variable-Stroke Reciprocating Drive Mechanism with Rotary to Linear Motion Conversion
C. A. Rohrmann	An Electrolytic Process for Preparing Uranium Hexafluoride