HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
AUGUST, 1960

Compiled by
Operations Managers

September 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE August 31,1960

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	134	112	246	135	114	249	1	1	2	3
Reactor & Fuels Research & Development	198	197	395	198	191	389	2	6	2	0
Physics & Instrument Research & Development	80	41	121	79	41	120	1	0	0	0
Biology Operation	40	43	83	42	42	84	0	2	2	1
Operation Res. & Syn.	16	4	20	16	3	19	0	1	0	0
Radiation Protection	35	101	136	34	101	135	1	1	0	1
Laboratory Auxiliaries	54	197	251	54	191	245	1	8	1**	2*
Financial	15	15	30	14	16	30	1	0	0	1
Prof. Placmt. & R.P.*	90	14	104	99	15	114	4	0	13	1
Programming	17	4	21	18	4	22	2	0	3	0
General	1	3	4	1	3	4	0	0	0	0
Totals	680	731	1411	690	720	1411	13	19	23	9 7
Totals excluding internal transfers.	680	731	1411	690	720	1411	9	17	19	7

* 1 weekly to monthly - 1 monthly to weekly.
** 1 monthly to weekly.

BUDGETS AND COSTS

August operating costs totaled $1,986,000; fiscal year-to-date costs are $3,743,000 or 15% of the $25,403,000 tentative control budget.

Hanford Laboratories research and development costs for August compared with last month and tentative control budget follow:

(Dollars in Thousands)	Cost				
	Current Month	Last Month	FY To Date	Budget	% Spent
HLO Programs					
2000 Program	$ 74	$ 67	$ 141	$ 597	24%
4000 Program	740	549	1 289	8 835	15
5000 Program	60	54	114	742	15
6000 Program	209	190	399	2 372	17
	1 083	860	1 943	12 546	15
IPD Sponsored	257	226	483	3 100	16
CPD Sponsored	151	124	275	1 658	17
	$1 491	$1 210	$2 701	$17 304	16%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels Research and Development

The PRTR Phase III contract is estimated to be about 97% complete as of August 31, 1960. The contractor has been informed by the AEC that his contract will be terminated on September 12, 1960. Remaining work will be completed by J. A. Jones Company on a CPFF basis to permit the reactor startup to proceed.

The PRTR Maintenance and Mockup Facility bids were opened on August 17, with an apparent low bid of $633,700. The fair cost estimate was $713,000.

Formal authorization for the startup and operation of the PRTR has been received from the AEC. This authority is for operation in accordance with the PRTR Final Safeguards Analysis, Supplement I thereto, and three instructions concerning an exhaust air filter, coolant void coefficients, and use of the automatic controller.

Additional experimental data were obtained of the pressure drop in the outlet fittings of the PRTR process tube during flows of steam-water mixtures. The data were used in an analysis of the detection of small leaks (between 75% and 175% normal flow) in the process tube.

Two w/o Ni has been specified for the Pu-Al elements for PRTR irradiation to impart corrosion resistance in the event of rupture. In recent tests, 1.75 w/o Ni appears satisfactory and a 1.5 w/o nickel alloy is now being tested to determine the lower limit of protection.

Pre-welded samples of Zr clad UO_2 have been swaged to 90% density in the plutonium facility in preparation for plutonium fuel fabrication.

Radiometallurgy examinations of a graphite coated Pu-Al cluster and a similar cluster with nine-mil diametral gap, both of which had been irradiated to about 50% burnout of Pu atoms, revealed no damage other than a slight diameter increase in the core with the nine-mil gap.

Attempts, as yet unsuccessful, are being made to form PuN, a potentially important fuel material.

A prototypical three-foot section of PRTR cold swaged UO_2 fuel was irradiated successfully for one ETR cycle at a power generation rate of 150% of PRTR design conditions.

Vibratory compaction was successfully used to fabricate nine thin-walled (8-15 mils) stainless steel clad fuel rods for irradiation in VBWR.

A swaged UO_2 fuel element was defect tested in the MTR and found to release much less fission gas than in previous tests. This behavior is attributed to the use of larger and denser UO_2 particles as starting material.

Zircaloy corrosion coupons exposed in static steam autoclaves pick up approximately twice as much hydrogen as in similar refreshed autoclave tests, presumably due either to a hydrogen overpressure built up in the static autoclaves or the accumulation of a higher oxygen concentration in the refreshed autoclaves. This offers hope of minimizing hydriding in Zircaloy in reactor service through proper control of environmental conditions.

An ultra-fine recrystallized grain size, about 0.006 mm, has been produced in warm-extruded Zircaloy-2 by salt bath heat treatment at about 1200 F and air cooling. This grain size is comparable to that of a Hareaus tube sample which exhibited exceptional swageability.

Magnetic force welding has proven uniquely useful in preparing special specimens for Physics studies free of the cadmium contamination encountered in heli-arc welding.

Ex-reactor, 300° C rupture tests of NPR-type fuel rods which had irradiated in 270 C water, showed rupture rates only one-fifth to one-tenth as rapid as in similar previous tests with fuel irradiated in low

temperature (65 C) water. A rapid cool-down from 300 C to 230 C during the ex-reactor tests was, nevertheless, beneficial in minimizing the extent of rupturing.

Laboratory hydriding tests simulating the NPR stack gas system continue to reassure that the presence of approximately 0.1 mm of H_2O vapor partial pressure in the NPR stack gas will effectively inhibit hydriding of the Zircaloy process tubes by traces of hydrogen in the gas atmosphere.

Two experimental hot pressed I & E fuel elements were successfully irradiated to 1400 MWD/T in the MTR at a power level of 140 kw/ft. These incorporated several refinements in this alternate process for production fuel fabrication.

NPR fuel studies included development of a method of attaching iron wear shoes to Zircaloy fuel supports after autoclaving which appears amenable to mass production. Also, it appears possible to suitably refine the grain structure of uranium by heat treatment following Be-Zr brazing of NPR closures.

Investigation was continued on cooling by boiling in a K process tube under reactor shutdown conditions. This method of cooling appears feasible only under very limited conditions of coolant inlet pressure and heat flux.

The EGCR oxidation prototype has been cooled with air from 625 C without spontaneous combustion of the graphite.

2. Chemical Research and Development

Two liter-scale runs were completed in the hot cells testing the flowsheet which will be used in the Purex head-end equipment for the isolation and partial decontamination of a raw strontium-90 product. Although the operability of the process was demonstrated, product recoveries were lower than expected (30 to 50 percent). The strontium-90 product contained no detectable barium but sufficient calcium to impair the capacity of the ion exchange equipment to be used for final product purification.

The ion exchange process for strontium-90 purification has been demonstrated in the laboratory. Product purity is greater than 99 percent. Control of the pH of the EDTA eluate is critical; loss of ammonia (for pH adjustment) results in the formation of precipitates in the ion exchange columns and subsequent equipment maloperation.

A sample of the slag which remained in the damaged Redox multipurpose Dissolver after decontamination operations was found to have a composition of about 72 percent iron, 9 percent chromium, 11 percent nickel and 8 percent uranium, and to have attained a temperature in excess of 1300 C at the time of the incident.

Forty-six pounds of electrolytic UO_2 have been prepared this month via the Salt Cycle Process. The first 28 pounds had an oxygen to uranium ratio of 2.04. The next 18 pounds of product, after process conditions were altered, had a more acceptable ratio of 2.01. Ratios as low as 2.005 were obtained. The fused silica vessel used for the molten salt electrolysis has survived 350 hours of operation at temperatures of 700-800 C.

Construction of the hot cell equipment for Salt Cycle demonstration runs with irradiated fuel materials is essentially complete; cold runs have been initiated. Removal of fuel core by air oxidation and the subsequent dissolution of U_3O_8 by chlorine gas in the molten NaCl-KCl bath has been successfully demonstrated.

The pilot scale facility for treating reactor effluent water with aluminum turnings has been operating continuously and, after ten days, resulted in the removal of 52 and 42 percent of the influent Cu-64 and As-76, respectively. Equilibrium is expected to be reached in 3 to 4 weeks of operation.

3. Physics and Instrument Research and Development

In the NPR program, a compromise design Fuel Failure Monitor incorporating features of both the IPD-developed system and of the HLO pro-

posal has been adopted as standard. Consultation assistance was provided in development of this new design. Testing of the NPR lattice continued in the PCTR and canning of tube-in-tube fuel for exponential experiments is under way. Further satisfactory tests were completed on several prototype radiological monitors for the NPR building. Also an analog model to facilitate design studies of the heat exchanger was completed.

A final hazards report has been completed for the Critical Mass Laboratory and is now being printed. The laboratory has been occupied and shakedown runs on the equipment began using non-fissionable material.

In the Non-Destructive Testing Program, a small research contract is being arranged with Professor W. H. Huggins of Johns Hopkins University whose leading work on signal theory promises to be of considerable assistance in the broadband eddy current studies. Efforts to improve the experimental equipment for the thermal bondtesting program also continued.

In the Neutron Flux Monitoring program, calculations began on plutonium isotopic composition to give increased monitor lifetime and an Invention Report was filed on a possible microwave technique for neutron monitoring.

The Gas Cooled Reactor physics program was concluded with the issuing of three customer reports.

The solution of certain difficult dosimetry problems may be aided by a study of small thermoluminescent dosimeters now in progress. Experimental results exceed original expectations with accurate measurements having been confirmed for doses from one milliroentgen up to several roentgens.

Progress in completing the atmospheric dispersion program done in cooperation with the Air Force was marked by transmission to them of the IBM data reduction on all of the samples.

Ability to treat reactor physics problems was assisted by development of a calculational method which gives critical masses of slightly enriched fuel rods in water to 10% accuracy and by measurements on the rate at which neutrons entering cool water from hot graphite approach equilibrium with the new medium.

In the basic data field measurements progressed on the energies following scattering from water of neutrons originally at 0.27 ev.

4. Biology

Dams were found to contain three to six times greater concentrations of Zn than were found in their fetuses following administration of Zn^{65}.

Another variable was found to affect the Cs^{137}/K ratio in plants. This was osmotic pressure that was studied by means of sodium chloride in the root environment.

Biological studies on Np^{237} for the Paducah project (at the request of the AEC) progressed.

By means of bile fistula, it appears that the diarrhea associated with GI irradiation injury is associated with biliary flow.

5. Programming

Plutonium values in an Advanced Pressurized Water Reactor were calculated for cases of self-sustaining and non-self-sustaining recycle with enriched and depleted uranium. Values ranged from about $10.50 to $16.00 per gram of fissile plutonium with depleted uranium and from about $11.50 to $13.50 for the enriched uranium case.

Preliminary cost calculations indicate that close coupled processing of reactor fuels within a single reactor system is not economically attractive. Combined processing of fuel from more than one reactor is needed to lower the costs to attractive levels.

TECHNICAL AND OTHER SERVICES

Several important analyses have been made in connection with run-to-rupture tests involving different self support concepts. Comparison between the controls in the several tests have lent support to the validity of the accelerated test program.

A report was issued presenting the results of the study to determine an optimum supplemental crew size.

The basic logical structure to which the process control computer being installed in the Z plant will be applied, has been completed along with about 60 per cent of the detailed programming diagrams.

The derivation of the time-dependent probability law for simultaneous failures of any fixed number of devices out of a given number of identical devices operated independently has been completed and an asymptotic expression which is much simpler, for computational purposes, than the exact expression has been obtained.

Work continued on the formulation of a kinetic mechanism for the dissolution of uranium in nitric acid. The set of simultaneous equations expressing the semi-empirical model of the dissolver process that is compatible with available data have been solved; however, the particular form of the solution makes estimation of the model parameters impractical, and current effort is directed toward expressing the solution in a more tractable form.

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There were no cases of plutonium deposition confirmed during the month; thus, the total on record remains at 262 of which 257 occurred at HAPO. There are 188 employees currently on the active rolls with plutonium deposition.

There are 21 currently active projects having combined authorized funds in the amount of $20,356,000. The total estimated cost of these projects is $23,818,000. All projects but seven are on or ahead of schedule. Six of these seven are at least 5 per cent behind schedule.

A program document setting forth the plan to automate the issuance, routing and mailing activities of the Classified Files was issued. Studies indicate that the project is feasible and offers an opportunity for cost reductions.

SUPPORTING FUNCTIONS

Approval was obtained for the transfer of $1,000 fee funds from travel and living variation budget to conference and other expense budget.

Expenditures and commitments for equipment for the first two months of FY 1961 are approximately the same as for FY 1960, however, purchase requisitions and appropriation requests are ahead of FY 1960 by more than $100,000 which should indicate a good expenditure pattern in the second and third quarters.

The FY 1960 physical inventory of movable cataloged equipment in the custody of HLO resulted in (1) a shortage of 38 items valued at $8,592 compared with 24 missing items in FY 1959 and (2) 194 unrecorded items valued at $99,340 compared with 32 items in the previous year.

As of August 31, 1960, the staff of the Hanford Laboratories totaled 1411 employees, including 680 exempt and 731 weekly salaried. Of the total, 585 possessed technical degrees, including 353 B.S., 129 M.S., and 103 Ph.D.

The medical treatment frequency for August was 1.48 as compared with 1.97 for the preceding month. There were no disabling injuries or serious accidents during the month. There were six security violations, bringing the total for the year to date to 23, as compared with 31 for the corresponding period last year.

One Ph.D. candidate visited Richland during the month for interview. Four offers were extended and offers were accepted by an experienced Ph.D. botanist and an inexperienced Ph.D. chemist. A total of ten acceptances were received during the recruiting year beginning September 1, 1959, and ending August 31, 1960.

Five Technical Graduates were added to the rolls, six accepted permanent assignment and six terminated, including four Engineering and Science Program members, one military leave and one temporary summer employee. At month's end there were 78 Technical Graduates, including four members

of the Engineering and Science Program and one Technician Trainee on program rolls.

The 1959-60 recruiting year officially was completed on August 31, 1960. For the Technical Graduate Program, 196 offers were extended and 82 acceptances were received. In the experienced category, 114 offers were extended, 65 acceptances were received. Included in this total are 28 offers for HLO components resulting in 18 acceptances.

Twenty-seven HLO exempt employees completed the second section of "Technical Report Writing" under the instruction of Professor E. Elliott of the University of Washington.

Eighteen weekly salaried vacancies were filled during the month.

F W Albaugh

for Manager
Hanford Laboratories

HM Parker:FWA:mlk

[redacted] REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Hydriding of Zircaloy-2 in Simulated NPR Atmosphere. Two groups of Zircaloy-2 samples were exposed 102 days at 300 C and 350 C in helium gas contaminated with 0.01% H_2 and 0.01% CO. This gas was prepared by passing tank helium over NPR graphite at 800 C where the traces of water in the gas were converted to hydrogen and carbon monoxide. The gas mixture flowed over the samples at a slow rate. As reported in June 1960, no significant hydriding of the Zircaloy-2 samples had occurred after the first 43 days of exposure. Likewise, the 102-day data do not conclusively show any hydrogen pickup. However, with due regard for scatter in the extraction analyses, the 102-day data tend to be slightly higher in H_2 content than the 42-day data, and this may indicate a slow hydriding reaction. This experiment is continuing, and a similar 400 C test has been initiated.

Hydriding of Zircaloy-2 in H_2-H_2O Mixtures. A series of vapor-blasted, vacuum-annealed Zircaloy-2 coupons were exposed at 400 C in 10 mm partial pressure H_2 with from 0.0001 mm to 23 mm water vapor added to vary the dewpoint. This system is representative of the NPR stack gas composition with approximately 1% H_2 and varying dewpoint temperatures from -86 C to +25 C.

Two-hour data from this experiment were reported last month. The six-hour data confirmed the earlier results, viz.: below a H_2O partial pressure of 0.1 mm the Zircaloy-2 hydrided rapidly, whereas above 0.1 mm the hydriding was strongly inhibited. Seventy-two-hour data a P_{H_2O} = 0.1 mm indicate hydriding is progressing at a slow but measurable rate. These experiments will be continued to procure hydriding rate data as a function of temperature, H_2 and H_2O partial pressures, and Zircaloy surface condition.

In-Reactor Test for Zircaloy Samples. A capsule for subjecting Zircaloy samples to proposed NPR stack-gas atmosphere conditions in the reactor has been designed. Preliminary drawings have been made, and calculations as to feasibility are in progress.

Radiometallurgy Laboratory Studies

Examination of the fourth purposely-defected ETR rupture (Zr-2 clad uranium metal tube) revealed that water had reacted with the uranium near the outer can wall to a distance of about one inch in each direction. The outer cladding was badly distorted while the contour of the inner cladding remained unchanged (RM-567). A Zr-2 clad 7-rod cluster with hot headed end closures was found to be in excellent condition upon

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examination. The only defects were slight bumping and a few cracks in the uranium core near the end closures (RM-703). Severe hydriding and cracking were found in both tubes of an element which ruptured in KER Loop 4. Two ruptures were found in the inner tube (RM-568).

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

Basic Metallurgy Studies

Mechanical and Physical Properties of Materials. The evaluation of zirconium - 2 a/o Sn - 2 a/o Nb alloy for fuel element applications has continued. The elevated tensile properties of this alloy in the annealed and quenched condition are being determined. After water quenching from 950 C, the alloy has a tensile strength of 86,500 psi at 300 C. Water quenched specimens broke out of the gauge sections so elongation to fracture could not be determined. The fractures appeared to be typical of a brittle material. Erichsen cup tests on the annealed alloy demonstrate excellent ductility. These tests also show good ductility for the quenched material.

The properties of zirconium - 2 a/o Nb - 2 a/o Sn as affected by heat treatment in the temperature range 650 to 750 C are important in evaluating the extent to which this alloy could improve the performance of zirconium fuel element cladding, since this is the range of temperature in which final fuel element heat treatment will be performed.

Little hardening is observed for oil quenching from temperatures below 750 C. Coupons of the alloy oil quenched from 770 C have been reheated to 600, 550, 500, and 450 C for times up to 1500 minutes. Below 500 C the softening rate is very slow.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material after irradiation is a direct way of detecting radiation damage in these materials. Thin films and foils suitable for electron microscopy offer advantages, since radioactivity is a minimum. Thin films of evaporated uranium dioxide undergo considerable change in both morphology and crystallinity as a function of irradiation. An experiment was performed to determine whether vaporization and condensation of uranium dioxide occurs during irradiation of approximately 100 Å thick films. A 200 Å thick carbon substrate, the collector, was positioned at a distance of one mm from a 100 Å thick uranium dioxide film during an irradiation period which resulted in an exposure of approximately 4×10^{18} nvt (thermal). Examination of the carbon collector taken from an air filled capsule revealed the presence of rosettes which had diameters as large as five microns. Electron diffraction patterns of these deposited rosettes yielded interplanar spacings of 2.012 and 1.723 Å, which compare quite favorably with U_3O_8 (1.99 and 1.171 Å). A similar exposure in an evacuated capsule, however, does not yield deposited rosettes, but instead many very dense particles having a maximum diameter of approximately 400 Å are observed. Electron diffraction analysis of these particles identifies them as uranium dioxide.

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Attempts at preparing thin metallic films of chemically reactive metals for subsequent irradiations have continued. An evaporation chamber containing a movable, water-cooled anode and a self-biased electron gun has been constructed. Uranium at the end of a 1/8" diameter rod is superheated by the impinging electrons and evaporates at high rates. Films prepared in this fashion have been formed on carbon substrates and coated with evaporated UO_3 at pressures of 10^{-6} mm of Hg. In each instance the sandwich contains UO_2 rather than uranium upon examination by electron diffraction. Other suitable covering layers which may inhibit oxidation of the uranium are being investigated.

Production Test IP-346-D, HAPO-243, covering irradiation of thin foils of reactor fuel, fuel cladding, and reactor structural materials in the 4B Snout Facility at 105 KW has been approved. A prototype special capsule and capsule holder required for the proposed irradiations is being constructed. Half-inch diameter foils of various materials and histories are being prepared.

Two articles entitled "Fission Fragment Damage in Non-fissionable Thin Films," and "Damage in UO_2 Films and Particles During Reactor Irradiation" have been submitted to the Journal of Applied Physics for publication.

Solid State Reactions. X-ray diffraction techniques are being used to study the effects of radiation on non-fissionable materials. The behavior during annealing of highly irradiated (5×10^{19} nvt) molybdenum is currently being investigated. Isochronal anneals of irradiated molybdenum have been carried out to 1000 C, and the changes in x-ray line profile and lattice parameter recorded. Concurrent anneals of 30 percent cold-rolled molybdenum are being carried out for comparison, changes in line shape and position being recorded in the same manner as for irradiated material. Additional samples of highly annealed and of ten percent, 20 percent, 40 percent cold worked molybdenum are being prepared for irradiation. These samples are intended for a comprehensive analytical study of line shapes by Fourier methods, with emphasis upon the annealing behavior. A supplemental study of single-crystal molybdenum has also begun. Available single crystals are being examined to determine their crystal orientation and quality.

Metallic Fuel Development

Tubular Fuel Elements. Further radiometallurgy work has been done on the fourth ETR intentional rupture test piece. The test element was a KER-size outer tube with the defect on the outer surface. Sectioning through the defect showed evidence of accelerated corrosion attack along the outer bond layer.

A KER tube/tube fuel element with uranium - two percent zirconium core failed in April after 1250 MWD/T. The element was 36 inches long and was enriched to 1.60 percent in order to approach NPR thermal conditions. During July the cause of the failure was shown to be hot spots resulting from warping of the inner component. Cladding penetration had occurred at

both hot spots. At the upstream end of the element the diameter of the inner tube had increased 0.020 inch. A metallographic section of this area showed radial cracks in the core and a large number of nonmetallic inclusions in the uranium. The clad in this area was extremely uniform and did not show any plastic instability. The uniform two percent strain taken by the clad is much greater than the small strains observed in rod cluster elements exposed to 2000-2500 MWD/T.

Production of test fuel elements from FPD extrusions began during the month. Twenty elements of NPR inner tube size are in process, ten of which have 0.020 inch clad on the inner and outer surfaces, and ten of which have 0.030 inch clad on the outer surface and 0.020 inch clad on the inner surface.

Further experiments with component treatment to promote bonding between the Zircaloy cap-ring and the uranium in the "Extrusion-Closure" process were carried out. The interposed shim of nickel, which in the last issue was reported as apparently bonded, was found to be infirmly attached to both uranium and Zircaloy. Evidently the temperature and/or pressing time were too low to bring about appreciable diffusion at the interfaces. In another trail, a shim of Armco iron with an AlSi overlay was interposed, the iron face next to the uranium. After pressing at ~650 C, the iron was found to be attached to the uranium and the AlSi seemed to have wet the Zircaloy, but the AlSi/Fe bond was poor. This trouble, however, can be remedied. Desirably, the closure should be made at a temperature within the alpha-phase of the uranium (< 660 C) to avoid uranium structures leading to distortion during irradiation, and for this purpose AlSi is ideal. Plain AlSi was found to diffuse rapidly into Zircaloy at a temperature slightly above its melting point, but Alcoa #716 (Al - 10 Si - 4 Cu) does not; the Al diffusion is apparently inhibited by the presence of Cu. An experiment was tried to see if this alloy behaved similarly with uranium. Unfortunately, Alcoa #716 was found to form a brittle, pyrophoric alloy with uranium, and thus is not suited for brazing. Present indications are that a Zircaloy cap preclad with iron on the face, either by diffusion bonding or by brazing with AlSi or other brazing material, may lead to success in the extrusion closure process. Iron plating on the uranium is another possibility. This has been tried with mediocre success, but the procedure is unwieldy and not readily adaptable to a production process.

Two BeZirc brazed NPR inner fuel elements were loaded into KER Loop 2, together with five other pieces including two defected pieces, at 6:00 AM on August 4, 1960. These elements were 18 inches long and were placed in Zircaloy sleeves. At 8:30 PM on August 7, 1960, activity in Loop 2 was strong enough to scram the reactor and cause discharge of the tube. Examination in the basin did not reveal an obvious failure in the brazed pieces. These elements are being removed to Radiometallurgy for further examination.

Fuel for Present Reactors. On July 11, 1960, two hot pressed fuel elements completed a goal exposure of approximately 1400 MWD/T in the GEH-4

facility of the MTR. These elements showed no sign of failure or other questionable behavior. They are now in Radiometallurgy being prepared for further examination.

Component Fabrication. A method has been developed for attaching iron wear shoes to Zircaloy-2 fuel element supports after the element, including supports, has been autoclaved. The Zircaloy-2 supports are of the "Suitcase Handle" configuration and are 0.150 by 0.055 inch in cross-section. The iron wear shoes were blanked from 0.010 inch shim stock. The inner blanks are formed into a channel which is wrapped around the Zircaloy-2 support by a crimping tool. This method is adaptable to 1/4 inch wide supports as well.

A test was completed that compared the uranium structures developed by beta heat treating prior and subsequent to brazing for end closure. NPR inner tube stock was brazed with Zr-Be, Zr-Fe-Be, and Zr-Cu-Be brazes at both ends of six-inch long sections before and after salt bath heat treatment. Beta treatment consisted of holding in NUSAL ten minutes at 730 C, ten-second air delay and oil quenching. A pronounced grain refinement was obtained by beta treating the brazed structure. As-brazed sections indicated a heat affected zone extending approximately 1-1/4 inch from the cap-uranium-interface containing extremely large, longitudinal columnar grains. The heat treatment following brazing has sufficiently refined this structure for reactor operation.

Closure and Joining. Two shipments of new brazing alloys have been received from Oregon Metallurgical Corp. These alloys were Zry-2 + 4 w/o Be + 12 w/o Fe and Zry-2 + 4 w/o Be + 14 w/o Cu. Some of the material was reduced to 20 mesh powder and used to braze some small fuel sections. The iron alloy was brazed at 950 C. This represented a drop in nearly 100 C in brazing temperature; also, the brazing time was reduced from two to one minute. Autoclaved samples in both the as-brazed and welded conditions showed a black, glossy autoclave film over the weld region, which looked like that on the Zircaloy jacket. The copper alloy was also brazed at 950 C, but was extremely fluid indicating that a lower brazing temperature is possible. The autoclave film was not as tenacious as the iron alloy and had a definite red color, probably due to cuprous oxide.

Several brazed fuel element autoclave ruptures have caused some concern. This material was brazed with BeZirc turnings, made by machining a bar forming chips. In each case rupture appeared to start at the base of the cap through the jacket. During brazing extreme gas evolution was observed. Braze material which was vacuum outgassed appeared to have better corrosion resistance. Gas analyses of the braze material have not been completed.

A decision was made to braze the next production test with the iron alloy. This test will be with KER inner and outer material with a 1.6 percent enriched uranium core alloyed with two w/o zirconium. The decision was based on several points. First, the lower melting point of the alloy and

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a shorter brazing time; second, availability of braze alloy; third, the excellent appearance of the autoclave film; and fourth, fewer voids and unbonded areas are found in the brazed regions.

An MTR test, GEH-4-57, 58, is being prepared to test the integrity of the iron alloy brazed closure. This test should be quite severe due to the high power generation and low fuel surface temperature. NPR inner tube material is being used. Other experiments are planned to test the other braze alloy concepts.

Attempts are being made to close coextruded Zircaloy-2 clad uranium KER-size rods by projection welding a Zircaloy-2 cap directly onto the projected cladding ring provided by acid milling the uranium from the end of the rods. This concept is being initially tried on rods as the capacity of the available spot welding machine is not sufficient to test the concept on tubular elements. The power required is expected to be approximately the same as required for the hot headed projection welded closure.

The pressure will be maintained on the cap and the power continued for several cycles after the initial projection welded closure in an effort to resistance braze the cap to the uranium. A very thin (0.003 to 0.008 inch) layer of braze material would be placed between the cap and the recessed uranium. A space (0.025 to 0.030 inch) is initially provided between the flat bottom of the cap and the uranium which will close when the cap settles from the initial projection weld, allowing contact through the braze material into the uranium core. The additional cycles of power would then braze the cap to the uranium.

The efforts to date have been to obtain the proper conditions for the initial weld between the clad and the cap with no particular effort being made to braze the cap to the uranium. The results to date have been promising and with a reliable initial projection weld, an attempt will be made to braze the cap to the uranium using one of the Zircaloy-2 - Be braze alloys. If this closure appears feasible for rods, the concept will be tested on tubular elements with a larger welding machine.

Acid milling of U - 2 w/o Zr alloy material in the as-extruded condition was found to be quite slow. Milling rates of less than one-half mil per minute were achieved using 37 percent HCl solution at room temperature. Milling rates increased to about eight mils per minute upon heating the acid to 65 C accompanied with severe undercutting along the clad wall.

Twelve inner and nine outer KER-size, U - 2 w/o Zr, 1.6 percent enriched stock material, 17 inches long were recessed for brazed end closure; material to be irradiated under Production Test 334-A. Because of a high tool breakage problem in machining, the pieces were first chemically milled to a nominal depth of 0.200 inch, then machined to the minimum required depth of 0.300 inch, followed by further chemical milling just to assure clean cladding walls. The stock material was given a 730 C, five-minute, water quench heat treatment to favor rapid acid milling. However, prior to milling, the pieces were subjected to a 600 C reheat for approximately 30 minutes during a necessary straightening operation.

Allied Fuel Studies. In a series of in-reactor swelling experiments using Zircaloy-2 clad uranium fuel rods, five rods incurred cladding failures during irradiation. Four of the failures occurred in 0.020 inch clad rods, and one is in a 0.030 inch clad rod. The latter failure was brittle in character. A metallographic examination of one failed and one unfailed rod for each nominal cladding thickness revealed no obvious differences in cladding thickness variations which would suggest why one failed and the other did not. The unfailed 0.020 inch clad rod shows evidence that necking of the cladding has started. Thickness in the necked area is 0.012 inch. Thickness of the cladding at the point of failure and at a necked area on the 0.020 inch failed rod is 0.008 and 0.009 inch, respectively. The thinnest point in the cladding of the unfailed 0.030 inch clad rod is 0.020 inch. However, at the point of failure on the 0.030 inch failed rod the clad thickness is 0.025 inch, and less than 1/32 inch from the failure the clad thickness is approximately 0.020 inch. It is probable that the failure was initiated in a thin section in the cladding located at another point longitudinally along the rod. Another series of capsule irradiations of Zircaloy-2 clad rods is being designed to help establish limits on allowable cladding thickness variations.

Five swelling capsules, GEH-4-98, 14-99, 14-101, 14-104, and 14-105, are presently being irradiated in the MTR with goal exposures in the range 2000-2500 MWD/T. Exposures and average center uranium temperatures for the fuel rods in these capsules through MTR cycle 142 are, respectively, 1680, 450, 2145, 1602, and 2710 MWD/T, and 500, 290, 450, 600, 335 C. Two swelling capsules, GEH-14-97 and 14-103, are now awaiting examination at the Radiometallurgy Operation. Volume changes, as determined from two Zircaloy clad fuel rods irradiated in NaK capsules in Hanford reactors indicate that at volume average uranium temperatures up to 425 C the uranium is swelling at a rate of eight percent per atom percent burnup of the fuel.

A second thermocoupled fuel rod was charged into KER Loop 1 on August 4, 1960, and operated successfully until the reactor was shut down on August 19. During the shutdown Loop 1 was decontaminated as part of the program to determine whether crud deposition would be enhanced as a result of the decontamination. Approximately 24 hours after the reactor started up, the thermocoupled fuel rod failed, terminating the test. Five minutes before the reactor was scrammed the two thermocouples located at the fuel-clad interface showed a temperature drop of several degrees and then showed fluctuating temperatures until the reactor scrammed. The cause of the failure has not been established.

The first thermocoupled fuel rod which was discharged from KER Loop 1 in July has been visually examined in a Radiometallurgy cell. No evidence of failure was found. It now appears that one of the tubular elements which were charged with the thermocoupled rod was probably responsible for termination of this test.

Continued defect-testing of irradiated coextruded fuel rods by CSDC in the IRP facility has revealed that failure behavior may be influenced by the irradiation temperature history. A fuel rod irradiated to 2450 MWD/T in a K through-hole (~30-40 C water) followed by five hours of exposure in 275 C water in the ETR 3x3 loop lost 183 grams of fuel and was severely distorted during the first 38 minutes of a NPR normal shutdown procedure test. Activity in the loop filter exceeded 40R and a considerable amount of particulate uranium was scattered throughout the loop. The 0.6 inch diameter rod distorted to such a degree that it had to be pushed from the 0.9 inch diameter test section. In contrast to this, a fuel rod irradiated to 2250 MWD/T in a KER loop at 250 C lost only 16 grams of fuel with but moderate distortion during the first 31 minutes of an NPR normal shutdown procedure test. Activity in the loop filter amounted to about 7R and the rod slid freely from the test section. The severity of rod failure is associated with the susceptibility of the irradiated uranium to crack or fragment when stressed by operational thermal stresses, thermal shock, or by corrosion induced volume changes. This susceptibility appears to be increased by irradiation at the lower temperatures.

Defect-testing of irradiated coextruded fuel rods at isothermal conditions, NPR normal cool-down rates, and NPR scram cool-down rates has demonstrated that fuel corrosion is greatly reduced when the temperature drops to 200 C and lower. The incentive for a rapid NPR cool-down rate following the detection of a fuel element failure is made evident by the test results tabulated below:

Fuel Rod History	Cool-down Rate	Loop Activity	Fuel Loss	Fuel Damage
2450 MWD/T in cold water plus 5 hrs ETR exposure at 275 C	NPR normal	40R	183 g	Severe
Same as above	NPR scram	1R	3 g	Mild
2250 MWD/T in KER at 250 C	NPR normal	7R	16 g	Moderate
Same as above	NPR scram	1/2R	(Being examined)	

Laboratory wear tests have shown that fuel element supports formed from low carbon steels or ingot iron with a maximum radius of curvature of three inches perform satisfactorily against an autoclaved Zircaloy-2 surface. The initial design considerations of a material for the NPR fuel element charging machine magazine has been stainless steel. Severe galling of stainless steel occurs when wear tested against low carbon steels and ingot iron if water lubrication is used. An addition of one percent by volume of Ucon charging oil to the water lubricant eliminated galling with the ingot iron supports. However, with the low carbon steels up to 25 percent additions of charging oil did not prevent galling.

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Cold rolled steel fuel element self-supports were fabricated for irradiation testing on elements in a KER loop. Cold work (65% reduction in area) was used to increase the crushing strength and the elastic deflection range of the self-supports. Sets of these supports will be attached to test elements to determine their performance under NPR conditions and to determine how well the steel supports slide through the Zircaloy-2 process tube.

A method now being developed to attach steel supports to zirconium jacketed material consists of: spot welding 1/16 inch high by 1/8 inch diameter studs to the jacket; pickling and autoclaving the fuel element; placing the support over the studs so that the studs project through counter sunk holes in the tabs of the support; and warm upsetting of the studs to produce a flush riveted connection.

Invention report HW-66546 was written describing a clip for locking an NPR inner tube to the outer tube. Dies for making these clips are on order and clips will be tested on elements exposed in the KER loop.

Fuel element jacket burst tests were made on coextruded Zircaloy-2 jackets under nearly uniaxial hoop stress conditions. The fractures obtained displayed localized necking similar in appearance to some of the jacket failures on irradiated fuel. Equipment was made for burst testing of Zircaloy tubes at various ratios of tangential (hoop) to longitudinal stress in order to further investigate the mode of failure of unirradiated coextruded jacket material and the cause of localized necking in preference to uniform elongation.

Irradiated Zircaloy-clad fuel elements have exhibited localized necking of the cladding with little associated uniform deformation of the cladding. This phenomenon is a form of a plastic instability. Plastic instability relations in terms of true stress-strain curves have been obtained for tensile specimens, thin-walled pressure tubes, and sheets under one to one-half and one to one ratio of biaxial stresses. In all cases, instability can occur with sheets initially of uniform thickness. For a material with a sharp break in the stress-strain curve, such as occurs in irradiated Zircaloy, the unstable stress value does not vary greatly with biaxiality. The effect of transverse stresses which cause notch strengthening have not been included in analyses. This effect will have to be included in a model based on secondary creep rates.

Metallurgical Development. Six BeZirc-brazed KER outer fuel element sections were placed in the ELMO-7 loop on April 26, 1960. After 152 hours, one of the unwelded pieces had ruptured. The cause for failure was a pinhole in the braze zone. The remaining elements were returned to the loop and run an additional 333 hours, for a total exposure of 485 hours. All of the unwelded specimens were removed from further testing due to appearance of porosity along the braze zone. Both of the welded specimens appeared sound with a tightly adhering corrosion product on the weld. These elements were returned to the loop and run an additional 801 hours for a total of 1286 hours of exposure. A very heavy, white, loose

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corrosion product had formed over the braze region. This product readily flaked off. Analyses have not yet been obtained. The operating conditions were 572 F (300 C) water adjusted to pH 10.0 with LiOH and run at 1600 psi. Tests now in progress involve thermal cycling NPR inner tubes which were brazed with the BeZirc alloy.

Facilities and Equipment. Installation of a combination furnace capable of making consumable, nonconsumable, and skull castings of reactive and refractory metals is 95 percent complete. This furnace is capable of melting a six-inch diameter by 240-pound uranium ingot. The first successful uranium ingot (50-lb) was made on July 23. Melting time was approximately 14 minutes, arc amperage was varied between 2600 and 4000 amps, and the vacuum during the consumable melt was approximately two microns. Three additional zirconium test heats are scheduled with estimated completion on or before August 31.

Equipment has been developed which records the exterior diameter and warp of cylindrical fuel elements. Linear differential transformers provide the signal for the ordinate as a diameter or radial displacement and a helipot provides the signal for the angle of rotation of the fuel element. These signals have been successfully recorded on a Mosley x-y recorder while a fuel element was rotated on a lathe. Measurements of this type are planned for our next experimental reactor fuel element charge.

2. REACTOR PROGRAM

Coolant Systems Development

Decontamination of Present Reactors. Three solutions for decontaminating present reactors have been tested during the past month: (a) Turco 4306 B, (b) Turco 4518, and (c) a mixture of sulfuric and oxalic acids with an inhibitor. The cyclic testing procedure consisted of exposure to 130 C process water in the 1706 KE Single-Pass Mockup Facility for 156 hours, followed by 30-minute flush with one of the decontaminating solutions. A separate mockup system was used for each solution, with a fourth system used as a control. The treatments with Turco 4518 and with the inhibited sulfuric-oxalic acids were conducted at a nominal temperature of 70 C, while the Turco 4306 B treatment was at 50 C. Six complete cycles were performed with each solution. The attack on aluminum was approximately the same for all solutions, with Turco 4306 B being the most corrosive. Turco 4306 B was also much more corrosive to Zircaloy-2, averaging 0.6 mil/cycle; whereas the corrosion of Zircaloy-2 by the other solutions was on the order of 0.03 mil/cycle. The mixture of sulfuric and oxalic acids was excessively corrosive to carbon steel, averaging 0.75 mil/cycle.

Corrosion Inhibitor Tests. A test to determine whether quachrom glucosate will inhibit aluminum corrosion in filtered process water has been started in the Single Pass Mockup Tubes, employing concentrations of 1.8 and 0.17 ppm quachrom glucosate, plus a control test with 1.8 ppm sodium dichromate. The 1.8 ppm quachrom glucosate concentration was chosen to be the same as the present process water sodium dichromate concentration, and the 0.17 ppm

concentration was chosen because this concentration results in a chemical cost competitive with 1.8 ppm sodium dichromate. One discharge after one week of exposure has been made, but weight loss data are not yet available. Visual observation indicated the samples inhibited with quachrom glucosate were lighter in color. Replacement samples of A-212 carbon steel were charged to obtain carbon steel corrosion data.

Rust Removal. Trade literature for the use of Rodine 82 as a corrosion inhibitor in sulfuric acid solution recommends a Rodine concentration of 1/4 to 1/2 percent by volume of the amount of 100% acid in solution. In contrast, HAPO usage has always been one-half to one percent by volume of the total amount of 10% acid solution. This is a factor of 10 higher rodine 82 concentration in the 10% acid solution than is normally recommended for descaling purposes. To determine the required Rodine concentration, carbon steel coupons were exposed for 60 hours in 10% by volume sulfuric acid solutions with Rodine 82 concentrations of 0.5%, 0.1%, and 0.05% of the total volume. At the end of this time the penetrations were 0.15, 1.95, and 4.05 mils, respectively. The coupons in the two lower inhibitor concentration solutions were covered with many hydrogen blisters and pits. The coupons in the one-half percent Rodine 82 inhibited solution did not have any blisters or pits. On this basis it is recommended that Rodine 82 be used at one-half percent of the total solution volume for all future descaling application.

Palladium Hydrogen Detector. A palladium hydrogen detection device was calibrated in an ex-reactor loop with neutral water at 250 C, 1500 psi. A linear calibration curve was obtained over a range of hydrogen concentrations between 16 and 160 cc/liter. The detector required about ten minutes to reach 95% of equilibrium, compared with seven minutes in previous tests at 300 C. One of the recently completed detectors has been installed in the IRP. From one rupture test in the IRP, the results obtained with the hydrogen detector were quite comparable to those from radiation instruments in following the rupture progression, except that the start of the rupture was not as well-defined by the hydrogen detector. This resulted because the detector is somewhat temperature dependent and in this test the water temperature was reduced immediately after rupture detection. Another hydrogen detector is being fabricated for installation in KER-1.

Pitting of Stellites by Alkaline Permanganate. Photomicrographs showed extensive chemical pitting of Haynes Alloy 41 after six two-hour treatments in the laboratory in alkaline permanganate solutions. The pits varied but reached a maximum depth of four to five mils. Colmonoy 6 showed the same type of selective chemical attack with pits of the same magnitude.

Samples of Stellite 6 and 12 were treated in the laboratory for six two-hour cycles in the 18-3 alkaline permanganate inhibited with various amounts of 1-phenyl-2-thiourea. The results are given below:

Amount of 1-phenyl-2-thiourea	Mils Penetration Stellite 6	Stellite 12
2.5 grams/liter	0.036	0.050
5.0 grams/liter	0.004	0.007
10.0 grams/liter	0.004	0.008

These data appear very promising since the uninhibited solution in comparable tests results in a penetration of 0.5 mil for Stellite 12 and 0.4 mil for Stellite 6. Photomicrographs are being taken to check for the extent of pitting which may be present after treatment.

Thermocouple Slug. To continue the study of crud buildup on fuel elements, a second thermocouple slug was charged in KER Loop 1 on August 4 to replace the one which had been discharged July 7, following a rupture indication. The thermocouple slug is a single rod, 1.00 inch diameter by 12 inches long, of natural uranium clad in coextruded 20-mil Zr-2. One thermocouple is located at the center-line, two just under the cladding, and two in the adjacent water. The thermocouple slug was positioned just downstream of the peak flux. Four, 24-inch, natural and one 18-inch, enriched outer tubes of KER tube-and-tube elements were included in the charge as downstream heater elements. The loop was operated at pH 10 LiOH with a maximum outlet temperature of 285 C. All five thermocouples indicated temperatures which agreed well with comparable thermocouples in the previous thermocouple slug. There was no indication of crud buildup. The loop was decontaminated August 19-20, with the fuel in place.

The thermocouple slug ruptured 23 hours after reactor startup following the decontamination when the loop temperature had been brought up almost to normal. The delayed neutron monitor rose rapidly, going off scale in a couple of minutes. Small sympathetic responses occurred in the monitors of two other KER loops. High gamma activities were encountered at many places in the loop. Water samples taken immediately after the rupture showed strong indications of fission products, including large amounts of iodine and neptunium. The loop was discharged August 22. On examining the elements in the KE viewing pit, the thermocouple element was found to have ruptured at the end where the thermocouples were brought in. The clad was separated from the end cap nearly all the way around the circumference. Two jagged longitudinal cracks, about two inches long, with blistered areas beneath about 1/5 inch wide, extended along the two thermocouples under the clad. The fuel elements appeared clean with no crud deposits. It was noted that five minutes before the rupture the thermocouples under the cladding dropped 5° and 10° C, respectively, while the center temperature remained unchanged.

Rupture Tests of Irradiated Fuel Elements in IRP. Rupture Tests 6 and 7 were conducted during the month. Test 6 was a normal programmed cool-down following first rupture indications, and Test 7 was a modified cool-down in which an initial temperature drop from 300 C to 230 C is made in two minutes followed by a normal cool-down. In Test 6, the filter activity reached about 6 R/hr (wt. loss 16 gm), compared with about 0.4 R/hr for

Test 7. In two previous tests, 4 and 5, which were run under the same conditions, the relative activity levels were 37 R/hr (wt. loss 183 gm) for the normal and one R/hr (wt. loss approx. 4 gm) for the modified cool-down. These tests show a strong incentive to adopt the more rapid, modified cool-down in NPR if shutdown is the result of a rupture.

It is interesting to compare Tests 4 and 5 with Tests 6 and 7, which were identical except that the rods were irradiated at different temperatures. Tests 4 and 5 used KW through-hole irradiated pieces (2400 MWD/T at about 65 C) and Tests 6 and 7 used KER irradiated pieces (2400 MWD/T at 270 C). The low temperature pieces ruptured much more severely than the high temperature pieces. Comparing equivalent tests of "cold" irradiated and "hot" irradiated rods, the "hot" performed better by ratios of 37 to 6 and 6 to 0.4. It appears that more severe uranium cracking in the "cold" pieces was responsible for the difference.

All fuel pieces had received severe thermal shock in previous reactor tests which probably accounts for some of the uranium cracks. Tests 4 and 5 pieces were part of a cluster used in the third ETR tests and Tests 6 and 7 pieces were part of a charge which ruptured in KER. In both cases very rapid cool-downs were employed.

Structural Materials Development

NPR Zircaloy Process Tubes. The radiographic specification for welds in the NPR process tubes has been tightened such that no finished tube may contain a defect whose greatest dimension is more than 0.050 inch. Tubes received from both vendors have been radiographed at HAPO and the results interpreted in the light of the new specification. This more rigorous inspection would reject nine out of 21 Chase Brass tubes and five out of 27 from Allegheny Ludlum. To prevent this degree of loss on future shipments, the as-welded joints will be inspected to a closer tolerance than formerly. It has been demonstrated that a defect elongates in the direction of the tube axis during cold working. Both vendors will be allowed voids in the as-welded joints, up to 0.050 inch in the circumferential direction. Because of the different amounts of cold work employed by the two vendors, Chase will be allowed 0.040 inch axially and Allegheny 0.035 inch.

In order to help improve the quality and reproducibility of the radiographs produced by the vendors, radiographic standard has been prepared at HAPO from a section of NPR extrusion. Voids of known size and location have been generated in this piece, and it has been radiographed at Hanford to establish the exposure factors which reveal the defects to best advantage. The standard has been sent to Chase Brass to aid in developing a technique which duplicates Hanford results. Their first exposures show an improvement over previous practice.

Nonmetallic Materials Development

Graphite Burnout Monitoring. Burnout samples were discharged from 3478-D on August 8, after 426 operating days. Samples near the rear gun barrel showed an average weight gain of 0.01% per 1000 operating days, while samples from the front and central sections showed average losses of 0.68% and 1.6%, respectively. This is an example of graphite mass transfer within a process channel. Carbon suboxide decomposition was evidenced by dark deposits on some of the samples.

Hot Test Hole Irradiations. Eight hundred graphite samples were charged into hot test hole facilities (500 to 600 C) at C and KE Reactors, including NPR reflector graphites, previously-irradiated reactor grade and experimental graphites, and many new experimental graphites.

New Compression Test. Two sample boats, each containing 15 NPR graphite samples, were charged in 2C at KW Reactor on August 9. Boat No. 1, with five samples under 136 to 161 psi stress, will be discharged for examination after approximately one month. Boat No. 2, holding five samples under 128 to 140 psi, will be irradiated for approximately six months. Four additional compression boats are being prepared for in-reactor and four boats for ex-reactor testing.

NPR Graphite Measurements. Eight compressive test samples were taken from four bars of AGOT-LS made by National Carbon Company and four bars of GLC-R1 from Great Lakes Carbon Company. These are NPR reflector graphites. The samples were cut as a parallel section of a full bar and measured 4" x 4" x 5". The 4" x 4" face was loaded during the compressive test. The following table summarizes the results of this ex-reactor test.

Graphite Source	Transverse Compressive Breaking Strength lb/sq in	Deflection*, inches
Great Lakes Carbon Corp.	3975	0.009
	2812	0.006
	5038	0.013
	4775	0.011
National Carbon Company	3375	0.0085
	3275	0.006
	2906	0.0085
	4000	0.010
Average	3770	0.009
Standard Deviation	± 22%	± 8%

(*Deflection just prior to breaking.)

NPR Reflector Graphite Irradiation. The GEH 13-5 experimental capsule containing NPR reflector graphite has been completed and will be installed in the N-5 corner of the ETR during the Cycle 32 shutdown. A holder was attached to the capsule so that flux monitors can be inserted and removed while the experiment is in the reactor. Flux measurements using bare and cadmium-covered Ni and Co-Al wires are being made in N-5 and N-14 during Cycle 31.

Thermal Hydraulic Studies

Heat Transfer Experiments Pertaining to Present Production Reactors. Some experimental boiling burnout data were obtained with a test section designed to study the effects on heat transfer of the eccentric positioning of fuel elements within a process tube. The test section was two feet in length and had a cooling annulus similar to that formed by the I & E fuel elements in a K process tube. Two runs were made with the heated section positioned concentrically with an annulus of 0.113 inches, and two runs were made with the top of the annulus reduced to 0.028 or 75% eccentric. The results are as follows:

Run	Flow (gpm)	t in °F	Q/A B.O. B/hr ft^2	Burnout Subcooling (°F)	Eccentricity
1	22.3 at	196	1.2×10^6	24	0
2	22.3 at	196	1.6×10^6	0	0
3	22.6 at	196	0.47×10^6	71	75%
4	23.1 at	233	0.47×10^6	35	75%

Burnout originated on the top of the rod 2-1/2 inches from the downstream end of the heated section in Run 1, while in Run 2 burnout occurred 90 degrees from the top and one-half inch from the downstream end. Burnout surface temperature rise showed up only at the three-inch position in Run 3 but occurred at the one, two, and three-inch position for Run 4.

Two test sections were destroyed during these experiments so the quantity of data is small. However, even with these limited data points, the results indicate that a large decrease in boiling burnout heat flux is encountered with eccentric positioning of fuel elements within a process tube. It is thought possible that such a mechanism is responsible for "hot spot" ruptures of fuel elements.

Cooling by Boiling Experiments. During reactor shutdown conditions and especially following a loss of pumping power, a question exists as to whether the Hanford reactors could be adequately cooled during boiling of the coolant in the process tubes. This problem was studied briefly in the heat transfer laboratory with the use of a test section simulating a charge of K I&E fuel elements in a full length process tube.

With the rear header at atmospheric pressure a head tank pressure of 6.8 psig was applied to the front header. Under these conditions the heater rod power was brought up to 50 KW with an outlet temperature of

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175 F. The pressure was briefly reduced which allowed boiling to take place in the tube. After boiling was well under way and local film boiling had commenced, the pressure was reapplied. The surface temperature decreased but the exit temperatures remained at saturation indicating the system was operating at reduced flow in the stable boiling region of the 50 KW tube demand curve. Surface temperatures remained close to saturation temperature in the downstream portion of the tube with two thermocouples showing a cyclic break into and out of film boiling.

The tube power was then boosted to 55 KW and the surface temperatures increased slowly into film boiling conditions. A steady state point was not reached. When surface temperatures reached approximately 1150 F and the tube outlet steam was superheated above 600 F, the power was reduced to 50 KW again. This caused the temperatures to level off. After operating under these conditions the temperatures had decreased only slightly, approximately 50 F, in a half hour and there was no real indication of returning to the original 50 KW condition. The power was then dropped to about 45 KW and the system completely recovered in 5-10 minutes.

The results of this experiment can not be immediately applied to the reactor for the following reason. During shutdown conditions approximately 20 percent of the heat is generated in the graphite and in addition, depending upon the graphite temperature, sensible heat is available for transfer from the graphite to the cooling water. The net effect on the boiling process due to the heat transfer from the graphite has not yet been fully developed.

Hydraulic Studies. A study was made of the experimental data obtained concerning the pressure losses due to the "suitcase handle" supports for NPR fuel elements. Pressure drops for the supports were correlated in terms of a drag coefficient for the support as follows:

$$f_D = C(R_e)^n$$

where f_D is the drag coefficient and R_e is the annulus Reynolds number. By means of this correlation the pressure drop of any size support for any given conditions of flow, velocity, and temperature may be calculated. The correlation may be easily incorporated into the machine program for fuel element design.

Critical Flow Experiments. The investigation of the critical discharge behavior of two-phase water mixtures was continued by a study of the influence of back pressure upon the axial pressure distribution during critical discharge, incipient critical discharge, and non-critical discharge conditions. A total of six runs were performed at qualities varying from approximately 5% to 95% in which continuous plots of the pressure at the various taps were recorded continuously on a "X-Y" recorder as a function of back pressure as the latter was varied from the minimum pressure obtainable to the maximum. The general shape of the axial pressure profiles obtained during the critical discharge conditions exhibited a close correspondence to that obtained by the continuous

traverse method employed at the University of Washington. Both of these methods demonstrate the rapid expansion which occurs in the final 1/2" to 3/4" of the flow passages. On the basis of a critical comparison between the data obtained here and of the previous work mentioned above, it was concluded the extrapolation technique would produce a valid representation of the pressure occurring at the location of choking if sufficient number of pressure taps are provided in the final one inch of the flow passage (as was the case in the test section used in this experiment).

Shielding Studies

Attenuation Measurements. The last irradiation of the 265 lb/ft^3 iron serpentine concrete (after being baked at 320 C) is currently under way. This will complete the testing of this type of concrete.

Shielding Instruments. The Perlow neutron spectrometer for use in shielding measurements is being calibrated in the 300 Area Ion Accelerator Laboratory. At present it has been calibrated for neutrons in the energy range of 150 to 600 Kev at a gas pressure of 8.00 cm Hg at 0 C. It was found that by using the theory developed by Ward Diethorn (NYO-6628) for gas amplification, the channel in which a neutron of any given energy falls can be predicted within two or three channels on the 100-channel analyzer.

Decontamination of the second Perlow counter removed over 90% of the radioactivity which had spread into the counting volumes from the internal calibration source. The counter is to be made gas tight and radiographed prior to calibration. It is proposed to use three identical counters together. Different internal gas pressures will permit a rapid scan of the neutron spectrum.

It was found necessary to rewire the filament circuit in the master clock pulse entry circuit in the 100-channel analyzer to eliminate a cathode-to-heater tube failure which has occurred twice this month.

Design and Component Testing

NPR Charging Machine. A proposal has been made for fabricating and testing a reduced length prototype charging machine to include development on certain critical items. The prototype would include all essential components.

The magazine positioner prototype is 90% complete. Conceptual design of a nozzle adaptor incorporating an integral relief assembly has been completed and comment prints issued. Further work is pending action on the prototype charging machine proposal.

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. Fabrication of 22 Mark I-G Pu-Al spike clusters for physics testing use has now been completed. The required five additional Mark I-G fuel elements are being recycled through grit blasting, etching, and autoclaving. Of the 36 Mark I-H clusters (35-mil Zr-2 jacketing, Al-2 w/o Ni-1.8 w/o Pu) required for PRTR loading, 10 are in an advanced stage of fabrication, billets have been cast for an additional 20, and some of these have been extruded into rods. Etching and autoclaving equipment difficulties, delayed fuel tubing deliveries, and failure of much of the new tubing to meet dimensional specifications have slowed this work.

Of 150 tubes received during the month, only half passed dimensional inspection. The first of this tubing which is specified to have an inside diameter of 0.495 to 0.500 inch was accepted below the tolerance limit in order to get tubing, and it cannot be air gaged with the equipment now in use. A new electronic gaging machine is being developed which will gage the inside diameter of a tube with 0.010 inch spread to within 0.0001 inch. Tubing with a maximum 0.002 inch ID spread within any one tube is expected to start arriving on site very soon. With this tubing, Mark I-H fuel elements can be fabricated with the desired 0.004 to 0.006 inch gap between core and cladding.

Fabrication Development. A cladding rupture occurred in an autoclave containing 36 Pu-Al spike fuel rods. The fuel rod (E-39) consisted of an Al-Pu-Si-Ni corrosion resistant core (CRB-54-F1) clad in a Zircaloy-2 tube (#3907) of the poor quality characteristics of 1958 and 1959 deliveries. Nondestructive tests on this tube (RTO#597) had given slight indications on eddy current testing and ultrasonic testing after rod assembly showed the tube to have 77 crack indications greater than 0.009 inch deep. Examination of the core after tube rupture showed small amounts of corrosion at two different points where split-type tubing failures had occurred. The core material exhibited good corrosion resistance considering the graphite coating and superheated steam atmosphere of 400 C at 1300 psi. A detailed examination and report is forthcoming. Preliminary decontamination experiments on the autoclave rack indicate that the autoclave vessel can probably be successfully decontaminated to a low level.

Since nickel has a high cross-section, the lower limit of nickel concentration required to impart corrosion resistance to the 1.8 w/o Pu alloy is being determined. Alloys containing 1.90 and 1.75 w/o nickel showed corrosion behavior similar to the Al-2.0 w/o Ni-1.8 w/o Pu alloy. At the time of this report an Al-1.50 w/o Ni-1.8w/o Pu alloy is being tested.

Samples from bottom, center, and top of the first two, 89 inches long, 1.83 w/o Pu, 2 w/o Ni-Al alloy pneumatic injection castings assayed:

Sample	Pu Content (w/o)	Sample	Pu Content (w/o)
1 Bottom	1.53	2 Bottom	0.891
1 Center	1.71	2 Center	1.97
1 Top	2.07	2 Top	2.02

The ingots for these castings were melted in vacuum, heated to 700 C and injected into Zircaloy tubing. Apparently the $PuAl_4$ was not completely in solution before casting. To correct this situation, another casting was made in which the Pu alloy ingot was melted in air, heated to 800 C, mechanically stirred, allowed to cool to 700 C while the system was slowly evacuated, and then cast at 700 C. Four samples were cut from this casting and are awaiting chemical analysis.

A preliminary corrosion test was conducted on the injection cast dejacketed core samples from Rod No. 2. The core exhibited 350 C corrosion resistance comparable to that of the wrought structure of extruded rods of similar alloy composition.

Since the swage hood has not been completely enclosed for plutonium work, exploratory work was begun on swaging pre-welded samples containing Spencer fused UO_2. By utilizing a proper particle size distribution it was possible to increase the tap density from 7.3 grams/cc to 8.1 grams/cc. This particle size distribution is obtainable by a single crushing operation and is not the result of particular size blending. Twenty swaging samples were prepared with varying initial densities. The results of these swaging trials are:

Sample	Initial Density gm/cc	Total Elongation Factor at 40% R.A.	Density* at 20% R.S. gms/cc	Etched Density at 42% R.A. gms/cc	Etched Density at 42% R.A. % Theoretical
1	6.70	1.13	8.50	9.88	90.2
2	6.97	1.16	8.98	9.85	89.8
3	7.14	1.18	9.05	9.84	89.7
4	7.40	1.20	9.10	9.90	90.3
5	7.60	1.23	9.24	9.85	89.8

*Calculated.

(All results were obtained on samples initially at 0.750" in diameter by 18 inches long.)

A mathematical relationship was derived which relates elongation factor, initial density, swaged density, wall thickness, and diameter with percent reduction in area. With the derived formula it is possible to calculate a variety of parameters at any reduction in area.

Diametral tolerances have been found to be much smaller on the high initial density rods than the low density rods. Rods with an initial density above 7.35 gms/cc showed a deviation of ±0.003 inch, while the lower density rods showed ±0.0055 inch. (It should be noted that much of this deviation is found in the end regions.)

In swaging pre-welded fuel tubes it has been found that the first swaging pass should be made with a low percent reduction in area. A high reduction in area on the first pass results in the powder being forced to one end of the tube which creates a gradient in initial density. This may in turn result in the tube rupturing on subsequent swaging passes. It is also of prime importance in swaging pre-welded samples to change swaging direction after each pass.

The changes in surface finish of swaged rods were studied as a function of feed rate and rotational speed. It was found that as the rate was decreased from five to one foot per minute, the quality of the surface improved. The improvement found by going below one foot per minute was negligible. Increasing the rotational speed from 20 to 60 rpm improved the finish; above this, no improvement was noted.

The gamma absorptometer was activated during the month. Although the standards now available are not satisfactory, it has been very useful in studying the relative density changes along the length of long rods. If the rods are loaded to a low (7.1 gm/cc or less) density an appreciable decrease in density is found at the lead end of the first pass. This persists through the swaging even though the rods are reversed after each pass. If a higher apparent density is used, 7.6 gm/cc or higher, the low density area is decreased in length to an inch or less. One rod showed less than a two percent variation in density.

Fuel Evaluation. Radiometallurgical examination of irradiated Pu-Al clusters in support of PRTR is continuing. Core measurements have been made on the eleven-inch long Zircaloy-clad three-rod cluster in which the cores were coated with graphite. No appreciable dimensional changes were detected in the diameters. Core density determinations are being made. There was no sign of bonding between the core and cladding.

The eleven-inch long Zircaloy-clad three-rod cluster which had as much as 0.009 inch diametral gap between the core and cladding is also being examined. All three rods were sectioned, and there was no sign of bonding between the core and cladding. A 0.002-inch thick layer of some unknown material was observed on the inside surface of one of the Zircaloy cans. The material appeared to be brittle and was not tightly adhered as some was knocked loose during polishing and etching. Metallography of the core indicated the presence of voids probably from fission gases. Measurements

taken on the center of the core indicate that it may have increased only one or two mils in diameter, but length measurements were not made because the ends were inadvertently cut during sectioning. Core density measurements are being obtained.

Experiments to investigate the reactivity and irradiation characteristics of the self-shielded and Phoenix fuel concepts are under way. Aluminum-plutonium alloys using plutonium which contains 5.46, 13.13, 21.1, and 28.88 percent of the isotope 240 are being cast for the capsule reactivity experiment to be conducted in the MTR. Measurements will be made in the PCTR, PRCF, and the RMF in an effort to determine the effect of exposure on the reactivity of fuels using the different types of plutonium. The capsules, holders, and modified X-baskets necessary for the experiment are being designed. Samples will also be fabricated which contain different amounts of poison, namely, boron. By making measurements with these samples and determining the weighting functions, the reactivity contribution of the fissionable atoms can be distinguished from the poison effect of the fission products.

In addition to the reactivity change experiment, another experiment will be conducted to follow the power generation of a Phoenix-type fuel with exposure. Two 42-inch long, 19-rod elements will be equipped with thermocouples so that the power generation can be followed during irradiation. The first element will be an injection cast cluster containing plutonium which has 5.46 percent 240. The plutonium in the second element will contain 21.1 percent 240 and will be fabricated by the PRTR process. Power generation curves for the two elements will be compared. A fairly reliable power generation curve for a similar U-235 enriched element can also be calculated for comparison purposes.

Calculations on the self-shielded fuel concept are continuing. The first analysis of a PuO_2 core surrounded by MgO indicates excessive core temperatures. Other designs are being evaluated in an effort to improve thermal conductivity and hence lower the operating temperatures. Some of the designs being evaluated are as follows:

1. A PuO_2 core surrounded by a thin wall tantalum container which is in turn surrounded by thick walled Zircaloy to form a one-half inch diameter rod.

2. A small diameter PuO_2 core surrounded by a thick walled Zircaloy jacket.

3. A PuO_2 core surrounded by a thick walled niobium jacket.

4. A small diameter PuC core surrounded by high density graphite which is in turn surrounded by a 0.035-inch Zircaloy jacket. This element would have the advantages of a core with a higher fissionable atom density and better thermal conductivity, surrounded by a material which has relatively good thermal conductivity and neutron economy.

One hundred percent self-shielding occurs in an 0.0625 inch diameter, 70% dense PuO_2 core; i.e., in a given flux, the power generation decreases as the core density increases. It is calculated that each of the designs mentioned above will generate from 14 to 16 kw/ft in a thermal flux of 1.26×10^{14} nv. Heat transfer calculations will now be made.

UO2 Fuel Development

PRTR Fuel Elements. Design and fabrication of a swaged UO_2 19-rod cluster PRTR fuel element which can be disassembled and reassembled were completed. Three fuel rods in the cluster contain special closures to allow insertion of a total of six metal foils at one time for physics measurements.

A prototypical, three-foot section of a swaged PRTR fuel assembly was tested in the ETR at an average estimated maximum power generation of 395 kw/ft and an outlet coolant temperature of 503 F. The test was completed successfully after an irradiation period of twenty days, at a specific power generation, at full reactor power, approximately 150 percent greater than the maximum anticipated for UO_2 elements in the first PRTR cycle.

A study which analyzes and compares the fabrication costs for some of the various types of UO_2 fuel elements being developed at Hanford is nearing completion. Three fuel geometries are being considered; the 19-rod PRTR cluster, a 7-rod cluster, and a nested tubular element. In addition, comparisons are being made of the swaging and the vibrational compaction processes. Cost estimates are included for hot swaging both untreated and fused uranium dioxide powders. This analysis indicates that uranium dioxide fuel elements can be produced for substantially less than costs presently being quoted for large commercial power stations. Lowest costs appear obtainable through use of the vibratory compaction process in combination with fuel element geometries other than the 19-rod cluster design.

Fabrication Development. Nine thin-wall stainless steel clad fuel rods were fabricated for irradiation in the VBWR. Four of the rods had a cladding thickness of 0.015", three had a cladding thickness of 0.010", and two were clad with 0.008" thick stainless steel. The fuel was vibrationally compacted in 0.563" OD x 38" long tube.

The fines (-100 mesh) were sintered UO_2 (95 percent T.D. particle density) enriched to ten percent U-235. The remaining material was fused natural UO_2 ($>$ 99 percent T.D. particle density). The average density of the 0.015" clad rods was 86.1 percent T.D. The 0.010" clad and 0.008" clad rods averaged 88.5 percent T.D. Several small dimples occurred in the cladding as a result of compaction.

All tubes were Zyglo fluorescent penetrant tested on the outside and inside surfaces prior to compaction. The finished rods were helium leak tested and autoclaved for one hour in water at 1000 psi and 280 C.

Four 0.005" thick stainless steel clad rods were also fabricated by the same techniques. The fuel density in these rods averaged 84.8 percent T.D. During autoclaving, the cladding collapsed and formed sharp, broad based ridges 0.001" to 0.002" high along the length of the rod. One of these rods was swaged, after autoclaving, to a final diameter of 0.547". The ridges were eliminated with no indication of buckling or folding of the metal. No ridges were formed when the rod was autoclaved a second time. This rod will be sectioned and examined to determine the character of the inside surface.

The low densities, especially in the 0.005" clad rods, were due primarily to low particle density in the sintered fines and less than optimum particle size composition in both the coarse and fine fractions. By correcting these conditions it should be possible to vibrantly compact 0.005" clad fuel rods to densities high enough to minimize collapse in the autoclave. For example, fused UO_2 with a favorable particle size composition was compacted in 0.0075" stainless steel cladding to 90-91 percent T.D. As a result of using smaller particles in the coarse fraction of the mixture, no "dimpling" of steel cladding occurred.

Photomicrographs and electron micrographs of hot swaged -100 mesh sintered UO_2 clad in Inconel-X indicate that:

1. Considerable plastic deformation of the UO_2 occurred in samples swaged at 800, 1000, and 1200 C.

2. Sintering occurred between UO_2 particles swaged at 1200 C. A lesser amount of sintering was observed in the sample swaged at 1000 C, and no sintering between UO_2 particles was observed in the sample swaged at 800 C.

3. The UO_2 did not react with the Inconel-X cladding at any of the swaging temperatures.

4. The structure of the Inconel-X cladding was not detectably changed or altered.

Fuel rods clad with 0.005" wall stainless steel were successfully swaged from 0.563" OD to 0.547" OD. The cladding on these rods showed no indications of folding or buckling after swaging.

Studies of uranium carbide fabrication were initiated. The material, supplied by Atomics International, will be vibrationally compacted in 9/16" OD x 0.010" wall stainless steel in two-foot and eight-foot lengths.

The magnetic force butt welder was employed to weld the closures on lead-cadmium fuel rods required for PRTR physics tests. The very effective use of this machine eliminated the problem of cadmium contamination encountered in the evacuable welding chamber during the initial attempt to arc weld the rods.

The welding machine settings were established and verified for making consistently high quality closures on 0.563" OD x 0.030" wall Zircaloy cladding. PRTR rods and Hanford reactor defect test rods were welded with reliable results. Each size fuel rods and each material requires machine settings to be accurately established to assure the desired weld quality. At present, destructive tests are required to determine the weld quality; sample welds have been evaluated by metallographic examination, tensile testing, and shearing tests. Radiographs of magnetic force butt welds were not interpreted reliably. Ultrasonic testing is being explored; problems of reflecting interference signals due to the changing metal cross-section in the vicinity of the weld were encountered. Another method of assuring weld quality is the accurate monitoring of the welding current and voltage of each weld as it is made. Minor deviations which result when an improper weld is performed will be indicated on the monitoring instruments.

Welding parameters are being investigated to weld closures on various sizes of stainless steel fuel rod cladding. Cladding sizes being evaluated at present are: 0.563" OD x 0.005", 0.010", and 0.015" wall thickness, and 1.00" OD x 0.063" wall thickness.

The problem of erratic acceleration encountered with the draw bench of the Thermatool machine was alleviated by tightening the carriage system and providing positive engagement to the draw chain. The draw mechanism and tube to be welded are allowed to accelerate for one inch of forward movement before the welding power is initiated. The previously erratic acceleration had required six inches of travel before current initiation.

Excessive tube distortion and metal expulsion beneath the rib was encountered when welding 0.075" diameter ribs on a 10" spiral to a 0.563" OD x 0.015" wall stainless steel tube. A structurally sound weld nugget was formed beneath the rib and tube; however, various attempts to minimize the distortion and metal expulsion were unsuccessful. Most of the wire cross-section reached a temperature well in excess of the temperature of the tube. Upon cooling, the wire shrinkage pulled the tube spirally out of concentricity by approximately 3/32 inch.

Immediate future use of the machine will be for continued evaluation of spiral welding ribs on Zircaloy tubing 0.563" OD x 0.030" wall thickness. A reduction of gas contamination of the heated Zircaloy after welding may be realized by rapid quenching of the material. An expansion nozzle for CO_2 gas is being incorporated immediately after the argon diffuser manifold to provide a quick chill. Evaluation of this chilling has not been completed; however, it is anticipated that the incorporation of the CO_2 will decrease the need for expensive argon.

The tooling design was completed for welding straight ribs on the Mark II-C tubular fuel element segments. This tooling should be fabricated by October 1.

A satisfactory weld joint design has been developed which works remarkably well for arc welding closures on thin fuel element cladding. A dovetail flange is provided on the closure cap. This flange serves a dual purpose of trapping the thin cladding, preventing it from "belling" on the end when heat is applied. The arc is established on this flange, which melts down against the cladding to secure the closure during the welding operation.

A line joint exists between the fuel and the closure cap which results in buckling of the thin cladding under pressure. A sleeve may be inserted in the end of the fuel cladding to reinforce this area of the cladding. The dovetail flange provided on the sleeve allows a welded closure to be made simultaneously between all three parts - cladding, sleeve, and cap.

Corrosion Studies

Hydrogen Pickup by Zircaloy-2 and Zircaloy-4 in 400 C, 1500 psi Steam. In June 1960, data were reported on steam corrosion tests of D141 Zircaloy-2 obtained from Bettis. These data showed excellent agreement with Bettis corrosion rates, but the HAPO data on hydrogen pickup were a factor of two lower. One major difference between HAPO and Bettis corrosion testing is that Bettis autoclaves are run static, whereas HAPO autoclaves are refreshed. To resolve this difference, coupons of several Zircaloy-2 and Zircaloy-4 ingots were corrosion tested in the HAPO autoclaves under both static and refreshed conditions. Preliminary data from this experiment again show excellent agreement for the corrosion rates, whether measured at Bettis in static autoclaves or at HAPO in either static or refreshed autoclaves. However, hydrogen picked up by the Zircaloy samples in the HAPO static autoclave tests was approximately two-fold higher than in the comparable HAPO refreshed autoclave tests. Hence, when operated static, HAPO hydrogen pickup values more nearly check Bettis values, which are also from static autoclaves. Further tests will be required to determine whether this difference in hydrogen pickup between static and refreshed autoclave conditions is due to the accumulation of hydrogen over-pressure in the static autoclave, dissolved oxygen added to the refreshed autoclave, or some as yet unrecognized factors. In any event, it appears demonstrated that environmental conditions can influence hydrogen pickup in Zircaloy such that hydriding of Zircaloy reactor components might be significantly minimized by proper environmental control.

Although the hydrogen pickup for the Zircaloy-4 generally was somewhat less than for Zircaloy-2 in comparable tests, this was not always the case, especially at the longest test exposure time of 28 days.

Aluminum Alloy Development. Aluminum alloys containing iron and nickel ratios comparable to the super alloys but with lower total alloying content are being prepared to establish the minimum second phase concentration required in 99.995% of pure aluminum base stock to protect aluminum in high temperature water. An alloy containing 0.5% Ni and 0.62% Fe shows a penetration after 10 days in 360 C water comparable to the super alloys. Alloys of lower contents are being fabricated.

Castings to determine the effect of casting variables on one of the super alloys are being made. The variables to be investigated are holding temperature, holding time, pouring temperature, and cooling rate.

Heat-Treating Damage to Super Aluminum Alloys. After being held at 550 C for three months, the 1.8% Fe, 1.2% Ni alloys still show no detrimental effect on corrosion rate as a result of the heat treating.

Structural Materials Development

PRTR Fuel Sheath Tubing. The vendor has fallen approximately two months behind schedule in deliveries of Zircaloy-4 fuel sheath tubes. In addition, a large percentage of the 0.495 inch ID tubes received to date do not meet the very tight +0.002" - 0" ID tolerance specification. From five to forty percent of the tubes received in various shipments have defects detectable by the fluorescent penetrant dye test (primarily pits, cracks, or scale inclusions). These problems and shortcomings have been discussed with the vendor's management with resulting assurances of a concerted effort to increase performance. On the plus side, the vendor has recently installed a new air abrasive machine to surface condition the extrusions, and it is hoped that this operation will substantially reduce the number of rejects due to inside surface defects.

Negotiations with Bridgeport Brass Company to produce sheath tubing with an ultra fine grain size are under way. Preliminary tests indicate this can be accomplished by a warm extrusion and careful time and temperature control on subsequent heat treating steps.

Small-scale HAPO tests produced an ultra-fine 0.006 mm grain size in warm extruded Zircaloy-2 by salt-bath heat treatment at about 1200 F, followed by air cooling. This grain size is comparable to that of a Hareaus tube sample which exhibited excellent swageability. Samples from warm extrusions were heat treated in Houghton 980 salt bath at various temperatures for times up to four hours. Complete recrystallization of the cold-worked texture to ultra-fine grains occurred in eight minutes at 1100 F, four minutes at 1200 F, or in one minute at 1300 F. The approximate average grain diameters were 0.006, 0.007, and 0.009 mm for annealing temperatures of 1100, 1200, and 1300 F, respectively.

Grain growth occurs when the annealing time is increased. Vacuum annealing produced grains about twice as large as salt bath annealing for the same temperature and time. Similar tests on hot-extruded and cold-worked samples are in progress. Relatively large grains were produced by salt bath annealing and vacuum annealing of 40 to 60 percent cold worked Zircaloy-2.

PRTR Process Tube Monitoring. The Mark I prototype, incorporating a TV camera and ID measuring gage, has been assembled and is being tested and modified in preparation for use on the PRTR early in September. All 85 process tubes will be inspected and measured internally while installed in-reactor, and permanent kinescope records of the tube inside surfaces

will be retained for comparison with future monitoring scans made after the tubes have been in operation.

Gamma-radiation testing of electronic components for the Mark II prototype tube monitor continues. Based on pre-post measurements, relatively little or no changes in the characteristics of vacuum and ceramic electron tubes have been observed at gamma doses up to 5×10^9 roentgens. All transistors and one tunnel diode irradiated to 5×10^9 R have failed or shown very substantial changes in electronic characteristics. Preparations are being made to test vacuum and ceramic tubes, resistors, and capicators under simulated electrical load in a high gamma radiation field.

Crown and flint glasses, as well as purified fused silica, show only little darkening at a total gamma dose of 5×10^9 R.

In testing ultrasonic transducers, the plastic used by the manufacturer for crystal mounting has undergone extensive damage which precludes further performance testing of the transducer crystals themselves. Current attention is directed toward finding more suitable potting materials.

For the gas gap measuring instrument, the first probe design has been completed. Coil wire with radiation resistant insulation has been received. A modified Magnaflux instrument for use with the probe coils has been ordered.

Radiometallurgy Laboratory Studies

Core-cladding diffusion was not found in the examination of two 3-rod Pu-Al clusters fabricated by different techniques (RM-659 and 660). A swaged UO_2 capsule was found to have an axial void and recrystallization of the UO_2. Fission gas was collected for analysis and a sample of the core was dissolved for burnup analysis (RM-271). Forty-eight UO_2 samples were prepared and transferred to Ceramic Fuels Development Operation for their high temperature studies of irradiated materials (RM-609).

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

Thermal Hydraulic Studies

Problems of a Small Leak Downstream of the Flow Monitor in a PRTR Process Tube. If a small leak should occur near the inlet of a PRTR process tube, the result would be an increase in flow through the inlet piping, including the flow meter, but a decrease in flow past the fuel elements. The concern, if such a leak should occur, is whether the increase in flow through the flow monitor is sufficient to cause a high flow trip and a reactor power reduction if the flow past the fuel elements were reduced to a point where boiling burnout would occur.

The first analysis of this problem indicated that an accurate knowledge of the pressure drop across the fuel elements and outlet piping,

especially during two-phase flow conditions, would be required in order to be certain that boiling burnout conditions would always be detected by a high trip. Since calculations of two-phase pressure drop are not highly accurate a test section was built to experimentally check the pressure drops across the outlet piping during two-phase flow.

The experimental pressure drops as reported in prior reports were significantly higher than those calculated. The test section was then rebuilt eliminating some deviations from the actual reactor geometry and additional pressure taps were installed. The latest data of over-all pressure drop confirm the earlier data and indicate the largest single pressure drop is from the top of the nozzle to the inlet of the jumper. Also contributing is the pressure drop through the four elbows at the end of the jumper.

Using the latest experimental results, an analysis of the original problem indicates that ruptures severe enough to cause boiling burnout will be detected by the high trip only if the ruptures occur very rapidly. In these cases a momentary flow increase will occur before boiling has had time to start and cause dangerous flow reductions. Ruptures of certain sizes that occur slowly will have to be detected by other means such as high outlet water temperature and an increase in the shroud tube pressures.

Analysis of Process Tube Ruptures Accompanied With a Failure of the Primary Water Makeup. A study is now being completed of the evaluation of the potential hazard of various size ruptures in the process tubes of the PRTR. It has been determined that within the size range from an equivalent diameter of 0.25 inch to 2.00 inches a hazard exists if there were a simultaneous rupture and failure of the primary light water makeup. Secondary light water makeup is not available until the system pressure decays to 100 psia. Before this would occur, fuel element melting would probably be realized.

The effect of both a 1-1/2" vent valve and a two-inch vent valve on the rate of pressure decay has been calculated. A 1-1/2" vent valve appears to be inadequate under some kinds of transients. A two-inch vent valve appears to be adequate for all possible transients.

An alternate method of protecting against this type of hazard would be to provide additional head on the secondary light water makeup system. A head of 500 psia together with a flow rate of about 350 gpm should protect the system against fuel element melting.

Evaluation of which method to incorporate into the reactor design was started.

Boiling Burnout Conditions for the 19-rod Cluster Fuel Element. A revised model of a test section representing a 19-rod cluster Mark I fuel element was constructed for heat transfer experiments. The test section was installed in the 189-D laboratory, and preparations were made to determine heat fluxes under boiling burnout conditions.

PRTR Project Management and Design

Phase III PRTR Contract. The Phase III contractor is estimated to be about 97% complete as of August 31, 1960, versus a scheduled 100% based on a contract completion date of June 24, 1960, the official AEC schedule. Over-all PRTR Project is estimated to be about 98% complete versus a scheduled 100% based on the official schedule. The Phase III contractor has been informed that his contract will be terminated September 12, 1960.

The 70-day run-in testing of the river pumps was started on August 12, 1960.

The contractor has replaced the shell plate in the temporary containment vessel opening. Welding the plate in place is approximately 75% complete.

During the hydrostatic testing of the high pressure steam piping, the contractor procured 12-inch expansion joint immediately outside the containment vessel failed at about 600 psig. Failure was due to overstressing of the tee rod anchor block welds, an item commented upon during review of the vendor's drawings. The vendor is making a new bellows section to be welded into the assembly in the field.

The vertical extensions from the calandria to the moderator storage tank were installed down to a point below the elevation of the inlet jumpers and the spiral shield plugs installed therein. It has been necessary to cut the 14-inch primary system inlet pipe to install the thermal barrier bellows at this pipe penetration due to a contractor oversight. The bellows is now in place and the pipe rewelded. Inlet jumper installation is in progress and is approximately 50% complete. Flowmeter venturi pressure tap tubing is being installed with the jumpers. Outlet water sample tubing lines have been installed on the reactor top face. The Inconel level switch standpipe has been installed on the pressurizer.

The fuel transfer system is partly operable but will require minor modifications to maintain alignment during operation. Without water in the storage basin, the travel speed of the conveyor is too fast. The speed may be acceptable underwater, however. Piping to the water pit conveyor is being installed. Minor difficulties were encountered in installing the inflatable seals on the rotating shields. The seals will have to be modified to allow installation.

The blower for the dry gas system has not passed the helium leak test so that the shipment date is uncertain.

Maintenance and Mockup Facility. Bids for the Maintenance and Mockup Facility were opened August 17, 1960, with the apparent low bidder being George A. Grant, Inc., with a bid of $633,700. The fair cost estimate was $713,000. Contract award is pending AEC funding approval. This bid assembly included the Critical Facility structure (Project CAH-842), the Rupture Facility structure (Project CAH-867), helium gas storage facility, stack filter and tie-in, and modifications to 309 Building, in addition to the Maintenance and Mockup Facility.

Rupture Monitor System. Procurement is still the major problem in the fabrication of the mechanical portion of the Fuel Element Rupture Monitor System. Delivery of the flow control needle valves is not expected until September 20, with the solenoid shutoff valves promised by September 30. Completion of the system is scheduled for October 15, based on these delivery dates.

Testing of the electronic portion of the rupture monitor system was rescheduled for the last week of August by the vendor. Delivery of this part of the system will not become critical until early October.

Loadout Cask. The cask shell has been lead filled and x-rayed for voids. The x-rays are now being checked by GE Inspection. Final finishing will take about three weeks, assuming the x-ray films disclose no voids in the lead.

Fuel Examination Facility. The vendor of the primary manipulator is proceeding with final assembly. He has requested a waiver of the finish requirements on the main frame. Action on the request is being held up pending receipt of photomacrographs showing the surface finish which has been obtained.

Fuel Element Rupture Test Facility (Project CAH-867). As mentioned previously, bids have been opened for construction of the Maintenance and Mockup Facility which includes the 309 Building Annex for the FERTF. The FERTF portion of the bid is estimated to be $115,000.

Inquiries from vendors regarding bid invitations for the circulating pumps, regenerative heat exchanger, and immersion heaters indicate that several firms will bid on each item. Bid dates on this equipment range from September 1 to September 12, 1960.

Test Section "A" pressure tube assembly bid packages were sent to prospective vendors. Several questions from vendors regarding permissible fabrication techniques and requests for dimension relaxations have been received and processed. It is indicated that at least two firms, Tube Reducing and Chase Brass, will submit bids on the tubes.

Detail design is estimated to be 21% complete. Preparation of procurement specifications for the makeup system ion exchange equipment has been completed and they are being routed for approval. Specifications for the loop storage tank, deoxygenator, chemical feed system, and cleanup system ion exchangers have been issued in comment form. A purchase requisition for the detail design by an outside architect-engineer of the water filtration plant and holdup tank is in process.

Plutonium Recycle Critical Facility (Project CAH-842). The PRCF portion of the Maintenance and Mockup Building bid is estimated to be $85,000.

A design schedule was prepared and approved. Design of the moderator temperature monitor is complete and purchase specifications have been

prepared. Design of the in-cell components is continuing. Drawings of the major design items have been issued for comment. The drawings and procurement specifications for the instrumentation console were issued for comment. Comments are being reviewed.

The contract for the Fuel Transfer Lock has been awarded to the Henry Pratt Company of Chicago. The lock will be constructed of carbon steel protected with a chemical resistant coating.

A study was made to determine the feasibility of using a spare PRTR heat exchanger (HX-3) as the heat exchanger for the PRCF thimble piping. This will be possible with minor modifications to the exchanger.

Design and Component Testing

PRTR Fueling Vehicle. Fabrication of the replacement shroud assembly is 85 percent complete (Phase III-A, Item No. 25). A requisition was issued for a single channel gamma monitoring alarm system (Phase III-A, Item No. 36). Six Phase III-A Work Instructions were issued.

PR-10 - Primary Loop Mockup. The spare PRTR primary process pump was shut down after 1584 hours of operation when the seal temperature, which normally operated at a steady 120 to 130 F, started fluctuating and the seal leakage increased from a normal 0.02 to 1.3 gph. The pump run-down time had decreased from 5-1/2 minutes to four minutes. The seal assembly will be removed for a thorough inspection. The prototype pump with the new self-adjusting type seal has operated for a total of 2028 hours without incident. Collected leakage from the high pressure seal varies from 0.5 to 1.5 gph, depending on operating conditions. This is a notable test run because of the poor experience other sites have had with this new type seal. The pump has had 31 starts and 51 thermocycles during this test run. The Aldrich injection pump has operated 741 hours with the R/M Vee-Flex rings with finger springs installed on the pressure side of the packing. No maintenance was performed on this packing until after 530 hours of operation when the leak rate for the three plungers were 250, 250, and 2000 ml/hr. The packing glands have been tightened twice since this time and now have leak rates of 200, 175, and 200 ml/hr.

Process Tube No. 586-6063 has operated for 478 hours and 20 thermal cycles during the past month for a total of 3750 hours at simulated reactor conditions.

Additional evaluations were made of rounded and tapered orifice designs for the process tube inlet. It was found that an orifice using a 15-degree entrance taper with a throat diameter of 0.755 inch and an entry diameter of 0.807 inch will yield the required 33 to 34 psi pressure drop at full flow conditions with the fuel element in place. Use of the taper design is expected to give more reproducible results than the sharp edge orifice design.

Average leakage rates for the nozzle cap, nozzle to process tube, and inlet connection have remained in the 0.1 to 0.5 ml/hr range during the month. A special nozzle-to-process-tube test piece has been prepared and is now ready for testing to assess damage to the process tube end flange from metal seizure during long-term operation. It is planned to thermal and pressure cycle this test piece 3000 times, which will require about three months.

PR-40 - Shim Control Mockup. The last unassembled drive received from GE-APED was assembled using two of the Western Gear motors. This assembly has been operated for 215 cycles, which is equivalent to 21-1/2 hours of continuous operation. The lower motor of this assembly, which drives a single rod, will not hold the rod in position when the power is turned off. This malfunction has not occurred previously with the original motors. Modification of the assembly to prevent this downward drift was started. This same modification may also be desirable for the reactor assemblies.

The Western Gear motor which was placed in the irradiation facility was removed after being exposed to 10^7 R gamma; mechanical and electrical characteristics were checked and found unchanged. The motor has been returned for further irradiation. During the checks on the motor, it was operated for 45 minutes continuously under a load of 20 in-oz and showed a temperature rise of less than 20 C.

Delivery of three more drive assemblies from GE-APED is scheduled about September 1, and the last two by September 15. Globe motors for these five drives have been received and have passed initial inspection testing.

Special Tools. The core saw with a new blade was set up and tested by cutting off a nozzle elbow. The only precaution necessary while cutting off the elbow was to maintain a slow feed in order to keep the saw from sticking.

Fabrication of the loadout cask wrench is about 50% complete and will be finished when the stainless steel bearings are received.

A wrench to remove and replace the three flange bolts holding the shim control to the top primary shield has been designed and placed in Tech Shops for fabrication. The wrench is designed to prevent a flange bolt from dropping during placement or removal.

Fuel Examination Facility. The fuel temperature monitor for the Fuel Examination Facility has been received and is undergoing modification to make it compatible with thermistor probes of Hanford design.

Design Analysis

PRTR Process Specifications. Ninety-eight percent of the Startup Process Specifications have been written in rough draft form and given initial review by the PRTR Startup Council, including one new specification which was drafted during the month. Ninety-one percent of the Process Specifications have been approved by the Startup Council. Eighty-nine percent have been issued in approved form.

Safeguards Review. Additional information developed since the last review by the General Electric Reactor Safeguards Council was forwarded to the secretary of the GERSC as the basis for the forthcoming review at the September meeting. The GERSC has been specifically requested to give consideration to the startup planning for the reactor and to the preliminary hazards analysis of the Gas-Cooled Loop.

Startup Activities. Review of PRTR operating procedures continued as the procedures were scheduled for Startup Council approval. About 40% of the procedures have been reviewed from the reactor safeguards standpoint.

Detailed procedures for the critical tests are being prepared in conjunction with the Critical Test Sub-council and PRTR Operations personnel. Special equipment requirements and data forms for each test have been reviewed. Results from measurements of KBO_2 retention on a mixed resin column have been received. The data indicates the resin will hold sufficient KBO_2 for adequate moderator cleanup. A final evaluation of the feasibility of Critical Test 15 (Poison Calibration of Level and Shims) awaits an investigation of boron adherence to aluminum surfaces.

Planning and review of power tests is continuing in conjunction with the Power Test Sub-council. An initial description of Power Test 18 (Photoneutron flux) has been written.

Formal authorization for startup and operation of the PRTR has been received from the AEC. This authority is for operation in accordance with the Final Safeguards Analysis, Supplement I thereto, and three instructions concerning an exhaust air filter, coolant void coefficients, and use of the automatic controller.

PRP Physics Analyses. Additional two dimensional, three-group calculations of the PRTR core with the 9 ANGIE Reactor Code have been performed for the following cases.

Case No.	No. of Pu-Al Elements	No. of UO_2 Elements	Moderator Level	Comment
A	34	51	Full	
B	34	51	Top of fuel	
C	34	51	3/4 Level	
D	34	51	1/2 Level	
E	34	51	36"	
F	24	61	Full	
G	24	61	Full	Outer shims inserted
H	24	61	Full	Reactor at 30 days burncut

Those cases reported previously have been rerun using new and improved input data. These calculations appear to verify previous one dimensional VALPROD studies.

A physics study of various cladding concepts for a PuO_2 or PuC 1/16" fuel rod has been completed. These include PuC bonded in carbon clad with Zircaloy; PuO_2 surrounded by Ta, which is surrounded by a thick jacket of Zircaloy; PuO_2 surrounded by Nb, jacketed with Zr, and PuO_2 surrounded by a thick zirconium jacket. These calculations are being used by Plutonium Metallurgy Operation in the development of fuel elements for irradiation in MTR.

Effective Multiplication Calculations. Changes in the effective multiplication of a reactor configuration are not directly deduced from a mere scrutiny of changes in the multigroup reactor parameters. What is needed is a complete set of the perturbation characteristics of the multiplying system with regard to any piece of the multigroup description. A method has been devised to pinpoint the deviation of effective multiplication as a result of changes or errors in any one or several of the "input" (for computer codes) parameters or pieces of data for the problem. Using this method, for example, it may be found that an error of 6.0% in the thermal absorption cross-section in the core of a particular reactor will have the effect of 2.7% error in the multiplication. From another point of view, the change in multiplication of a certain system can be determined for a specified addition of extraneous material in the active zone.

The method being used is based on a proposal by H. Grumm and F. Herre*, and the model is being extended to include reflected reactors and three-group diffusion theory. The solution is obtained using well known perturbation methods of reactor theory. Information needed for the variational calculation is three-group flux and adjoint flux distributions which may be obtained using the FLUX-WEIGHT Code for the IBM-709.

PRTR Primary Coolant Piping Stress Analysis. The carbon steel to stainless steel weld at the pressurizer inlet nozzle was analyzed for stresses and a rough draft report will be issued. The stresses will be high enough to cause some yielding during normal cycling, but a fatigue analysis (using the technique described in the Bureau of Ships Reactor Vessel Code) showed that the joint was safe. Further analysis of this joint and other bimetallic weld joints in the primary coolant piping will be made.

PRTR Operations Planning

Preparation of PRTR Operating Standards continued; essentially all first drafts have been completed. Twenty-eight of the 100 standards were issued in final form during August.

Proposed Phase III-A construction items were listed and reviewed.

*H. Grumm and F. Herre, Tolerances for Group Constants in Reactor Calculations, Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958, Vol. 16, p. 492.

Stock requests for reactor spare parts are complete with exception of spares for the fueling vehicle, electronic power supplies, and special gaskets.

Procurement of spare parts for the Hofer helium compressors continues to be a problem. The U.S. vendor does not maintain an adequate stock of essential components such as check valves and diaphragms. Vacuum-melted, cold rolled sheet stock has been ordered for the purpose of fabricating sufficient spare diaphragms before the need becomes critical.

Complete layout information for the temporary maintenance shop has been supplied to the project group. Minor Construction will make this installation shortly after the lump sum contractor leaves the site.

Several acceptance tests were witnessed during the month.

The Manager - PRTRO, the Test Engineer, and the Facility Engineer visited the National Reactor Testing Station at Arco, Idaho, to discuss maintenance planning and operating problems of the ETR and MTR and associated test loop facilities with General Electric representatives as well as Phillips Petroleum management and engineers.

Two PRTR engineering assistants have worked this past month in the Radiometallurgy Building to gain experience in inspection and handling irradiated fuel elements.

Training continued during the month with emphasis on operating and emergency procedures, electric circuits, leak detector operation and techniques for sample analysis.

Preparations were made for a temporary analytical laboratory in the Service Building basement. The final comment issue of the PRTR Building Safety Rules was completed. Plans are being made for the initial property accounting inventory for PRTR which will be made in early September.

Assistance was rendered the third party inspector in reviewing the piping and vessels for code compliance.

Work continued on the preparation, review, and issuance of Design, Power, and Critical Startup Tests in concert with other components.

The exhaust filter design was reviewed and comments were submitted to Design Development Operation. Proposed waste disposal limits for waste holdup tank contents were reviewed with and approved by Chemical Effluents Technology Operation.

The extended period testing of the river pumps began on August 12. The pumps are being run on alternate days. Testing to date indicates the pumps will operate satisfactorily.

Liaison was maintained with the designers of the PRP Critical Facility, the Gas Loop, and the Fuel Element Rupture Loop.

2. PLUTONIUM CERAMICS RESEARCH

It has been found at Harwell and confirmed at Hanford that PuO_2 and Al_2O_3 form a perovskite type compound, $PuAlO_3$, during heating in hydrogen. This compound is hexagonal close packed but can also be indexed on a rhombohedral symmetry. The formation of this structure had been attributed to the reaction of Pu_2O_3, which results from the hydrogen reduction of PuO_2, with Al_2O_3 according to

$$2\ PuO_2 + H_2 = Pu_2O_3 + H_2O$$

$$Pu_2O_3 + Al_2O_3 = 2\ PuAlO_3$$

To check this hypothesis, PuO_2 and Al_2O_3 were heated in helium at 1350 C for four hours. X-ray diffraction showed two phases nearly equal in quantity, PuO_2 and $PuAlO_3$. This would indicate that $PuAlO_3$ formation is not dependent on the hydrogen reduction of PuO_2. Rather, vaporization may account for an oxygen loss giving the following reaction:

$$2\ PuO_2 + Al_2O_3 = 2\ PuAlO_3 + 1/2\ O_2$$

Several experiments were run in an attempt to make plutonium nitride. Alpha Pu metal powder was heated to 1000 C in the presence of both 350 and 500 mm Hg of nitrogen. In both cases PuO_2 resulted. Since the metal powder may have had an oxide coating, a small amount of carbon was added and the mixture heated to 1000 C in 650 mm of nitrogen. The result was a PuO_2 phase and another phase indexed on the face centered cubic system. The plane spacings conformed to the PuC and PuN structures; however, since the low angle spacings of these two compounds are identical in value and intensity, it is impossible to determine which phase was present. High angle evaluations will be carried out with logarithmic response when the GE diffractometer is available. This machine has been hooded and is now being aligned.

The kinetics of the PuO_2 + C reaction are being checked in detail. Samples have been heated to 850, 1000, and 1150 C for one hour in a 10^{-4} mm Hg vacuum. These samples are awaiting x-ray diffraction.

A PuO_2-ZrO_2 specimen containing 0.5 w/o PuO_2 was sintered in a hydrogen atmosphere at 1500 C for eight hours and slowly cooled. One hairline crack was observed; otherwise, integrity was good. The stabilization of ZrO_2 by PuO_2 additions appears to be inconsistent with concentration up to 10 w/o PuO_2. The integrity of all pellets sintered which contained at least 10 w/o PuO_2 was excellent. X-ray diffraction patterns have been received for thirteen of the twenty-eight specimens prepared. These are presently being analyzed and correlated with photomicrographs.

3. URANIUM DIOXIDE FUELS RESEARCH

Fuel Evaluation. To study hydriding in both Zircaloy-2 and Zircaloy-4 under similar conditions, a 24" long, 0.565 ± 0.002" diameter, fuel rod, having 12" of Zircaloy-2 cladding and 12" of Zircaloy-4 cladding butt-welded together, was fabricated. The fuel rod contained 3.37 w/o enriched UO_2 vibrantly compacted in the cladding materials. It was autoclaved, then defected with an 0.005" - 0.006" diameter hole at the center of the butt weld. This fuel rod will be irradiated in the GEH-4 facility at the MTR.

Various ceramic fuel enrichment methods (e.g., coarse, fused, natural UO_2 particles surrounded by finely divided, enriched UO_2 powder) are being evaluated by testing a four-rod cluster fuel assembly in the MTR. The fuel element was successfully irradiated for nineteen days at a power generation of approximately 105 kw/ft (600,000 BTU/hr-ft^2).

Swaged UO_2 (sintered and crushed) irradiated for one and one-half years (13,500 MWD/T) in MTR released approximately 31 percent of the fission gases. The uranium dioxide capsule had an OD of 0.690", and was irradiated at specific power generation of 25 kw/ft.

A similar swaged capsule irradiated to only 3000 MWD/T at the same heat generation released 56 percent of the fission gases generated.

Defect tests of deliberately defected UO_2 fuel elements will be conducted in HAPO reactors. Three, 12" long, Zircaloy-2 clad, UO_2 containing 4-rod clusters were fabricated and a test proposal approved. All fuel rod diameters are 0.565 ± 0.002". One of the three assemblies contains pressed and sintered UO_2 pellets in 0.030" Zircaloy-2 cladding. Two of the rods in this assembly contain 0.005" diameter defects through one cladding wall midway along the length of the assembly. The other two fuel assemblies were cold swaged. Each of these assemblies had two Zircaloy-2 clad and two Zircaloy-4 clad rods, with one rod of each cladding material defected as above. One of the latter two assemblies contains fused UO_2; the other contains sintered and crushed material.

A surprisingly small amount of fission product activity was detected in the coolant during irradiation testing of a deliberately defected, swaged UO_2 fuel rod at a maximum heat flux of approximately 700,000 BTU/hr-ft^2 in the MTR. The improvement probably should be attributed to the use of relatively large, dense, outgassed UO_2 particles.

Basic Studies. Modifications to an existing laboratory were completed to accommodate the JEM electron microscope. This electron microscope was received in Milwaukee, where it is to be assembled and demonstrated before shipment to Hanford. A Ceramic Fuels representative participated in the initial installation and testing. All components performed satisfactorily in tests made; tests for ultimate resolution and operation of accessory components will be completed after permanent installation at Hanford in September. Design details of the cine attachment appear to be

satisfactory. Continuous photography of specimen changes can be accomplished while observing most of the image on the fluorescent screen.

The design and fabrication of carbide dies for impact forming of UO_2 in the Dynapak machine was discussed at the General Electric Carboloy Division in Detroit. Carbide dies should permit an eight-fold increase in the size of samples capsules used for high energy impact forming of UO_2 to densities greater than 99 percent T.D.

Thermal Conductivity. A thermal conductivity specimen was fabricated by vibrational compaction, using a shallow cup required for the Battelle measurement apparatus. Ratio of depth to diameter resulted in poor shaking conditions, leading to a specimen having a density of about 75 percent T.D. The specimen was transferred to BMI for physical examination, trial placement of thermocouples, and general evaluation. A higher density specimen is expected to result from a redesigned cup and preparation accessories.

Initial measurements were made at BMI on a UO_2 specimen prepared at Hanford on the 300-ton press. Initial data, up to 1200 C, indicate the thermal conductivity curve will fall between the curve previously obtained from UO_2 fabricated by isostatic pressing and by extrusion.

A detailed review of the current world-wide status of the measurement of thermal properties of UO_2 was completed, particularly concerning thermal conductivity. A summary was presented in a panel discussion of heat transfer problem at the AIChE meeting in Buffalo, New York.

High Temperature Microscopy. High temperature microscopic examination of irradiated UO_2 with in-reactor exposures of 40, 125, and 440 MWD/T was completed. The melting points of these materials were 2830 C, 2890 C, and 2920 C, respectively. Unirradiated UO_2, under the same conditions, consistently melts at 2790 C. These melting temperatures are averages of five observations for each burnup. A curve showing melting point versus percent burnup for in-reactor exposures of 40 to 1500 MWD/T was established. The highest reliable melting temperature measured was 3040 C at 1500 MWD/T. Extrapolation of the plot predicts further melting point increases with higher burnup, although a maximum is apparently being approached. A vapor pressure inhibition in the temperature range 2400 C to 2900 C was apparent for the 40 to 440 MWD/T exposure oxide. Vapor deposition crystals grew, but at a slower rate than those from unirradiated UO_2.

4. BASIC SWELLING STUDIES

Irradiation Program. The general swelling capsule that was inserted in the reactor in the latter part of February is continuing to perform satisfactorily at a control temperature of 550 C. The control instrumentation has performed quite well since installation of new potentiometers and premium tubes. Control of the capsule temperature has been within 10 C for the past two months. The second capsule has now been

charged. The capsule contains two natural and one three percent enriched uranium spheres. It is being operated at a temperature of 500 C to establish the effect of temperature of irradiation, burnup, and burnup rate on swelling in uranium.

Two other general swelling capsules containing split, hollow cylinders are in the final stages of assembly. Numerous heat treatments were given typical specimens in an effort to produce fine, randomly oriented grains in the dingot uranium used as stock material. Various combinations of beta and gamma quenching, and high alpha annealing were unsuccessful in producing grains that were considered fine enough. None of these treatments changed the original large grain size present in the dingots. In some areas only one or two grains existed across the 30-mil wall thickness of the hollow cylinders. Fine grains were finally produced by extruding the second ingot prepared by the Tamescal Metallurgical Corporation by electron beam melting. Extruding in the high alpha region produced grains having an ASTM grain size of about six, but some (110) orientation of grains exists in the extrusion direction. For purposes of the swelling study it is felt that the preferred orientation is less undesirable than large grains. Irradiation of specimens having the same enrichment but different thermal histories may be necessary to determine the importance of grain size and orientation on swelling.

The impurity level of the second ingot that Tamescal prepared is essentially unchanged from the original dingot melting stock composition. This is to be contrasted with the marked improvement that was achieved after electron beam melting of fairly "dirty" uranium. Apparently, the impurity level in the dingot uranium is already so low that extreme difficulty will be experienced in improving it. Electron beam melting may still offer a convenient way to consolidate high purity dingot uranium into a more convenient form.

Two capsules each containing a precharacterized, cylindrical specimen of uranium have been assembled. One of these capsules has been tested under conditions simulating reactor shutdown. With one kilowatt of electrical heat energy being dissipated by the heaters, the temperature of the NaK environment one millimeter from the specimen was 591 C. The data obtained will permit determination of the contact resistance of the fins and calculation of the optimum control temperature of the specimen during irradiation. The metallographic swelling capsules will be irradiated at the ETR where high fluxes are available.

Pore Size and Distribution. Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. In addition, exploratory experiments on the bonding of uranium to uranium are being conducted. The ultimate extension of these experiments is to study fission gas mobility in couples consisting of irradiated and non-irradiated uranium. Post-irradiation annealing studies, bulk density measurements, and electron microscope determinations of pore void densities and pore void fractions are continuing. This work is being conducted on specimens with burnups of 0.29 a/o and 0.41 a/o,

irradiated at core and peripheral temperatures of approximately 500 C and 300 C, respectively. The effects of a one-hour and 100-hour post-irradiation anneal at 600 C on the swelling in declad, unrestrained specimens are: (1) the one-hour annealing treatment is sufficient to cause a two-fold and a twelve-fold increase in the volume associated with the measured pores for the 0.29 a/o and 0.41 a/o specimens, respectively; (2) long-term annealing, 100 hours, does not cause additional volume change; (3) the pore void fractions appear to be similar for irradiation temperatures of 300 and 500 C; (4) the void density (pores/cc) after the one-hour annealing treatments increases by a factor of two, with little dependence on the temperature during irradiation or the level of burnup; (5) the 100-hour annealing treatment introduces little additional change in void density; (6) the void density appears to be greatest in the case of high burnup (0.41 a/o) in regions of the specimen irradiated at low temperatures (approx. 300 C). Similar type comparisons for different annealing treatments are being prepared.

Since annealing of couples consisting of unirradiated and irradiated uranium may disclose information on the mobility and mechanism of fission gas migration and growth of pores, various methods for bonding uranium to uranium are being investigated. Specimens are currently being prepared for ultrasonic joining experiments.

Two specimens, GEH-14-33 and 35, irradiated at temperatures of approximately 200 C to burnups of 0.03 and 0.07 a/o have been examined. The free surface of these precharacterized specimens shows no evidence of fission gas pores; after removal of less than a 10-micron deep layer from the specimens by etching, again no fission gas pores were observed. The specimens will, therefore, be ground to a much deeper depth to permit examination of the internal microstructure and gas porosity.

5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

The purpose of this program is to measure the mechanical properties of structural materials during irradiation. The study of in-reactor creep properties of Zircaloy-2 is now in progress. The test is being conducted in a prototypical capsule in-reactor. At the same time a duplicate specimen is being tested in the laboratory to provide a direct comparison with the in-reactor test.

Comparisons between the creep rates of the in-reactor specimen and the laboratory specimen have been reported for a stress of 30,000 psi at 500 and 550 F. Since then, the stress has been raised to a new value, 33,000 psi, on both tests. The capsule appears to be operating satisfactorily, but difficulty in the monitoring equipment has prevented the determination of the creep rate during the month. The transducers in the prototype capsule require nearly 900 hours of continual monitoring before a creep rate can be calculated with accuracy.

Negotiations are now in progress with reactor personnel for the charging of one of the second generation creep capsules. One of the four capsules is scheduled to be charged into the reactor near the end of September. The capsules are completed, and assembly of the digital monitoring equipment has been started. The latest estimated completion date for the digital recording installation is mid-October. Since the delivery of the data recording equipment will not coincide with the charging of the first capsule, the system will be monitored manually until the automatic system can be placed in operation. The other three capsules will be used to check out the operation of the digital recording equipment before they are shipped. Then, as test holes become available, these capsules will be charged in the reactor.

Studies are continuing on various methods of making measurements with in-reactor capsules. Refined methods of strain measurement are necessary to improve the sensitivity obtained with the prototype capsule. The ideal extensometer should be sensitive to a micro-inch, accurate over long distances, and stable during the exposure in the reactor. Laboratory studies show that the systems built into the second generation capsules offer many improvements over the one used in the prototype capsule. There are two complex systems of extensometry built into the second generation capsules. One system uses a mechanical screw to close an electrical contact and the other system uses two three-range electrical transducers. The mechanical extensometer has both sensitivity and range, but tests confirm that it is subject to wear and should not be used continuously. The mechanical device can be used to periodically check the electrical transducers without danger of wear. An improved system of extensometry has evolved from the two systems devised for the second capsules. The method combines the advantages of the mechanical extensometer with the sensitivity of the electrical transducers. The mechanical extensometer is used to position an ultra-sensitive electrical transducer so that measurements are always made within the limited range of the sensitive sensor. In this way many parts are eliminated while retaining the best features of each of the two sensing systems. Drawings are now being made to build and test a model of the combination extensometer system.

6. GAS GRAPHITE STUDIES

EGCR Graphite Irradiation. Capsule H3, containing EGCR prototype graphite, continues to operate successfully in the GETR. One of the nine thermocouples failed after approximately 1000 hours, but the others are operating satisfactorily.

Pyrolytic Graphite. A systematic difference in length changes in the a_o direction (viz., parallel to the carbon planes) has been noted in samples of as-deposited and graphitized pyrolytic carbons irradiated for 132 MWD/AT at about 600 C. For such a short irradiation, no length changes would be discernible in conventional graphites. In the as-deposited pyrolytic samples, an expansion was noted in the a_o direction amounting to an average of + 0.042 ± 0.01%. This behavior of the a_o direction is in striking contrast to regular graphites in which a contraction is noted in the a_o direction at all irradiation temperatures.

An expansion in the a_o direction has been noted in pyrolytic graphite after heat treatment above the deposition temperature. Such an expansion is attributed to straightening of the pyrolytic planes. A similar mechanism is believed to operate in the above irradiation tests, since the c_o crystallite parameter (viz., distance between carbon planes) apparently did not change upon irradiation. For the ungraphitized material, the c_o value was 6.85 A both before and after irradiation.

Thermal Oxidation Studies in CO_2. A 7.9604 gm sample of CSF graphite was heated in helium to destroy surface oxide and then exposed to CO_2 at various temperatures. The buildup of surface oxide was followed with an automatic recording microbalance. The following results were obtained:

Run	Pretreatment	CO_2 Temp.	Max. Wt. Gain	Time to Max. Gain
1	He at 750 C	750 C	6.35 mg	80 min
2	He at 800 C	800	6.30	77.5
3	He at 800 C	600	6.41	97.5
4	He at 800 C	550	6.26	91.3

If all the weight increase is due to formation of surface oxide, $CO_2 \longrightarrow CO + C(O)$, approximately 3×10^{19} sites per gram of graphite are involved. If an equal number of CO and O species are involved in the weight increase, $CO \longrightarrow C(CO) + C(O)$, then about 2.19×10^{19} sites per gram of graphite are used. The observed specific surface area of this graphite is 0.266 m^2/gm for samples of this type, so the number of sites involved per square meter of graphite surface are 8.21×10^{19} and 1.13×10^{20} for the two cases considered.

Oxidation Studies on Dragon Graphite. This study was conducted to compare the oxidation rates of British Dragon graphite with rates of "F" purified graphite and to determine whether regraphitization would provide greater oxidation resistance, since the Dragon graphite was processed at a relatively low temperature.

During regraphitization, samples were heated to 2850 C in an inert atmosphere. The temperature exceeded 2600 C for a period of 25 minutes. However, x-ray data indicate that there were small regions of incompletely graphitized material even after the regraphitization.

Oxidation was conducted at 750 C in a flowing (2.0 cfh) stream of O_2.

Data tabulated below show that regraphitization reduced the oxidation rates from three to six times, but never down to the value for CSF graphite.

OXIDATION DATA - DRAGON GRAPHITE SAMPLES

Graphite Type	Oxidation Rate (g/ghr x 10^{-2}) Pre-regraphitization	Post-regraphitization
HS HX-10	2.78	0.876
Morgan EY-60	(4.89	1.49
	(9.17	1.61
	(9.39	
CSF	0.350	

Microwave Glow Discharge of Carbon Dioxide. The following species have been identified in the microwave glow discharge of carbon dioxide gas: CO, CO+, CO_2, CO_2+, C_3O_2, and O_2+.

Microwave Activation of Nitrogen Gas. A glow was maintained in flowing nitrogen in a pressure range from 200 to 1000 μ Hg. In the absence of any graphite in the system, no deposit was observed on the quartz reaction tube. In the presence of graphite placed directly in the glow, a yellow to brown deposit was formed. The weight loss rate for the graphite sample was 2.09×10^{-4} gm/gm-hr. Based on chemical and infrared analyses, it is thought that the principal compound involved in the deposit is paracyanogen, $(CN)_x$.

EGCR Oxidation Prototype. Two preliminary runs have been made to determine whether graphite in the EGCR prototype would ignite at about 600 C. In each case, a heating element failure just prior to admittance of the air caused the runs to be made with the power off. In the first run, the graphite temperature, T_G, was 570 C, and the inlet air temperature, T_A, was 25 C. In the second run, T_G was 625 C, and T_A was 180 C. Combustion did not occur in either case. However, the normal heat losses in the system may exceed the heat evolved by oxidation. In order to make the system adiabatic, modifications have been completed which permit a low power to be maintained separately to the outer ring of heating elements. The ΔT between the inside and outside of the block can thus be maintained at zero during burning experiments so as to make the system entirely adiabatic.

Gas Loop Project Management and Design (Project CAH-822). Construction specifications, drawings, and special conditions for the installation of the Struthers-Wells package of the gas loop were issued during the month. Minor Construction is currently preparing material take-off lists so as to start the preliminary work during the second week in September.

The Phase "A" package by Struthers-Wells is approximately 98% complete. The pre-heater has been fabricated but not tested. The pre-heater and several valves are all that remain to be installed for physical completion of this order.

The primary blower status has improved somewhat. Bristol-Siddeley is currently testing the second blower in an effort to reconfirm results attained with the first blower. These results may be summarized by the following equation:

$$\frac{P}{T} \times N^3 = K$$

where P is in psia, T in °K, and N in RPM. Bristol-Siddeley feel they can guarantee a K of 1×10^{11}; however, the design point condition requires a K of 6.65×10^{11}.

A revision to the gas loop project proposal was forwarded to the AEC requesting extension of the completion date to June 30, 1961. No increase in funds was requested.

The remainder of the helium shroud coolant loop is being forwarded from Struthers-Wells for use in the in-reactor section mock-up test.

Gas Loop Component Testing. The gas loop mockup is 65% complete. Final assembly of the second prototype in-reactor section was delayed pending installation of the first prototype assembly.

A Solar Aircraft gimbal expansion joint for the outlet was installed in the test furnace and brought to temperature and pressure. It has operated 60 hours at steady state conditions of 500 psig and 1450-1550 F, and 160 hours of cycling operation. Cycling consists of flexing the joint 3-1/2° each side of neutral while simultaneously altering the temperature from 900 to 1500 F. No leakage has been detected.

An extensively modified dome seal was hydrostatically tested at 1800 psi. This assembly will be installed in the first prototype assembly and tested at 1500 F and 500 psig.

Final comment prints on the graphite cask have been issued.

Equipment has been obtained for monitoring in-reactor movement of the high pressure tube relative to the shroud tube in the PRTR Gas Loop. Out-of-reactor tests on the Fenwal line detector were begun in preparation for the in-reactor tests. Arrangements have been completed to provide a second detector assembly without cadmium which is present in trace amounts in the unit now on site. The second unit has been scheduled for similar testing. The thermocouple and velocity head instruments have been fabricated for installation on the gas loop mockup in the 314 Building.

7. GRAPHITE HIGH TEMPERATURE IRRADIATION DAMAGE STUDIES

Graphite Microscopy. A method of preparing graphite samples for electron microscope examination has been developed to facilitate the location of selected areas for examination before and after irradiation. An Ernest F. Fullam Company specimen marking pin mounted on the nose piece of an optical microscope was used for reference scribing. The depth of scribe

marks was successfully controlled by determining the contact resistance at the correct depth and maintaining that resistance during the scribing operation. The scribed locations have been photographed at magnifications ranging from 50X to 750X on both the graphite samples and shadowed replicas. With a series of photographs of increasing magnification, very small areas may be located at magnifications too high to include reference scribes in the field of view. Locating these areas on grid mounted replicas will be attempted with the electron microscope, and, if successful, the samples will be irradiated.

Metallographic Studies. Twenty-eight graphite samples, six calcined coke samples, two green stock samples, two baked samples, and a silicon carbide coated sample were prepared and examined under bright field and polarized light. Binder and coke are readily distinguished in the green stock, but difficult to distinguish in baked stock. After graphitization, it is not possible, with present methods, to positively identify graphitized binder and distinguish it clearly from graphitized coke.

Special Graphites. Initial delivery of samples under contract AT(45-1)-1603 with the Parma Research Center of the Union Carbide and Carbon Corporation was completed during this month. These samples are currently being prepared for irradiation.

The initial samples represent readily available graphites which were selected in an attempt to elucidate the mechanism of radiation damage at high temperature. The following types of material were included: (1) Natural and artificial flake graphite. These samples are intended to verify the correlation of changes in sample dimensions with changes in the x-ray inter-atom dimensions and to ascertain density changes under irradiation. Also, ground natural flake is included to determine the effect of heavy mechanical strain. (2) Block natural graphite. Samples of this material are designed to reveal radiation effects in large unstrained crystals of graphite. (3) Graphitized Continental Coke. These samples are designed to study irradiation effects in a binder-free system. (4) Constant orientation, variable density graphite. A series of samples was included to study the effect of density variation only on radiation damage. (5) Highly oriented graphite. Graphite with an orientation ratio of seven to one was included to determine the effect of extreme orientation on radiation damage. (6) Lampblack Graphite. These samples were intended to determine the effect of radiation on graphite made from poorly graphitizing material.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals, namely, copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. Tensile properties, microhardness, electrical resistance, and x-ray diffraction spectra are being studied to determine the characteristics of recovery mechanisms. A new isothermal annealing fixture has been fabricated and is expected to give better results than the former system which was composed of a quartz specimen tube under static vacuum, heated in an air

furnace. The new fixture is constructed entirely of stainless steel and utilizes a dynamic vacuum. A basic design feature is the ability to operate the annealing system remotely. The specimen tube is in intimate contact with the specimen and its holder and the heating medium is molten lead. Cooling from temperature is accomplished by quenching the entire fixture in water while still under a dynamic vacuum. Provision has been made to charge helium into the system if the heat transfer rate in vacuo is too low.

Post-annealing x-ray studies have been completed on isochronally-annealed zirconium and nickel specimens. Although microhardness and electrical resistance measurements indicated that damage recovery was complete in both irradiated zirconium specimens, a small amount of lattice distortion remained in the form of a shrinkage in the C_o lattice parameter. The A_o parameter for both specimens recovered completely. As a result, the line width of the (220) reflection in both specimens recovered to the unirradiated value, but the line width of the (302) reflection showed a retained broadening of 22 and 10 percent, respectively, at exposures of 4.7×10^{18} and 1.5×10^{20} nvt. Recovery of lattice parameter in irradiated nickel (1.0×10^{19} nvt) was complete, but the line width of the (222) reflection was 4.5 percent greater than the unirradiated value.

Isochronal annealing of copper and titanium was continued during the month, the latter showing no further recovery stages up to 575 C. A microhardness recovery stage was observed in copper at 375 C for specimens with exposures of 0.9×10^{19} and 1.5×10^{20} nvt.

Interim x-ray measurements on irradiated molybdenum showed that recovery was not complete after annealing at 800 C, and further anneals are scheduled up to 1000 C.

E. CUSTOMER WORK

Radiometallurgy Service

Visual comparison of the second and third aluminum process tube failures shows the two to be nearly identical. Metallography shows a discontinuity of the grain structure at the failure area (RM-406).

Examination of three self-supported I & E production fuel elements confirmed that surface bumping is associated with a large grain size (RM-408).

A sample of undissolved residue from the Redox Multipurpose dissolver was found to be spongy in appearance but appeared to be metallic when sectioned. A portion of the sample was dissolved in aqua regia and submitted to the analytical laboratory for spectrochemical analysis (RM-339).

A side-other rupture (I & E production element) was found to have a large blister extending more than half way around the circumference and from the center to the male end. Water attacked the uranium core uniformly under the blister, but did not form the usual rupture cavity (RM-409).

Metallography Laboratories

Although the uncolored transparency of Lucite is preferred rather than the slightly colored resin for mounting some metallographic specimens, Lucite has the disadvantage of requiring a relatively long time (one-half hour or more) for mounting a specimen. To overcome this disadvantage, a mold for heating and cooling Lucite mounts in the minimum possible time has been designed and built. Tests show that this model will save at least 15 minutes per specimen. The unit consists of a standard Buehler 1-1/4 inch diameter mold which has been wrapped with alternate coils of a 1000-watt calrod and a copper cooling coil. The outside of the entire assembly is flame-sprayed with copper. This new unit required five minutes for heating and three minutes for cooling versus the corresponding times of 12 and 15 minutes, respectively, for the old method.

Electron microscopy service work for the month included examination of replicas from cathodic vacuum etched UO_2 in aluminum fuel plates, irradiated and ruptured fuel rods, UO_2 specimens hot pressed at GERL in the diamond press, copper which had been exposed to glow discharge at NMI, irradiated high density UO_2-PuO_2 pellets, and fractography and metallographic surfaces of irradiated UO_2 before and after annealing.

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

Samples Processed During the Month:

Total Samples	401
Carbon Replicas	36
	437

Photographs	
Micrographs	482
Macrographs	80
Electron Micrographs	180
	742

Special Fabrications

To date, 1344 coextruded fuel rods have been shipped to the Savannah River Laboratory as scheduled. The final 100 rods needed to complete this work will be shipped during the first week in September. Billet casting has now been completed with a total of 1931 castings made during the year. Yield of acceptable billets after radiography was 90%. Over-all yield for the entire process was about 75%.

Two I & E rods clad in X-8001 Al and containing a C823 Al core were co-extruded. The billets, in both cases, were designed to give a 0.050 inch cladding thickness and a 0.165 inch core thickness. The two billet designs (Mark II & Mark III) had different core end configurations, roughly

2-1/4 inch and 1-3/4 inch radii, respectively. The extruded cladding thicknesses were within 0.005" of the design value except for slight dogboning at the leading and trailing ends of the core. The 2-1/4 inch radius on the Mark II core gave satisfactory results, but a slightly larger radius would appear to be optimum. Nondestructive tests will be required to determine the integrity of the core to cladding bond. The Mark II design with slight modification will be used in fabricating Pu-bearing I & E elements.

F. W. Albaugh

Manager, Reactor and Fuels Research
and Development

FW Albaugh:kb

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

AUGUST 1960

[redacted]

FISSIONABLE MATERIALS - 2000 PROGRAM

REACTOR

Neutron Spectrum Studies

a. Detector Foils of Lutetium

The report Lutetium as a Spectral Index Detector, HW-66319, has been prepared and distributed to those who have requested it. The wide interest which this technique has received is reflected by the facts that twenty requests for this report have been received from offsite and approximately half of the requests are from laboratories abroad.

b. Neutron Rethermalization

1. Graphite Experiment

The counting data have been corrected for a shift in counter efficiency and a reanalysis using calculated diffusion coefficients will soon be started.

2. Water Experiment

All of the experimental data have been decay corrected, using APDAC I. The corrected data are being processed to yield traverses of the thermal activity of copper and traverses of the epicadmium activity of gold.

An evaluation of the available data on the diffusion coefficient of thermal neutrons in water has been completed. Data recently published by Rockey, et al (NSE 8, 1960) and by Kuchle (letter to the editor NSE 8, 1960) have been compared to Stanley's (ANP) compilation of two group parameters. Rockey has published measured values of the diffusion length of thermal neutrons in hot water for temperatures from 26 to 295 C. These data have been used to calculate diffusion coefficients under the assumption that the microscopic transport cross section of water varies as 1/v. Kuchle has published diffusion constant results for water temperatures of 22 to 80 C. The diffusion constants, Dv, have been reduced to diffusion coefficients, D, under the assumption that the energy distribution of thermal neutrons was Maxwellian with a characteristic temperature equal to the physical temperature of the water. The latter values compare favorably with those from Stanley in the temperature interval 20 to 250 C. To date temperatures between 0 and 50 C are the only ones of interest and it has been concluded that these data are adequate for the analysis of the experimental data obtained in our experiments.

[redacted]

A preliminary set of values for relaxation lengths of hot neutrons in water at room temperature has been obtained from the water rethermalization experiments. These values were obtained from traverses of the thermal activity of copper in the water only. The analysis was made with a two-thermal-group diffusion model under the assumption of no source of thermal neutrons. The results are given in Table I.

TABLE I

RELAXATION LENGTHS FOR NEUTRONS FROM HOT GRAPHITE IN WATER AT 20 C

Graphite Temperature °K	Relaxation Length (cm)
420	0.46 ± 0.10
570	0.54 ± 0.13
700	0.60 ± 0.15

These results and a summary of the work have been submitted to the ANS for presentation at the December 1960 winter meeting in San Francisco.

The rethermalization properties presented in Table I are subject to additional uncertainties which are not included in the errors which have been quoted. The traverses of the thermal activity of copper which were taken on a diameter through the water exhibit an unexplained asymmetry. This asymmetry was averaged for the purpose of the approximate analysis.

Digital Computer Codes for Reactor Analysis

Debugging of the HAPO version of the multigroup neutron diffusion code F-N is continuing. The two neutron group test case, which was described last month, has been successfully run. Debug runs are now being made with a more complex test case, an infinite medium thermal spectrum calculation. This test case is the first to utilize the matrix for energy transfer to both higher and lower energies. In the model being used, the thermal neutron energy distribution is divided into eight groups, with arbitrary absorption in each group. Attempts of the code to solve the resulting set of coupled diffusion equations have so far been unsuccessful.

Several additional test cases have been run on the diffusion theory code AIM-5 to gain familiarity with its use and clarification of its instructions. The problem of generating an adequate set of cross sections for AIM-5 is also being investigated. Two codes, NUDATA and C-3, have been used to generate these cross sections. NUDATA, which utilizes the Nuclear Data Tape, gives group cross sections averaged over Maxwellian or 1/E spectra but does not give transfer cross sections. C-3 gives cross sections, including transfer cross sections, averaged over a calculated spectrum but is limited to three groups. Neither of these codes has furnished a satisfactory set of cross sections for the AIM-5 test cases being investigated. The comparison of the F-3 code with AIM-5 has been delayed until better cross sections are obtained.

Work has begun on adapting the ANP code C-5 for local use. C-5 calculates the slowing down density, flux, and corresponding adjoint quantities for a homogeneous medium using either the modified age or the Coveyou-Macauley slowing down model. The flux and adjoint flux are used to compute weighted group parameters and system multiplication. Input data defines the material and geometrical configuration of the reactor with the Hanford nuclear data tape supplying the necessary cross section. This code, when completed, will complete a preliminary system of codes for neutron spectrum calculations.

Computational Programming Services

Errors in the fast source correction portion of BKL, the production code for exponential pile data reduction, have been corrected so that the programmed equations are now properly evaluated. A question still remains about this correction, however, because the values determined by the code in some test cases do not agree with values calculated some years ago by hand, supposedly using the same equations. Efforts to explain this discrepancy are so far unsuccessful. The inclusion of these corrections in the COFIT code is being delayed pending resolution of this discrepancy. Conversion of both codes to the Monitor system has also been delayed.

A tape transferring subroutine, DTRANS, to broaden tape usage on the Monitor has been written and checked out. The purpose of this subroutine is to transfer information from other output tapes to the Monitor output tape. This subroutine will facilitate the preparation of multiple reports during one pass through a program. It will also facilitate conversion of non-Monitor codes to the Monitor system, by making unnecessary the locating and changing of all output statements to conform to the Monitor output tape. Instead, DTRANS can be utilized just before exiting from the code. The conversion feature of DTRANS was in fact the incentive for its preparation, and the time invested should be repaid in full in the conversion of BKL and COFIT.

Analysis of Flux Traverses in Lattices with Large Diameter Fuel

Flux traverses for several lattices have been calculated using the P_3 method. An adjustment of the neutron temperature in the moderator (used as a variable parameter) has fitted the flux ratio, moderator to fuel, for these lattices. When the temperature required to fit the flux ratio is plotted versus the fuel to moderator ratio, a smooth curve results, although the temperatures seem high (40 to 280 C above physical temperature). A correction for epithermal flux depression was made at one point, showing that about half of the derived temperature is due to epithermal effects. Thus when the model is used to calculate flux traverses for other systems, the traverses should be correct, but the artificiality of the neutron temperature used should be recognized.

A summary of the work "Effect of Neutron Temperature and Epithermal Flux on Lattice Cell Flux Traverses," has been submitted to the American Nuclear Society for presentation at the December meeting.

Exponential Measurements for N Reactor

Canning of low enrichment (.94% U^{235}) NPR fuel elements is about 60% complete. Diffusion length measurements have been taken in the NPR mockup graphite stack with fuel and control rod channels empty. The preliminary results imply a dif-

fusion length L of 87.7 cm using an estimated extrapolation length of 1.0 cm. The diffusion length in this stack without voids is calculated to be L_o = 51.2 cm (standard pile corrected to a density of 1.70 gms/cm^3). The ratio L/L_o = 1.66 compares favorably with a Behren's correction for neutron streaming of 1.61.

PCTR Measurements for N Reactor

The PCTR measurements of the lattice parameters for the dry condensed lattice have been completed, and the measurements with the water-cooled assembly are now beginning.

N Reactor Temperature Coefficient in the PCTR

Approximate calculations have been made for the NPR lattice parameters hot and cold. The ratio of the average flux in the graphite to that in the fuel changes by 20%, and the copper reaction rate will change by 30% due to the added change in neutron temperature. f changes by 0.028 so the effect of the change in flux distribution is large enough to be measured in the PCTR.

Flux matching becomes a more severe problem with the core hot since a matched cadmium ratio criteria assumes that the neutron temperature is constant in the core. However, the driving region would be cold and the neutron temperature may not reach equilibrium in the buffers. This effect will require investigation although the flux traverses are much less sensitive to the spectral match than the reactivity measurements. Lutetium ratios could be taken together with the usual gold cadmium ratios to indicate the neutron temperature match. Even though the lutetium may not give a realistic value for the actual temperature, the comparison should be meaningful.

N Reactor Fuel Temperature Coefficient

Data from the 0.925-inch diameter test assembly described last month have been analyzed to obtain curves of $\Delta\rho$ vs T(°C). The final run has been fitted by least squares to the quadratic function of temperature given below:

$$\Delta\rho = (8.3 \pm 4.5) \times 10^{-2} - (1.34 \pm 0.1) \times 10^{-3}\, T + (4.0 \pm 1) \times 10^{-7}\, T^2$$

Differentiation of this expression yields:

$$\frac{d\rho}{dT} = -(1.34 \pm 0.1) \times 10^{-3} + (8.0 \pm 2) \times 10^{-7}\, T$$

Assuming the values of k_∞ and p as measured and derived for the 6 1/2-inch lattice by Donahue, Lanning, and Bennett(1)

$$\frac{1}{RI}\frac{dRI}{dT} = -(1.29 \pm 0.1) \times 10^{-4} + (7.69 \pm 1.8) \times 10^{-8}\, T$$

(1) "The Nuclear Parameters of Some Graphite, Natural Uranium Lattices Measured in the PCTR," ANS paper, Pittsburgh, 1956.

The errors quoted are standard deviations, based on the goodness of the quadratic fit, and do not include any uncertainties due to the assumed k_∞ and p.

Examination of the temperature distribution in the PCTR core showed that at a point ~1 inch from the surface of the heated rod, the graphite temperature rose by 12°C in 45 minutes, while the fuel rod temperature rose by ~ 700°C. The spatial temperature distribution was quite peaked around the heat source. Since corrections must be made to the observed reactivity changes to account for this non-uniform heating in the core, equipment is being prepared which will monitor the temperature distribution with more precision than previously obtained. A single point Brown recorder is being modified to present temperature in °C, with a 10°C span and four overlapping ranges from 16°C to 53°C. The sensing elements will be resistance thermometers. Selection of the desired range and thermometer will be made by a manual switch. Temperatures accurate to ± 0.05°C should be easily obtained.

Fabrication of the NPR mockup assembly is proceeding, with the quartz and graphite work about 50% complete. The niobium wire and Al_2O_3 ceramic tubing is expected by September 12, 1960.

Instrumentation and Systems Studies

A cooperative program to investigate and develop reactor automatic control systems has been started with the IPD Research and Engineering Section. Reactor operating data are being collected for the purpose of determining reactor transfer functions and related dynamic and static reactor characteristics. An attempt will be made to correlate these records in such a way that useful information on reactor control characteristics can be obtained.

The analog evaluation of the reactor sub-critical neutron flux monitor was completed this month. The purpose of this study was to determine the effect of the time constants in the period meter of the sub-critical monitor. This was done by simulating the kinetics of a reactor on the Goodyear Analog Computer and applying reactivity changes according to a number of schedules. A voltage proportional to the logarithm of the reactor flux level was introduced into the period meter from the computer. The inverse period as determined by the computer was recorded, together with the reactivity, the inverse period modified by lag circuits having time constants of 2, 8, 18, and 28 seconds, the logarithm of the reactor flux level, and the inverse period as determined by the period meter.

A magnetic storage device has been selected for the 1000-channel slow neutron time-of-flight analyzer. This device works like a conventional magnetic drum, but it is instead a spinning disk. The information is stored on circular tracks on the face of the disk. This type of memory device seems to be cheaper per bit and more trouble-free than the standard drums.

Radiation shielding and source-detector geometry requirements have been determined for the new NPR Fuel Failure Monitor design which combines the IPD developed Geiger tube system with the HLO developed gamma-energy spectrometer system. Developmental work on the experimental mockup of the HLO fast-scan slow-scan system has been temporarily suspended in order to provide CEcAJO consultation assistance on the chosen design.

[redacted]

Continuous field testing is proceeding on the Dual-Probe NPR Scintillation Remote Area Monitor by IPD. These tests are concerned with aging qualities (anode current from the phototubes versus gamma field dose rates) of the phototubes. In addition, radiation damage effects are being determined for the probes in a 2×10^3 r/hr gamma dose rate field.

The electronic circuitry portion of the prototype NPR Beta-Gamma Air Monitor was received from fabrication, and it was successfully debugged and tested. All of the transistorized circuitry is now complete. Information was given to Instrument Design, CEMUC, to guide preparation of instrument drawings.

A prototype (alternate) scintillation logarithmic area monitor for possible NPR use has completed 2.5 months of satisfactory testing. The circuit is now deemed complete and ready for use. Three direct copies of the above were fabricated, tested, and delivered to IPD (100-H Area) for reactor elevator installation. The three units cover the range from 5 mr/hr to 5 r/hr.

A study was made to obtain data for determining time constants and trip settings for the NPR period meter. This was done by simulating the kinetics of the reactor on the Goodyear Analog Computer and applying reactivity changes in the form of ramp functions, step functions, and sine-squared functions. Data recorded included the reactivity, the logarithm of the reactor flux level, the inverse period, and the inverse period modified by lag circuits having time constants of 5, 10, 20, and 30 seconds.

Work was initiated on the NPR confiner pressure buildup problem; the analog circuit was prepared and is presently being modified in an attempt to negate the effects of multiplier noise.

A five region heat exchanger model for NPR has been constructed. This model will be checked out on the EASE computer early in September. Equations have been obtained for constructing a heat transfer model of the reactor. These equations were derived by determining the transfer functions for that system which would give the known response to a step function. This is a somewhat novel approach and eliminates the difficulties encountered in constructing an analog from the equations derived using the text book type of approach. The primary closed loop can be broken down into three blocks: the reactor kinetics, the heat transfer, and the heat exchanger. The approach being taken is to construct each block separately and check it out, then tie the blocks together after the validity of each has been assured. In the closed loop system, long transport lag times are encountered. These lag times will be simulated using closed loop tape transport units that have been purchased from Ampex Corporation.

More work was done on the reliability study of the NPR emergency cooling system. There are several parts of the instrumentation circuitry that probably will require a detailed analysis.

SEPARATIONS

Plutonium Critical Mass Facility

Personnel of Critical Mass Physics have completed the move into the new facility.

The hazards report ("Summary Report of Hazards of the Hanford Plutonium Critical Mass Laboratory" - HW-66266) is now complete and in the hands of Technical Information Operation for publication. The formal report will be forthcoming before October 1.

The in-hood reactor components for the initial critical experiments have not yet been completed. The problems mentioned last month were both associated with the safety rod drive. Destructive vibration occurred when the drive was operated, and galling occurred between the drive screws and the carriage nuts. Elimination of these problems required sufficient redesign that it was necessary to obtain approval of a quotation from the fabricator for the additional costs involved. The design changes have been started, and a rather uncertain completion date of mid-September has been given. No other problems are known to exist with the rest of the in-hood components. No shipment will be made until the whole system is assembled, and tests are witnessed at the vendor's plant.

Testing and checkout of the instrumentation and control system have continued. The data channels and two of the safety channels are operative and are being tested Of the remaining channels, one has not been tested, and the other two suffer from incompatible components or faulty design.

Some valve changes in the solution handling system have been made, and it is ready for trial operation.

Criticality Hazards Specifications

a. Nuclear Safety in HLO

The nuclear safety of a new graphite mold design for casting 6 Kg of plutonium metal into small rods was reviewed. The new design is designated as type 11 and is shown in drawing H-2-31530. It was concluded that the charged mold, which will have a carbon to plutonium atom ratio of less than 100, will be critically safe. To assure safety in the actual casting operation, the mold is to be used in accordance with the HLO nuclear safety specification that covers the casting of plutonium metal in quantities up to 6 Kg.

b. Data Correlation - Enriched Uranium Rods in Light Water

A study correlating criticality calculations with experimental measurements on uranium rod lattices in water at enrichments of 1.3%, 2.0%, and 3.063% U-235 has been completed. It was found that material bucklings at these three enrichments could be calculated reasonably accurately by using the one-group criticality equation, $B^2 = \frac{k_\infty - 1}{M^2}$, with small adjustments in the value of eta. Reactivity parameters and migration areas were calculated by the IBM 709 Idiot code. Critical masses were calculated using the experimental extrapolation lengths. A review of the results show that the calculated bucklings vary from -1% to +4% of the experimental values and the calculated minimum critical masses vary from +1% to -10% of the measured values.

Calculated and experimental values of maximum buckling and minimum critical mass are compared in the tables below. The value of the water to uranium volume ratio at which the computed and experimental maxima and minima occur

are also tabulated. The 1.03% experimental data is from BNL and the 2.0% and 3.063% data, from HAPO. All of the rod sizes that have been measured to date at these enrichments are included.

TABLE I

1.03% ENRICHED URANIUM RODS IN WATER

Comparison of Theoretical Calculations to Experimental Data

Rod Dia. (in.)		Maximum Buckling* Vw/Vu	B^2 (m^{-2})	Calc. B^2 / Exp. B^2	Minimum Critical Mass Vw/Vu	Mc (lb.)	Calc. Mc / Exp. Mc
0.387	Calc.	2.9	34.30	.994	3.4	4300	.949
	Exp.	2.7	34.50		3.3	4532	
0.60	Calc.	2.4	39.40	1.021	2.8	3969	.936
	Exp.	2.2	38.60		2.7	4239	
0.75	Calc.	2.2	40.40	.998	2.4	4079	.970
	Exp.	2.0	40.50		2.4	4206	

* 2.50 m^{-2} added to experimental bucklings to compensate for 28 mil Al cladding.

TABLE II

2.0% ENRICHED URANIUM RODS IN WATER

Comparison of Theoretical Calculations to Experimental Data

Rod Dia. (in.)		Maximum Buckling* Vw/Vu	B^2 (m^{-2})	Calc. B^2 / Exp. B^2	Minimum Critical Mass Vw/Vu	Mc (lb.)	Calc. Mc / Exp. Mc
0.600	New Calc.	2.7	113.20	1.011	3.7	518	1.016
	Exp.	2.9	112.00		3.8	510	
0.925	New Calc.	2.2	110.00	1.000	2.8	654	.948
	Exp.	2.2	110.00		2.8	690	

* 2.50 m^{-2} added to experimental bucklings to compensate for 28 mil Al cladding.

TABLE III

3.063% ENRICHED URANIUM RODS IN WATER

Comparison of Theoretical Calculations to Experimental Data

Rod Dia. (in.)		Maximum Buckling* Vw/Vu	B^2 (m^{-2})	Calc. B^2 / Exp. B^2	Minimum Critical Mass Vw/Vu	Mc (lb.)	Calc. Mc / Exp. Mc
0.175	Calc.	5.3	147.40	1.024	9	155	.912
	Exp.	5.3	144.00		9	170	
0.30	Calc.	4.5	154.50	1.000	7.5	186	.959
	Exp.	4.5	154.50		6.9	194	
0.60	Calc.	3.1	154.20	1.011	4.4	270	.957
	Exp.	2.8	152.50		4.3	282	
0.925	Calc.	2.2	147.60	1.038	3.1	376	.972
	Exp.	2.2	142.20		3.2	387	

* 2.50 m^{-2} added to experimental bucklings to compensate for 28 mil Al cladding.

Prior to this correlation, the age equation was used to calculate bucklings for uranium rod-water lattices and an extrapolation length of 8 cm was used for all critical mass calculations. The calculated maximum bucklings differed from the experimental data by approximately + 10% at 1.03% U-235 and - 15% at 3.063% U-235 and calculated minimum critical masses varied from - 20% and + 5%, respectively, at the same enrichments.

It is concluded from this study that for uranium rod lattices in water, the one-group method of calculating nuclear safety parameters described above is more accurate than the method used in the past and will therefore be used in future nuclear safety evaluation.

c. Criticality Data for Uranium Rod Lattices in Water with U-235 Enrichments of Less Than 5%

Calculations of an up-to-date set of nuclear safety parameters for uranium rod lattices in water are about 80% complete. These calculations will cover up to eight rod diameters (up to 1.0 in.) at each of the enrichments 1.0%, 2.0%, 3.1% and 5.0% U-235. The one-group criticality equation is being used for buckling calculations. Extrapolation lengths for critical mass and geometry calculations are being estimated from experimental data. Curves will relate uranium enrichment, water-to-uranium volume ratio, and rod diameter to such variables as buckling, critical mass, critical slab thickness, and critical cylinder diameter. The magnitude of some of the changes that will be made in currently accepted values is illustrated in the following table.

TABLE IV

COMPARISON OF CALCULATED AND EXPERIMENTAL CRITICALITY PARAMETERS

Enrichment (w/o U-235)		Maximum Buckling (in^{-2})	Minimum Critical Mass (lb.)	Minimum Critical Cylinder Diameter (in.)	Minimum Critical Slab Thickness (in.)
3.063	Present Calc.	156.00	153	10.4	5.1
	Exp.	155.80	164	10.4	5.1
	Past Calc.(1)	132.00	176	10.2	4.5
5.0	Present Calc.	194.80	64	8.9	4.2
	Past Calc.(2)	150.50	82	9.2	3.8

(1) Nuclear Physics Research Quarterly Report, April, May, June, 1957, HW-51983, P. 26.

(2) Nuclear Physics Research Quarterly Report, July, August, September, 1958, HW-57861, P. 24.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

Revision of the 18-group cross sections for use in multigroup codes has been completed for H_2O, U-238 and Pu-239. Work is continuing on other Pu isotopes.

The debugging of the HISMC code (Homogeneous Infinite Systems by Monte Carlo) is now in progress. One neutron history has been run which pointed out several clerical and logic errors. These errors have now been corrected and a recompilation of the program is under way.

Work has resumed on the derivation of three-group parameters appropriate to homogeneous plutonium solutions with H/Pu ratios from 177 to 1000.

Error in the Kjn(X) Tables

An error in the values of the Kjn(X) function given in HW-30323 has been called to our attention by C. D. McKay of Atomic Energy of Canada, Limited. Mr. McKay found, in the course of a machine calculation of the neutron flux distributions in cylinders, that the table was in error by approximately one percent for the value of $K_{j,7}(4.0)$. The discrepancy decreased from there with n until at n = 9 the error is less than one in the seventh significant digit. The error only occurs for odd value of n. Similar discrepancies occur at other values of X. The existence of the errors have been confirmed by hand calculations.

Miscellaneous Experiments for Nuclear Safety Specifications

Measurements were made in the PCTR to determine k_∞ of a one percent enriched UO_3 mixture at a nominal H/U atom ratio of 5. This measurement was a repeat of an earlier measurement and was made as a check for evaluating the limiting enrichment for which $k_\infty \leq$ unity for a homogeneous UO_3-water mixture. Preliminary estimates of results indicate agreement with the earlier measurements. Slightly different techniques were used in the more recent measurement.

Preparations for the final set of measurements to determine the maximum concentration of Pu for which k_∞ is less than or equal to unity are being made. Preparation for a series of similar experiments on U-235 are also being made. New solution tanks have been designed and the necessary U-235 has been requested of the AEC.

Criticality Studies in Support of Processing Power Reactor Fuels

1. Critical Approach and Exponential Measurements with Two Percent Enriched Uranium Rods

   Critical approach and exponential measurements were completed with the two-percent enriched uranium. The fuel rods used were of 0.6-inch diameter and 32-inch length. The rods were encased in thin-walled (1/32 in.) lucite tubes for insertion in a hexagonal lattice with 1.60 in. spacing. The assemblies were effectively infinitely reflected.

   A value of the extrapolation length, λ, was determined by equating the expression for the buckling from the critical approach measurement to that from the exponential measurements.

   The results of the experiments are summarized below:

CRITICAL MASS DATA AND BUCKLING FOR 2.00 PERCENT U-235, 0.600 IN. DIAMETER RODS

Lattice Spacing (inches)	H_2O/U Volume Ratio	Number of 32 in. Rods (Crit. Cylinder)	Calculated Critical Mass (Sphere)	Extrapolation Length (λ) (cm)	Critical or Material Buckling ($\times 10^6$ cm^2)
1.60	6.84	174 (1072 lbs. U)	889 lbs. U	5.72	6,185

EXPONENTIAL MEASUREMENTS WITH TWO PERCENT ENRICHED URANIUM (0.60 in. dia., 32 in. length)

Lattice Spacing (inches)	H_2O/U (Volume Ratio)	No. of Rods	Effective Radius (cm)	Relaxation Length (cm)
1.60	6.84	109	22.3	28.95
1.10*	2.71	85	13.5	18.38

* Rerun, see July monthly report.

2. Measurements of k_∞ in the PCTR for Three Percent Enriched Uranyl Nitrate

Work on the measurement of k_∞ for enriched uranyl nitrate solutions has continued. The measurement of k_∞ at a nominal H/U atom ratio of 9 was completed and the results are being analyzed. The preliminary value of k_∞ is 1.11. The value of k_∞ for a 3% enriched UO_3 mixture at the same H/U ratio is 1.33, indicating the effect of the nitrogen in the nitrate solution in reducing k_∞.

Kinetics with Time Dependent Reactivity

At the request of Critical Mass Physics personnel, the reactivity subroutine of the kinetics code HAIREK was rewritten to include a different formulation for the reactivity due to void formation. As results obtained with the new expression gave closer agreement with the P-11 burst data, the survey problems done last month for Critical Mass Laboratory hazards report were recalculated using the revised subroutine.

Interactions of Subcritical Systems

The investigation of the interaction of spatially distinct multiplying systems is continuing. Re-examination of earlier work on this subject done here by Stuart, HW-40947, and Journal of Applied Physics, 27, 1294 (1956), has led to a considerable improvement in the form and usefulness of his results. Interaction integrals which he evaluated approximately were found to be expressible more simply and in closed form.

Mass Spectrometry

The mass spectrometer for this program was shut down because of repeated malfunction of the source vacuum interlock. The vacuum interlock was removed and precision measurements were performed to determine possible reasons for the faulty operation. The pieces are being lapped to obtain the required tolerances.

A new high voltage cable was fabricated for the spectrometer in the hope of reducing high voltage breakdown.

NEUTRON CROSS SECTION PROGRAM

Crystal Spectrometer Operation

Most of the month was spent in maintenance of the crystal spectrometers and testing of associated equipment. The DR spectrometer was realigned following the repair of the beam shutter and consequent misalignment of the collimators. The boron chamber normally used at the DR spectrometer was intercalibrated with the boron chamber beam monitor used at the KE spectrometer.

A commercial zinc single crystal was tested at the DR spectrometer for intensity and rocking curve widths. The reflectivities obtained to date indicate that the reflection efficiency is only 10 to 20 percent of that of a good beryllium crystal although the rocking curve widths are of the same magnitude.

Six new RCL BF_3 counters were received and tested for use with the KE spectrometer. All the counters had about the same efficiency and all had satisfactory pulse height distributions. The counters were mounted at the KE spectrometer in such a

fashion that the detectable scattered intensity in a scattering cross section measurement was about three times that of the counters previously in use. The signal-to-background ratio was roughly preserved.

Slow Neutron Scattering Cross Sections

Measurements have continued on the scattering of neutrons of 0.247 ev from a room temperature water sample. Energy analyses near the elastic peak have been made for water scattering at 10, 20, 30, and 40 degrees scattering angle; for air at 3, 10, and 20 degrees scattering angle; and for vanadium at 3 degrees.

Crystals for Neutron Diffraction

Two aluminum crystals were grown. The first ingot, 3 inches in diameter and 7 inches long, was grown in the short time of 1.7 hours. This ingot consisted of two large grains. Another ingot, 2 inches in diameter, was grown in 15 hours with a large temperature gradient. This ingot was essentially a single crystal with probably a broad rocking curve. Neither crystal has been studied by neutron diffraction.

Fast Neutron Cross Sections

Work has continued on the development of a satisfactory system for evaporating thick lithium targets in situ.

The slit boxes for the Van de Graaff are being assembled.

Procurement has been initiated for some 26 elements for fast neutron total and scattering cross section measurements.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE

Low Exposure Plutonium Lattices

Data from the six foil normalization irradiations have been reduced, using APDAC-1. A systematic two percent difference in the ratio of the U^{235} monitor activity to the Pu monitor activity was noted in all six cases between the two separate counting systems used. This difference may be due to slight differences in discrimination levels. It is planned to examine the fission product gamma spectrum of both Pu and U^{235} in the vicinity of 450-480 kev using the 256 channel analyzer to determine the sensitivity of this effect to discrimination level.

Preparations have been made to make four irradiations in the 10 1/2-inch graphite lattice with the 19-rod clusters of Pu-Al fuel in order to verify some of the previous results. A similar set of four irradiations is planned for the 8-3/8-inch lattice.

PRTR Startup Experiments

Rough drafts of the Detailed Procedures for Critical Tests 1, 2, 12 and 13 have been prepared. A general description of these tests are contained in HW-61900-B.

Critical Facility of the PRP

When the draft of the "Proposed Studies for the Critical Facility" was circulated, the Appendix had not been prepared. This section now has been written and circulated to those who have received the draft. The Appendix contains program schedules which will help in planning for the facility.

The design drawings for the reactor tank, grid plates, moderator storage tank, and poison injection system were reviewed. Initial positions for temperature and flux monitoring devices were suggested to the designers. As planned there will be 10 positions available for measuring the temperature in the D_2O moderated facility. Seven of these positions will furnish a vertical profile of the temperature. Each of the seven sensors will be equally spaced in a vertical line in the facility. Their radial position corresponds to 1/4 of the total volume of the tank. The three remaining sensors will be placed radially at positions which each represent a cylindrical annulus of 1/4 of the total volume of the reactor tank. The three single sensors, and one of the vertical string, will be placed horizontally in the mid-plane of the reactor. It will be possible, however, to reposition the sensors for other reactor configurations.

Eight holes will be furnished as flux monitoring holes. Six are placed so that they are in equivalent lattice positions. The other two are on the periphery of the tank cover. These two are arranged so that a mechanism which would take radial traverses can be positioned from the top of the tank. A second means of obtaining radial traverses is provided by a tube which runs through the sides of the tank.

The holes which monitor the flux are the same size as the ones which receive the temperature sensors. Therefore, each hole can be used for either measurement.

An experiment to measure the change in reactivity of plutonium samples as a function of irradiation is being planned in cooperation with Plutonium Fuels Development Operation. The irradiation will be made in the Materials Testing Reactor (MTR) and the reactivity measurements will be conducted in the Reactivity Measuring Facility (RMF). The purpose of the experiments is two-fold. First, the effects on exposure lifetime due to different initial concentrations of Pu-239 and Pu-241 (Phoenix fuel) will be obtained. By utilizing the MTR and the RMF some answers to this important question can be obtained prior to the operation of the PRPCF. Secondly, experience will be gained for conducting and analyzing similar experiments in the PRPCF. It is planned to measure several of the samples in the PRPCF as well as in the RMF. In this way, a check on the analytical methods of analysis can be obtained since the same quantities will be measured in different facilities.

Effect of Absorber on Neutron Energy Spectrum

The investigation of the effect of an absorbing cylinder on the thermal neutron flux spectrum in the surrounding nonabsorbing moderator is continuing. Introducing the Breit-Wigner resonance in the ordinary 1/v absorption spectrum has resulted in some integrals which are difficult to evaluate. A satisfactory evaluation procedure for these integrals has not been found.

The solution to the problem of 1/v absorption in the rod, without the resonance, has been programmed, and is now being debugged. This solution uses a reciprocal blackness which depends upon $E^{1/2}$, which has been found to be an extremely good approximation for most of the energy range. The program is called ARMIE II, and will give output similar to program ARMIE, which used, however, a less accurate recriprocal blackness dependence which was linear with E.

Instrumentation and Systems Studies

The period portion of the PRTR controller evaluation has been delayed due to the failure of the contractor in completing the construction work. At this writing, it seems probable that this work can be performed during September.

A hazards analysis was started on the analog computer. This work is an extension of the original hazards analysis completed in 1959.

It is planned to use one of the experimental neutron counters being tested for use in PRTR Critical Tests to obtain the "noise" signals required to measure the PRTR neutron lifetime. However, there is some question as to whether the counter sensitivity will be adequate for this type of measurement. Preliminary tests to determine the magnitude of the noise signal during low-power operation will be made as soon as PRTR is started up. If additional sensitivity is required, a larger counter tube can be fabricated by the 300 Area Tube Shop.

Work was completed on a Unit Motion Camera designed to assist in measuring movement of the PRTR Calandria with respect to the top shield.

Tests of the effects of gamma radiation on several infrared transmitting materials for possible use in temperature measurements in the Fuels Examination Facility were completed and a memo has been written describing the tests and results. Briefly, doses of 10^8 R result in lowering the transmission by little more than 10 percent for germanium, silicon, and arsenic trisulfide. Arsenic trisulfide suffers damage to its surface finish and this effect is the main reason for the loss of transmission.

The Phase I process tube inside diameter measuring probe was assembled, calibrated, and delivered to Materials Development Operation. The accuracy of test measurements was well within the required specifications; however, the physical configuration must be improved.

An order has been placed with the Magnaflux Corporation for an F-400 series eddy current instrument for use in performing the PRTR process-to-shroud-tube gas gap measurement. This instrument will be used in conjunction with two dual coil probes aligned in quadrature in the process tube, with the instrument interrogating each probe alternately, utilizing a dwell time of approximately seven seconds for each probe. Work has continued on the design of the probe assembly with various methods of optimizing power transfer being evaluated to increase over-all sensitivity. The test jig to be used for final calibration of the instrument has been designed, and fabrication is 70 percent completed. The test jig will be capable of varying the proximity of the shroud tube with respect to the process tube with an accuracy of one mil, and will accommodate sections of process tubing having various wall thicknesses throughout the range of interest.

NONDESTRUCTIVE TESTING RESEARCH

The evaluation of the use of orthogonalized exponentials for use in analyzing the broadband eddy current test signals is being continued. Dr. W. H. Huggins of The Johns Hopkins University, a leader in the field of signal theory and the use of orthogonalized exponentials, visited Hanford by invitation and conducted a seminar on these subjects. Detailed discussions were held with Professor Huggins which may lead to a research contract with the University concerning the application of the principles of signal space concepts to the broadband eddy current problem.

There are several different ways in which the principles of orthogonalized functions may be applied to eddy current nondestructive testing. One approach using techniques of signal analysis used at The Johns Hopkins University in a different application would require excitation of the test coil by a selected driving function. The pulse output of the test coil and input bridge circuit would then be reversed in time and applied to an orthonormal filter designed to read out the components of the non-reversed signal on a selected orthogonal basis. The output of the orthonormal filter would provide a set of numbers whose patterns, it is expected, can be related to different test specimen parameter conditions. The time reversal requirement presents a practical problem which would complicate the application of the proposed method to actual test instruments. Various ways of performing the time reversal in the few tens of microseconds' range required are being considered.

The possibility of eliminating the need for the time reversal operation by use of specially constructed driving functions is being studied.

Machining estimates on the recently designed device for rotating and translating test pieces during heat transfer tests indicate that approximately 550 man-hours will be required for fabrication. A lathe is being adapted to test an alternative, less expensive method of scanning. The test piece will be rotated in the lathe and the induction heating coil and radiation pyrometer will be translated along the length of the test piece on the tool carriage. Motion of the induction heater output leads will undoubtedly cause a problem. However, the severity of this problem can only be determined experimentally.

Several induction heaters at HAPO which would be available on a part-time basis for use in the heat transfer testing studies have been evaluated. The maximum power that can be induced in an aluminum-clad fuel element from a single turn work coil with these units is about 1/2 KW. Arrangements have been made to evaluate a 10 KW induction heater to be loaned by the Radio Frequency Company. According to the manufacturer, this unit should heat our samples efficiently from a single turn coil of 1/8-inch-diameter copper tubing.

Modifications of the infrared radiometer head to include a 12-inch-diameter commercial-quality objective mirror have been made. The purpose of this change was to allow greater separation between the test piece and radiometer, and to reduce interference from the induction heater work coil field. Reduction in efficiency due to imperfections in the commercial quality mirror system were greater than expected, and it will be necessary to replace it with a precision system.

A lead selenide refrigerated infrared photodetector having a detectivity of 2.6 x 10^9 cm/watt for a 500°K blackbody has been ordered. Calculation of the 50°C black-

body detectivity of the cell, from the spectral detectivity characteristics, shows that it will provide a factor of approximately 24 increase in sensitivity of the radiometer in this range.

Since the detectivity of most infrared detectors depends strongly on the spectral distribution of the incident radiation, it is desirable to know the spectral emissivity of the radiating object. A section of X-8001 cladding from an autoclaved fuel element has been sent to the Naval Ordnance Laboratory, Corona, California, for a spectral emissivity determination.

The single vacuum tube self-excited oscillator type inductive thermometer has readily detected a 25-degree Centigrade "hot spot" on an aluminum can. Electrical noise due to vibration of the test probe caused by scanning was equivalent to about four degrees Centigrade temperature variation. It is desired to reduce this by a factor of 5 to 10, and circuit changes to accomplish this are now being made.

NEUTRON FLUX MONITORS

The AEC Division of Reactor Development has authorized a new research program on extended lifetime neutron detectors. Major emphasis will be given to evaluating the possible uses of plutonium isotopes for minimizing the target atom burnout problem experienced with conventional neutron detectors in high flux reactors. Background information is being obtained for the initial analytical investigations.

The balance of the program will be devoted to exploring other new ideas for improved neutron detectors. As part of this phase an Invention Report, HW-66574, was submitted on a new neutron detector for in-core use on high flux reactors. In the method described, a gas is placed in a microwave cavity in the neutron field. When a neutron is captured by an appropriate gas nucleus, the molecular rotational states will be changed. These changes are then detected by the method of microwave spectroscopy. A calculation was made, based on the gas $CNCl^{35}$. This gas was selected because information is available on minimum detectable concentrations. The results of this calculation show that at a flux of 10^{13} n/cm^2sec, a one percent measurement can be made, with a ten-second time constant. Since the method is inherently insensitive to gamma radiation, high temperatures, and gas impurities, many of the current in-core monitor problems might be alleviated.

GAS COOLED REACTOR

Lattice Parameter Measurements

The customer reports on the PCTR measurements of the reactivity effect of a stainless steel loop tube in the EGCR (HW-66181) and the EGCR control rod worth (HW-63767) are now being distributed. A revised nitrogen correction was applied to the data early in the month, and the values quoted in both reports differ slightly from those quoted earlier.

The customer report on the PCTR measurements of k_∞ and f for UO_2 fuel of 2.6 w/o enrichment (HW-66182) has been completed and is being prepared for distribution early in September.

A summary of a paper on the measurements of the reactivity effect of a stainless steel tube and of k_∞ and f for UO_2 fuel of 2.6 w/o enrichment has been submitted

for presentation at the December, 1960, meeting of the American Nuclear Society in San Francisco.

Rough drafts of papers on the PCTR measurements of the EGCR control rod strength and EGCR lattice parameters have also been completed. These will be submitted to Nuclear Science and Engineering for publication.

This work concludes the lattice physics work in support of the Gas Cooled Reactor Program.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

New summaries of mass and exposure determinations for all samples collected during the Summer 1959 field experiments in atmospheric dispersion and transport were prepared. Calibration curves based on the phosphorescence method of assaying the amount of tracer material collected on the filters were utilized. IBM data tabulations and cards were forwarded to the Air Force Geophysical Laboratories for use in their computation program, and for inclusion in the Geophysical Research Papers that will comprise the general report of the "Green Glow" work.

Considerable editing of the data compilations for distances of 8 and 16 miles from the source was required to account for the missing entries for samples used in earlier attempts to calibrate the tracer system. Best estimates of these data were obtained from the visual counts, neutron activation, and Tri-Carb counts and were inserted in the summaries with appropriate notations.

Activities in the current series of field experiments in atmospheric dispersion and transport included completion of three additional tests in five attempts. The time interval of release of the tracer material was increased from earlier experiments to provide a greater ratio of release to travel time as required in Pasquill's "beta" theory. Dosage data were obtained to a distance of 3200 meters from a ground-level source, utilizing both the horizontal and vertical sampling grids.

In our preliminary work on precipitation scavenging processes, climatological summaries of precipitation and fog were prepared for the Hanford Area. Investigations to determine the predictability of precipitation times and intensities were started.

DOSIMETRY

Our large, thin NaI crystal was remounted on a large light pipe. This greatly improved the resolution of the counter and its response to sources in different positions relative to the crystal. This was done at some expense of signal to noise ratio. Tests indicate that this improved counter should be able to detect less than one milligram of uranium in a person's lung.

An AEC Radiological Physics Fellow made a detailed study of our present plutonium wound counter. This counter is actually calibrated separately for each individual

case of a wound; however, the present study indicates what over-all performance can be expected of the counter. Two particular observations of interest were: First, that plutonium could be spread throughout an area one centimeter in diameter and still be measured correctly when a point source was used for calibration; second, the positioning of a wound under the counter can be in error by as much as 0.8 cm without appreciably affecting the measurement.

The positive ion accelerator operated satisfactorily during the month.

A precision long counter made at Hanford and one made at the National Bureau of Standards were tested at 7 neutron energies between 0.15 and 16.7 Mev. The counters showed a relative sensitivity within 0.3% of each other at all energies. This was considered a very significant result in the development of reproducible counters.

It was found that the Perlow spectrometer was responding to neutrons that should have been outside its range. This effect is interfering with the measurement of low energy neutron spectra.

Methods were developed for measuring certain characteristics, oscillator efficiency and gas flow rates, that affect the operation of the helium ion source being prepared for the Van de Graaff.

On the advice of the National Bureau of Standards a new value was used for the half-life of Co-60 in comparing ours and their measurement of their standard source. This resulted in 1.7% difference between our results which is poorer agreement than reported last month. It is believed that our measurement is the more accurate. The gamma ray calorimeter was also used to measure one of the Hanford radium sources.

Final tests were made on the beam current stabilizer for the electron Van de Graaff. The stabilizer has substantially improved the performance of the Van de Graaff. It was found necessary to redesign the high voltage portion of the beam sweep system to prevent corona discharge.

Two AEC Fellows used the electron beam calorimeter to make a measurement of the stopping power of aluminum for high energy electrons. Although this was the first measurement of this type that we have made and it contains many errors that can be reduced or eliminated, the result was very close to that expected on theoretical grounds.

Two other AEC Fellows measured the change in resistance of a silicon diode when exposed to Co-60. It was expected that a significant change would take place if the irradiation were done at liquid nitrogen temperature. The change observed was considerably less than that expected. The reason for this is not known.

INSTRUMENTATION

All experimental digital readout circuitry was completed--and is being tested--for the coincidence-type alpha air monitor. Continuous testing for several weeks is in order to obtain adequate information.

Ten P-N silicon diodes were gold-plated and nine of the ten were satisfactory for gross alpha detection work. Now that a "working stock" of successful diodes

(11 total) is completed, experiments will proceed using the devices. Two miniature hand-held gross alpha monitors (transistorized) are now being experimentally fabricated using two 0.75-inch-diameter silicon diode detectors.

A design was completed for a medium-level alpha air monitor which utilizes a mechanical method of time constant introduction to compensate for the filter deposition of natural background (radon-thoron components). The design calculations show a time-to-alarm of two minutes in an atmosphere containing 1.2×10^{-11} μc/cc of airborne Pu^{239}. The filter collection efficiency is nearly 100 percent for all particles exceeding 0.1 micron in size. Considerable cost reduction is possible through the new innovation, and all circuitry can be easily transistorized.

The log quantizer circuit, using a tunnel diode as a voltage comparator, was tried with the RIDL 200 channel pulse height analyzer. It permits presentation on one chart of a gamma energy range from 40 Kev to 1.3 Mev. Over this range, the unit is quite useful for low-level source work.

Good experimental progress was made concerning the miniature thermoluminescent dosimeters. One unit was fabricated and successfully tested over the accumulated radium gamma dose range from 1 mr to 1 r. It appears that linearity can be extended down to 0.1 mr. Arrangements were completed to permit obtaining of response versus gamma energy values using the Calibrations Operation facilities.

The Dog Counter, designed for the Biology Operation and used for 1.5 years now, is being modified to permit in vivo determination of Ce^{144} in various animals.

The experimental prototype scintillation transistorized alpha-beta-gamma hand and shoe counter, which was used in making as-built plant drawings, was reassembled, satisfactorily tested, and was returned to general personnel use in the 329 Building. At later dates, the prototype will be demonstrated at 100-H Area, Purex, and Biology.

A new digital odometer and turn integrator system was developed and tested for the robot monitor. The measurement makes use of the sum and difference of the motions of the drive wheels.

The manual entry keyboard for the whole body monitor multichannel analyzer was assembled and tested. Preliminary operation was satisfactory.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis

The mass spectrometer for this program operated at about 125 percent efficiency during this month while two technologists were available for operation. This was done in spite of three days time lost from operating difficulty and maintenance.

In order to determine if there is a systematic error produced in isotopic analyses by this mass spectrometer, the results of 22 analyses of natural uranium performed over the past 12 months were statistically combined. The combined result yields a

value of (0.7188 ± 0.0008)atom percent U^{235} where the error is the standard error of the mean. This result is not significantly different from the best value obtained at KAPL of (0.7196 ± 0.0006) which leads to the conclusion that there is no detectable over-all mass discrimination in this instrument.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month. There was one unscheduled shutdown caused by faulty by-passing technique.

The 3% uranyl nitrate-H_2O experiment for k_∞, at H/U = 8, and the 1% UO_3.H_2O experiment for k_∞ were completed.

The NPR condensed lattice experiment for k_∞, f, p, and ϵ, wet and dry, was started during the month.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	85.6
24-Hour General	62	80.2
Special	147	83.0

Temperatures during August ranged from a high of 105 on the 11th to a low of 41 on the 22nd. The latter mark came within one degree of equaling the all-time-record August low established in 1918. The over-all average temperature for the past month was 71.4, which was 2.7 degrees below normal. The precipitation total of 0.26 inch was 0.10 inch above normal. Intense thunderstorm activity occurred on the evening of the 2nd and the morning of the 3rd.

Consultation service was rendered on meteorological and climatological aspects of 1) reactor accidents, 2) the environmental conditions attendant with operation of large electrical transformers in desert regions, 3) the frequency of suitable days for pouring concrete during the winter months, and 4) contaminant releases from the Separations Area process stacks.

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

Instrumentation and Systems Studies

The "Sentinel" alarming (selectable level) scintillation dose-rate monitor (portable) designed for IPD use was slightly modified to improve the response linearity. The unit (prototype) was used successfully and twelve units have been ordered to be fabricated offsite. The units will be used on the reactor elevators for dose-rate level alarming use.

The prototype scintillation transistorized alpha-only hand counter, after 2.5 years successful demonstration use in six different plant locations, was installed

at the Biology Operation for another demonstration. Operation continues to be satisfactory with a 200 d/m Pu^{239} source easily detectable above warning levels.

At the request of Radiation Monitoring, 100 KE, a modified scintillation counter (in a lead pig) used for filter counting was examined and tested. This modification was earlier designed by us to replace the fragile and unreliable mica window G-M tubes previously used. It was found that the scaler being used was faulty because of excessive drift in an RF high-voltage supply.

A hanger system for coveralls was designed for the mechanical portion of the Laundry Monitor Unit. The hanger unit drops the coveralls automatically after monitoring (alpha and beta-gamma) is complete.

A special scintillation probe (for Biology) for measurement of the 17-Kev X-rays from under-the-skin injection of Pu^{239} was completed in fabrication and is being tested.

All tests were completed, and only calibration work remains on the specially-designed in-cell beta-gamma monitors and the special hot cell filter monitor for the Chemical Research Operation, HLO.

The Pu^{239} (17-Kev X-ray) Wound Probe for Records and Standards Operation, HLO, was completed and initially tested. Further tests will be done to determine the resolution and sensitivity of detection abilities of the probe. This unit has undergone extensive delays due to non-arrival of parts.

Fabrication was completed on the final 13 scintillation linear (0-200 mr/hr) 614 Building monitors for Radiation Protection Operation, HLO. In addition, a magnetic amplifier circuit was designed and tested satisfactorily for use with the monitors to permit driving of Leeds and Northrup Micromax Chart Recorders if desired.

Arrangements are being made to perform a comprehensive set of calibration tests on the reference system for evaluating the Schaevitz DRS-100 (micro-displacement) system to be used by the Physical Metallurgy Unit for making in-reactor creep measurements. Minor modifications to the system supports are necessary to make the system compatible with commercial equipment in the Metrology Laboratory to be used for calibrating the reference system. Present intentions are to use the Metrology Laboratory equipment for a final, composite reference system calibration before placing the reference system in service as a reference standard.

A problem concerning the dissolution of zirconium alloy cladding of reactor fuel elements was completed on the analog computer. This work was performed at the request of the Chemical Research and Development Operation. The results were satisfactory. A memorandum report was issued.

The analog computer was used to determine the effects of changes in various heat transfer coefficients on a calciner step function temperature response curve. With the aid of this information and through consultation with the customer, it was possible to determine several sources of error in the coefficients used in the original system equations. Corrections to the equations and to the process section of the computer simulation circuit have been made. The complete closed loop system will now be tested for stability and satisfactory responses to various types of disturbances.

A review of nondestructive techniques for determining isotopic concentrations in reactor fuel components was completed. This is to be included in a Nuclear Materials Management report being prepared for the AEC by HLO Operations Research.

Optics

Fabrication of a Zyglo inspection device has been completed. The device is to be used to inspect inside surfaces of 1/2-inch inside diameter tubing for small flaws. It provides an alarm signal when a flaw is in the field of view. A borescope is used to relay the fluorescent light of the Zyglo penetrant from the flaw to a photomultiplier detector.

The infrared radiation ratio pyrometer to be installed on the metallograph for Physical Metallurgy is being calibrated against the Barnes radiation standard. It has performed well over a 400°C to 500°C range from as low as 400°C to higher than 1000°C. Small changes in the thickness and geometry of the filters used affect the range and linearity of the unit so efforts are now concentrated on covering the 500°C to 1000°C range and obtaining more linearity.

The construction of the infrared radiation ratio pyrometer under development for measuring the temperature of FPD Zircaloy-clad uranium billets has begun. Electronic components are being assembled in 328 Electronic Shops and the mechanical components are being fabricated in the Optical Shop.

Two infrared radiation pyrometer telescopes have been fabricated and delivered--one to FPD and one to the HLO Ceramic Fuels Operation. All are of the same design which permits viewing of an upright image of the source while its temperature is being measured.

A total of 984 manhours of optics shop work was performed during the eight week period (July 3 through August 28). Of this, 15 percent was for FPD, 7 percent for IPD, 18 percent for CPD, 47 percent for HLO, and 13 percent for others. The work included:

1. Fabrication of three infrared radiation pyrometers.
2. Fabrication of a projection lens for an optical internal diameter micrometer.
3. Evaporation of gold on twelve silicon wafers to be used for silicon diodes.
4. Fabrication of ten quartz windows.
5. Lapping three pump seal faces flat to ten microinches.
6. Fabrication of reflecting optics for an infrared pyrometer.
7. Repair of four crane periscope heads.
8. Preparation of glass irradiation samples.
9. Grinding and polishing 24 microscope slides.
10. Collimation of one pair of binoculars.

Analog Computer Facility Operations

The major problems on the analog computers this month were:

Evaluation of a sub-critical monitor.
NPR period meter study.
Reactor Kinetic equations study.

NPR confiner pressure study.
PRTR safeguards analysis.
Zirflex process study.
Calciner process study.
Reactor lithium loss study.

The tape transport relay units were received and then returned to the factory for modifications necessary for them to meet our specifications. The units will be shipped from the factory by August 27, 1960.

A class was started on August 23 in Analog Computer Techniques. This class is being taught in the 762 Building and is attended by sixteen students. This class will meet twice a week for the next five weeks.

The computer operating times were as follows:

GEDA	154	hours up
	16	hours idle time
	5	hours unscheduled downtime
	0	hours scheduled downtime
	175	hours total
EASE	142	hours up
	32	hours idle time
	1	hour unscheduled downtime
	0	hours scheduled downtime
	175	hours total

For the computer reliability improvement program, all parts have been obtained and the design is complete for the amplifier tester. Instrument maintenance personnel will fabricate the tester in the near future. When complete, it will test two different Beckman EASE amplifiers and two different Goodyear GEDA amplifiers. Three spare EASE amplifiers have been ordered and three spare GEDA amplifiers will be fabricated to provide the necessary replacements for a routine maintenance program. Routine maintenance procedures have been written for most of the components in both computers. Maintenance record cards have been printed. The maintenance program will be started as soon as all spare equipment has been received and the amplifier testing device fabricated.

Instrument Evaluation

One Model II alpha Scintran was demonstrated and left for temporary use at the Biology Operation. This unit uses the new plastic non-gamma sensitive alpha probe. Operation was highly successful.

The experimental combined transistorized alpha "Cart Poppy" for use with both air proportional and scintillation probes was taken to 234-5 for demonstration use and field testing. The light-shield of the scintillation probe was punctured after five days of use. Operation to that point was quite satisfactory and a new probe was delivered.

Another prototype Model II alpha Scintran was given to IPD for testing using a beta-gamma sensitive probe. This particular model instrument is quite versatile

in that alpha-only, beta-gamma, or neutron-sensitive scintillation detector probes can be directly employed as desired with no changes necessary in the instrument. Thus, one transistorized instrument can be used (110 VAC operated) for any such desired monitoring work. This is another step toward standardization of 110 VAC line-operated monitoring equipment.

Three scintillation logarithmic (5 mr/hr to 5 r/hr) area monitors fabricated for IPD were tested, calibrated, and delivered. The units, for reactor elevator use, are now in successful operation.

Acceptance tests continued on the final 13 scintillation 614 Building Monitors employing our designed and reliable high-voltage supply.

Evaluation tests were started on a Victoreen Dual Logarithmic Count-Rate Meter (vacuum-tube type). To date, the drift is excessive.

Acceptance tests continue on 65 C-P and 29 CP-TP portable ionization-chamber dose-rate instruments. These were all fabricated to our plant standard specifications.

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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

Study was made of fission product release from uranium irradiated to about 5×10^{17} nvt (twice that of any previous run) and heated for 24 minutes in air at 1215 C. The measured percent releases were: I^{131}, 95; Xe^{133}, 95; Te^{132}, 57; Cs, 23; Sr, Ru^{103} and Ba-La^{140} between 0.1 and 0.2; Mo^{99}, Np^{239} and Zr-Nb^{95} between 0.01 and 0.1; and the rare earths less than 0.01. Only the measured release of cesium deviates to an appreciable extent over that measured at the trace level. This is attributed to inabilities to recover and analyze the very small quantities of cesium present at the trace level rather than to any scale-up effect.

NPR Effluents

One candidate decontaminating agent for the carbon steel portion of the NPR primary coolant loop is Turco 4512, a commercial phosphoric acid cleaner. The decontamination waste resulting from the use of this material is being studied with regard to phosphate ion removal as well as possible radioisotope removal prior to its disposal. Experiments showed that more than 99 percent of the phosphate could be removed by neutralization with $Ca(OH)_2$ and that more than 95 percent was precipitated with $CaCO_3$ treatment. These removals were possible only with long settling times or centrifugation and large excesses of the calcium compound.

Reactor Effluent Treatment

The pilot scale facility for reactor effluent treatment operated continuously from August 4 to month end. After ten days operation, 52 percent of the influent Cu^{64} and 40 percent of the As^{76} were being retained on the aluminum turnings bed. The decontamination was about that expected after the relatively short operation. Equilibrium is expected to be achieved after three to four weeks of operation. Pressure drop across the bed increased from two inches to four inches during the period of operation. A temperature drop of 1 to 2 C across the bed was recorded. Radiation level at the point of maximum dose rate against the tank wall reached 310 mr/hr.

SEPARATION PROCESSES

Feed Preparation

Redox Multipurpose Dissolver Slag Sample - A sample of the slag remaining in the Redox Multipurpose Dissolver after dissolution and decontamination operations were completed has been obtained, and metallurgical examination has been completed. The sample obtained weighed approximately 100 grams and resembled a furnace "clinker" in appearance. Although the grey-black outer surface of the 2-1/2 inch long, 1 inch thick sample was quite porous, sectioning revealed a solid metallic

inner core resembling cut stainless steel. This metallic surface was not noticeably attacked by three hours immersion in boiling nitric acid. The sample was dissolved in aqua regia, and analysis indicated the sample was approximately 72 percent iron, 9 percent chromium, 11 percent nickel, and 8 percent uranium. Phase diagrams indicate that temperatures in excess of 1300 C existed in regions of the dissolver during the incident.

Zirflex Process - Attack of NPR Cores - The rate of attack by Zirflex decladding solutions on several uranium alloys which have been proposed for NPR fuels was measured. Samples of the alloys were exposed in the decladding solutions along with dissolving Zircaloy-2. Conditions were such that the dissolved zirconium concentration increased from zero to about 0.8 M in four hours. Total attack on the uranium alloys was determined rather than soluble uranium which would be lost to the decladding waste solution. The average attack rate (over the four-hour period) on U - 2 percent Zr, and U - 1 percent Zr alloys was about 0.28 g/hr-sq.cm. In these two cases it was not possible to dissolve Zircaloy-2 to 0.8 M zirconium because of the fluoride used in the formation of UF_4. Similarly, the average attack rate was 0.024 g/hr-sq.cm. on U - 0.38 percent Zr, 0.019 g/hr-sq.cm. on U - 0.045 percent Zr, and 0.033 g/hr-sq.cm. on U - 0.03 percent Si - 0.02 percent Fe. The average penetration rate for aluminum alloy 6061 during one hour exposure in 5.5 M NH_4F - 0.5 M NH_4NO_3 at 100 C was less than one mg/hr-sq.cm.

Solvent Extraction

Purex 1BX and 2A Columns Studies - A series of runs were made in three-inch diameter pulse columns to demonstrate the suitability of nozzle plate cartridges for the Purex 1BX and 2A Columns. The 1BX Column contained 15 feet of four-inch spaced 23 percent free area nozzle plates with the 3/16-inch diameter nozzles pointing up. It also had 28 percent free area louver plates located at four-foot intervals. The 2A Column contained similar nozzle plates which were spaced three inches apart in the six-foot high scrub section and two inches apart in the twelve-foot high extraction section with the nozzles pointing down. The 1BX Column was operated with the aqueous phase continuous and the 2A Column was organic-continuous.

The maximum stable capacity achieved in the 1BX Column was 1350 gal/hr-sq.ft., sum of flows. To obtain this capacity, it was necessary to operate at about 55 C. At 42 C the column was mildly unstable at the same rate. In a brief test with the present Plant cartridge installed (33 percent free area sieve plates with 3/16-inch holes, 4-inch spacing) essentially the same capacity was obtained. In both cartridges, two or three of the plates appeared to be organic wet. At these plates the tight, efficient emulsion would coalesce into large organic drops which, when near flooding, obviously stabilized the column at that point. The coalesced drops formed by the nozzle plates, however, were smaller and should present less of a channeling problem than those which were formed by the organic-wet sieve plates. On this basis, the nozzle plate cartridge would be preferred slightly over the sieve-plate cartridge, although capacity-wise they have similar characteristics.

The 2A Column operated satisfactorily at volume velocities (extraction section) in excess of 1800 gal/hr-sq.ft., either heated or at room temperature. At throughput rates of 1000 to 1500 gal/hr-sq.ft., the minimum operating frequency for good scrub section performance (i.e., aqueous phase well dispersed with greater than 5 percent holdup) ranged from about 85 cycles/min at the lower rate to 75 cycles/min at the higher rate. This frequency was typically about 20 cycles/min below the extraction and/or scrub instability threshold. The flooding data agreed quite well with data for similar cartridges described in HW-40550.

Purex Decontamination Studies

The possibility that recycle of waste rework streams is introducing constituents contributing to poor decontamination in the HA Column was briefly examined. Laboratory-grade 30 percent TBP in Shell E-2342 was contacted with a sample of simulated Purex F-8 from the 321 cold semiworks which was spiked with Purex feed activity, and subsequently scrubbed with two molar nitric acid. The distribution of zirconium-niobium between the organic and this undiluted F-8 was a factor of five lower than that with an F-8 solution made up with chemically pure chemicals. This same behavior has been observed by T.R. McKenzie with Purex plant F-8 material.

Attempts made to determine if solvent quality was lowered by the contacting with cold semiworks F-8 indicated that such was probably the case but the results were somewhat inconclusive.

A rough test was made to determine the effect on HA Column performance of adding F-8 solution to the HAF. For this test the 2A Column previously described was used to simulate the Purex HA Column. During operation (at the scrub section instability threshold) the HAF was switched back and forth between a control feed and a similar feed containing 11 percent by volume of a "cold" synthetic F-8 prepared and refluxed in the 321 Building.

With the control feed, a foamy, emulsion interface built up at the top of the scrub section. The emulsion broke shortly after introduction of the F-8 containing feed and reformed on changing back to the control feed. No effect was seen in the extraction section performance. This stabilizing effect of F-8 addition is consistent with observations made in the Plant.

Observation Wells

The contractor on Project CAH-885 completed six of the 19 wells, having drilled a total of 1885 feet. The work is about 15 days behind schedule primarily because of equipment failure.

The considerable thickness of clays and silts encountered in well 699-15-15 at the Hanford wye precludes the ready movement of much ground water from the vicinity of the separations areas toward the Columbia River through this site other than by means of the shallow, unconfined ground waters. The first materials containing other than large quantities of silt and clay below a depth of about 180 feet (about 322 foot altitude) were some clean gravels at 632 feet. This is about 100 feet below sea level and nearly 500 feet below the Columbia River.

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

Disposal to Ground

The 216-A-2 crib received about 20,700 gallons of waste organic solvent from the Purex plant during July, bringing the total of such material discharged to this crib to about 40,000 gallons. This represents about 7 percent of the soil volume immediately below the crib and above the water table. To obtain an approximation of the retention ability of soil for TBP, centrifuge experiments were performed using standard drainage methods. For the soil used, a specific retention capacity

of 7.8 percent (by weight) for TBP was determined, compared to a measured value of 13.3 percent for water. These absolute values are not considered particularly significant, but the relative retention of the organic compared with water is of interest. The ratio of these measured soil retention values agrees reasonably well with that predicted from the surface tensions of the two liquids.

WASTE TREATMENT

Fluid-Bed Waste Calciner Prototype

Operation of the prototype waste calciner has continued using the extended-tip feed nozzle and a feed of simulated high-acid Purex waste at a rate of 15 liters/hour. Five runs were completed during the month.

The first three runs were performed with a fluidizing gas distributor plate having smaller air distribution orifices than those in the plate used in the last two runs. The smaller holes during the first three runs resulted in an air velocity through the air distributor orifices of 670 feet/second compared to 110 feet/second during the last two runs. Contrary to the results expected (and to those obtained when calcining simulated ICPP wastes), the calcine particle size did not seem to be affected by the change in impingement velocity. Moreover, no effect of the change in impingement velocity on entrained fines in the calciner off-gases (three to five percent of the total calcine) could be detected.

An interesting sidelight to the variation in fluidizing air impingement velocity is that erosion, completely through some of the 1/16-inch thick caps, was observed at the completion of the first three runs. The majority of this erosion undoubtedly occurred during the eight hours of fluidization of garnet sand (at sonic impingement velocity) while cleaning scale off of the internal electric heaters. However, it does indicate that a relatively short operating life is possible for a bubble cap type of air distributor operating at relatively high impingement velocities.

Inspection of the calcine from runs using simulated Purex feeds indicates that the majority of the whole, single particles are in the - 35 to + 100 mesh size range. The + 35 mesh fractions are composed almost entirely of agglomerates of the smaller sizes; the - 100 mesh particles are primarily attrited particles of the + 100 mesh sizes. An increase in fluidizing gas velocity from 0.66 to 0.81 feet/second after one hour in one run was found to effect a slight reduction of 1.6 percent (from 8.7 percent) in the total agglomerated; however, a larger increase (approximately 5 percent) in attrited particles resulted from the increased fluidizing gas rate.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium Recovery

Hot Cell Operations - Two liter-scale hot cell runs have been completed with full-level Purex 1WW. These runs were designed to test (and better outline details of) the flowsheet which will be used in the Purex head-end equipment for isolation of a crude strontium product suitable for aging in the 244-CR vault and subsequent further purification at the Oak Ridge F3P plant, the Hanford High Level Radiochemistry Facility, and the Hanford Hot Semiworks. The runs also served to define the composition of the crude product, which is the feed material for the purification processes. The two runs were successful in demonstrating the operability of

the process with full-level waste and dispelled concern that radiolytic decomposition of reagents would be excessive. Decontamination factors from zirconium-niobium, ruthenium, and cerium were in very good agreement with earlier tracer-level experiments; however, overall strontium recoveries were lower than expected. Although strontium carrying on the initial sulfate precipitate was excellent, about one-third was lost in the acidic oxalate metathesis (which removes rare earths and lead), and there was further excessive loss in the basic oxalate or carbonate isolation steps. The best overall recovery seen was 50 percent. The recovered strontium contained no detectable barium, but the calcium to strontium ratio (on a mole basis) was 4:1. This concentration of calcium would limit capacity in the Hanford hot cell ion-exchange purification operation to about 8000 to 9000 curies of strontium-90 per run.

Strontium Purification - An ion-exchange process has been developed (though not yet tested with full-level feed) for purifying Purex-produced, aged strontium crude in the High Level Radiochemistry Cells. The process is very similar to the promethium purification process previously developed and can be applied in the same equipment. The crude, containing strontium, calcium, barium, lead, iron, and residual cerium and rare earths, is loaded onto a Dowex-50, X-12 column. The absorbed band is then eluted with pH 8.8, 0.015 M EDTA solution at 50 to 60 C through Dowex-50 columns in the mixed copper-hydrogen cycle. Laboratory studies show that the bulk of the strontium can be recovered better than 99 percent pure. Capacity of A-Cell with four-inch primary columns and two-inch secondary columns would range from 10,000 to 40,000 curies of strontium-90 per run (depending on the composition of the feed), the duration of a run being two to three weeks.

Three runs were made during the month in the A-Cell equipment to test the above process with a cold, synthetic feed. Although the process had worked perfectly in a series of experiments in laboratory-scale columns, the first two A-Cell runs had to be terminated because of plugging by a precipitate which formed in the columns. This perplexing difficulty was finally traced, after a similar precipitate began to form in the third run, to an insoluble acid form of the chelating agent. Its formation was caused by operating the solution degasser at too high a temperature, thus evolving ammonia and lowering the pH. As soon as the temperature was lowered, the precipitate began to dissolve, and the run is now proceeding smoothly.

Another ion-exchange process for strontium purification also shows much promise and is operationally very simple. This involves absorption of strontium (and its impurities) on a Dowex-50 column followed by sequential elution with buffered solutions of α-hydroxy-isobutyrate. Lead, cerium, and calcium are removed from the column with 0.8 M reagent at pH 4.8. The strontium is then eluted with 1.2 M reagent at pH 6, and barium is finally removed from the column with 6 M HNO_3. The strontium is obtained after passage of fewer column volumes of eluate (30 versus 100) than in the EDTA process and at higher concentration (8 gm/l versus 1.5). It is also potentially feasible to use only one column. The major disadvantage is the high cost of the reagent (ten cents/gram). An attempt will be made to substitute less expensive reagents for the α-hydroxy-isobutyrate since the cost of the latter would contribute about eleven cents/curie to the cost of purified strontium.

Strontium Shipment

It was reported last month that the synthetic inorganic alumino-silicate ion exchanger, Decalso, has a high capacity for strontium and that this affords a

potentially attractive method for off-site shipment. Since the crude strontium which will be produced in Purex will contain substantial amounts of cerium (about two percent of that in 1WW according to hot-cell tests), the behavior of cerium on Decalso has also been determined. Cerium and the other rare earths were found to absorb just as firmly as strontium. This implies that the 2.2 Mev cerium gamma will control the amount of strontium which can be shipped in an ORNL Shielded Transfer Tank ("STT"). Shielding calculations indicate that a cerium decontamination factor of at least a thousand may be required if normal radioactive shipment specifications must be adhered to in shipping strontium crude in STT's.

Because of the above limitation, experiments were performed with synthetic 244-CR rough cut to determine whether additional cerium decontamination could be obtained by adding "cold" cerium and precipitating cerium oxalate at pH 0.7. An additional decontamination factor of 5 was obtained for an overall process DF of about 250. This might conceivably be improved by repeating the precipitation but it appears very unlikely that an overall decontamination factor of 1000 could be obtained in plant equipment without the addition of several complicating steps.

Strontium Carbonate Filtration Studies

Consideration is being given to the possible off-site shipment of strontium-90 carbonate in the cask currently being procured for cerium shipment. Consequently, studies have been made in the 321 Building filter (a thirteenth segment of the proposed filter) to determine the "filterability" of the strontium carbonate slurry which might be produced at the Hot Semiworks. These preliminary studies have indicated:

(1) The slurry can be easily filtered if an equal amount of filter aid is added to the fine strontium carbonate precipitate. Although the filter aid dilutes the precipitate, approximately 250,000 curies can be loaded in a single cask.

(2) The filter aid strontium carbonate mixture can be partially dissolved with acetic acid and easily fluidized from the cask.

(3) Quantitative leaching of strontium carbonate in the filter proper would be time consuming. Time cycles would be shorter if the slurry were fluidized from the filter and leached in an agitated vessel.

Slurry Drying

A slurry of calcium carbonate (believed representative of strontium carbonate and similar fission product slurries in drying characteristics) in water was fed into an agitated pot at approximately 10 ml/min for more than an hour. The system performed well except for plugging of the vent line. Solids did not adhere to the pot wall or to the agitator. No lumps were found in the residual powder in the pot. Approximately 85 percent of the total solids were recovered. The other 15 percent were lost as dust in the off-gas stream.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Strontium Analytical Development

Development continued on analytical methods in support of the strontium recovery program. α-hydroxy-isobutyric acid elution from a Dowex-50 column followed by

flame photometry was found to be a satisfactory method for determining calcium and barium in strontium.

The excellent decontamination obtained with the above procedure suggested that it might serve as the basis for a rapid method for radiostrontium. In a single test, a sample previously run by the classical strontium nitrate carrier method was purified by α-hydroxy-isobutyrate cation exchange and counted. Agreement was within five percent of the standard method, and a gamma scan and a beta absorption curve showed no detectable radioactivity other than strontium-89 and strontium-90. The total time required for this analysis was less than two hours. Further development is planned.

EQUIPMENT AND MATERIALS

Z Plant Centrifuge Test

Vibration of the Bird 6 inch continuous centrifuge has been brought within satisfactory limits by mounting the machine firmly on a one-ton block of reinforced concrete. In a short process test the centrifuge was operated at 6000 RPM with a feed slurry of cerous oxalate (stand-in for plutonium oxalate) at a feed rate of 50 liters/hour. The liquid effluent contained 0.6 wt. percent solids (0.5 percent is the allowable maximum). The discharged solids contained 30 wt. percent liquid and were sticky.

234-5 Reclamation Facility Pulser

Three carbon-graphite piston pulsers were operated pulsing water in a test solvent extraction column, to study their feasibility for use as Reclamation Facility pulsers. Major results of the studies include the following:

(a) The "U-Column" pulser (piston with long shaft and upper pulse leg) is hydraulically and mechanically feasible and is recommended for the Facility pulsers;

(b) The "J-Column" pulser (piston with short shaft, no upper pulse leg, and graphite-ring rod seals) was also operated successfully. It is more compact than the U-pulser, but also less "fail safe;"

(c) High pulse efficiencies (column amplitude/piston stroke ratio) for both split-ring sealed and plug pistons were obtained; and

(d) Piston leakage for the split-ring piston was correlated with the orifice flow equation, where the liquid "head" is the mean pressure across the piston.

Hot Semiworks Strontium Recovery Program Pulsers

Piston pulsers for the HSW strontium recovery columns will be of the "U-Column" type, with a piston mechanically driven through a 30 foot long piston rod.

Purex HA Column Plastic Plate Testing

Samples of linear polyethylene from a spare Purex HA column plate were irradiated to 10^8 R in the presence of Purex HAX and then tested for stress cracking at

room temperature and at 50 C in a one percent solution of sodium lauryl sulfonate (Duponal). After 212 hours no cracks were apparent. The samples were mounted with one end fixed and the other displaced enough to impose a stress of approximately 4500 psi. At the end of the test the samples were found to have relaxed enough that the final stress was in the order of 1600 psi.

Griscom-Russel Tube-to-Tubesheet Joint

Huey corrosion tests were made on samples of a new type of tube-to-tubesheet joint developed by the Griscom Russel Company. This joint is made by welding the tube to a tubular stub milled from the tube sheet itself. Crevices are absent in a joint of this type. The samples tested had good corrosion resistance to boiling 65 percent nitric acid; average penetration rates were about 0.8 mil/mo during ca. 500 hours exposure. There did appear to be a slightly accelerated attack in the heat affected zone of the tubesheet.

NON-PRODUCTION FUELS REPROCESSING

NaK Handling and Fume Disposal

HW-66562, entitled "NPF Mechanical Cell NaK Disposal and Fume Abatement," is being issued. This document discusses the development of safe methods for deactivating the NaK reservoirs present in some of the fuels originally scheduled for Hanford reprocessing as a portion of the non-production fuels reprocessing program.

Feed Preparation

Zirflex Process - Development work on the Zirflex Process has been completed and document HW-65979, "The Zirflex Process Terminal Development Report," is being issued.

Dissolution of Zircaloy Cladding in Acidic Fluoride Solutions - Laboratory work on decladding Zircaloy-clad uranium dioxide fuels in acidic fluoride solutions has been concluded. A feasible decladding scheme was established. Corrosion tests indicate one of the experimental alloys produced at BMI (No. 20) would be satisfactory material of construction. A report covering the work on this procedure is in preparation.

UO_2 Leaching Studies - Nitric acid leaching of swaged UO_2 from chopped fuel rods was investigated this month on a laboratory and pilot plant scale. Stainless steel and Zircaloy-clad UO_2 rods 1/2 inch in diameter were used for the studies.

In laboratory studies, the difference in UO_2 dissolutions times for different length elements was determined. One, two, and three-inch long sections of swaged UO_2 rod clad with Zircaloy were leached with 6 M nitric acid at a HNO_3/U charge ratio of five. As expected, the UO_2 dissolved from the shorter elements more quickly. However, dissolution was complete in every case in less than one-half hour. This fast dissolution time is attributed to erosion of the UO_2 from the cladding resulting in high surface area exposure.

The pilot unit, recirculating, tubular dissolver was modified for the pilot plant leaching studies. A special dissolver sparge head was attached to the dissolver bottom and a canister for transferring chopped fuel from a shear to

the dissolver was constructed. The canister is designed to provide an air sparge outlet above the chopped bed and provide total containment of the chopped fuels during transfer to the dissolver. In operation, the conical sparge head pierces a brass sealer plate, as the canister is lowered into the dissolver, and seats in an air distributor cap in the canister. The torn brass plate will dissolve rapidly in the nitric acid dissolvent providing free flow access to the chopped fuel.

Two runs were made in the modified recirculating dissolver to demonstrate the operability of the dissolver canister. In these runs, one-inch long sections chopped from swaged UO_2 rods clad with stainless steel and Zircaloy were leached with 6 M nitric acid at a HNO_3/U ratio of five. The dissolver canister provided air flow above the bed as it was designed to do, but dissolvent flow could not be initiated through the four-foot packed beds until considerable dissolution had occurred. In spite of the fluid circulation trouble, the dissolution was complete in less than one and one-half hours, indicating that the nitric acid leaching of UO_2 is feasible. However, the difficulty in providing circulation through packed beds shows that the batch size will be limited by the packed bed height and not the total dissolver tube capacity.

Materials of Construction

Physical properties - tensile and yield strength, modulus of elasticity, proportional limit and percent elongation - were determined for four (No. 4, 11, 20, 21) of the experimental alloys prepared at BMI. The data are desired for use in design and in writing specifications for the material of construction to be used in the HAPO non-production fuels dissolver.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Pilot Plant Quantities of Electrolytic UO_2 - Production of electrolytic UO_2 from a starting material of $UO_2Cl_2.H_2O$ has been continued. Improvements in the sparger have been made and both chlorine and hydrogen chloride sparges have been equally effective in reducing oxygen to uranium ratios in the product. About 45 lbs. of UO_2 have been produced this month with a maximum batch size of 5 lbs. A composite analysis of the first 28 lbs. of product, produced by sparging for three hours at 710 C followed by electrolysis at 710 C, is 360 ppm chlorine, 1500 ppm carbon, and an oxygen to uranium ratio of 2.0397. The sodium content of those samples analyzed for sodium was about twice the chlorine content.

Sparging at 800 C followed by electrolysis at 710 C gave a composite oxygen to uranium ratio of 2.0115 for the next 18 lbs. of product. Product with oxygen to uranium ratios as low as 2.0049 was obtained. Exhaustive washing of the UO_2 with dilute HCl and water reduced the sodium impurities to 77 ppm. Chlorine and carbon analyses are not yet available. Carbon in the UO_2 may be due to corrosion of the electrodes by air at the liquid surface.

Screening of the UO_2 showed two peaks in the particle size distribution. The bulk of the UO_2 is made up of agglomerates larger than 14 mesh; however, there

is a secondary peak in the particle distribution curve at - 35 + 65 mesh which is composed of primary particles according to microscopic examination.

The single fused silica pot used for these electrolyses has survived 350 hours at operating temperatures with no apparent corrosion.

Hot Cell Installation - Construction of the hot cell equipment for salt cycle demonstration runs is essentially complete and cold uranium runs have been started. An oxidative removal of UO_2 from the cladding and dissolution of the resultant U_3O_8 have been successfully completed. Some difficulty was initially experienced with cracking of the Vycor melt containers which is believed to have been caused by a bonding layer of iron oxide sloughed off by dummy fuel element samples. Possibly the U_3O_8 would behave in a similar manner if not completely removed into solution and, hence, it may be good practice to thoroughly chlorinate the melt before allowing it to cool and solidify.

Production of Electrolytic UO_2 - Four additional one-pound lots of electrolytic UO_2 have been prepared under different operating conditions.

The previously described attack on the platinum cathode has been tentatively attributed to the depositing of the alkali metals on the cathode at the high cell voltage which developed during that run. The cause of the increase in cell resistance which resulted in the high voltage has not been determined.

Corrosion of the platinum-sheathed cathode has varied from 0.009 mg/hr,cm^2 to 0.69 mg/hr,cm^2 based on the area exposed to the melt. Chlorine attack at the salt-vapor interface is the chief form of attack.

Solubility of Chlorine in Molten KCl-NaCl - The solubility of chlorine gas in a molten equimolar mixture of KCl-NaCl was measured (with good reproducibility) to be as follows:

Temp., °C	g Cl_2/g KCl-NaCl	ppm
800	$(6.3 \pm 0.1) \times 10^{-5}$	63
700	$(5.3 \pm 0.1) \times 10^{-5}$	53

Effect of Adding TlCl to KCl-NaCl System - Previously it was shown that 50 mole percent and 25 mole percent of TlCl with KCl resulted in a very large increase in the rate of dissolution of UO_2 crystals by chlorine gas in the molten salt. It has been shown that a high rate of dissolution of UO_2 (325 - 100 mesh, O/U = 2.001) is likewise obtained with only 1.4 mole percent addition of TlCl.

Mole Percent				U Dissolved in
TlCl	KCl	NaCl	Temp., °C	30 Minutes, g
0	50	50	700	0.155
1.42	49.29	49.29	700	6.2

The presence of a small amount of TlCl not only increased the rate of dissolution by a factor of 40, but also increased the solubility of uranyl chloride in the melt to a remarkable extent and the resulting quaternary system appeared to have a melting point in the neighborhood of 400 C, some 250 C lower than the melting

point of the starting ternary salt system. Furthermore, after dissolving 14 g of UO_2 in 10 g of the salt (7.0 molal in uranium(VI)), UO_2 was still dissolving at a relatively high rate. This behavior provides additional support for the previously-stated supposition that thallous chloride acts as a catalyst in this reaction, Tl(I) being oxidized to Tl(III) by chlorine, and the Tl(III) acting as the dissolving agent for UO_2. Thallous chloride ionizes completely in molten chlorides and is a good source of chloride ions in such melts and this may be a factor also in the more rapid dissolution of UO_2 in the presence of TlCl.

Dissolution Rate of "Activated" U_3O_8 - Some UO_3 was ignited to U_3O_8 and half of this material was activated by two cycles of reduction with hydrogen at 650 C, followed by oxidation with air at 450 C, which produced a fluffy expanded U_3O_8 typical of a high surface-area oxide. Surprisingly, no appreciable increase was seen in the rate of dissolution of this high surface area U_3O_8 by chlorine in molten KCl-NaCl at 700 C.

Growth of Single Crystal of UO_2 - An attempt is being made to grow a single large crystal of UO_2 by electrolytic deposition from the KCl-NaCl system. Equipment has been obtained and assembled, but there has been no success in growing any large crystals either by deposition on a platinum electrode or by overgrowing on single crystals of arc melted UO_2.

Metallic Materials of Construction - Samples of Hastelloy A; Haynes alloys R-235, Multi-met, and Stellite #21; nickel; tungsten bronze; tantalum; tungsten; as-cast molybdenum; 60 nickel-40 tungsten; and BMI experimental alloys 23 and 24 were exposed to hydrogen chloride sparged equimolar sodium chloride-potassium chloride melt at 750-800 C for periods of about seven hours each. Of these alloys and metals, only tungsten and molybdenum had corrosion rates of 100 mils/mo or less. Of many materials tested in this environment to date, the only other material having corrosion rates in this range are Hastelloy B and platinum. A Hastelloy B electrode has been put in service in the 321 Building electrolysis equipment to determine corrosion rates under conditions more nearly simulating anticipated process conditions.

Non-Metallic Materials Testing - Screening studies are continuing in an effort to find non-metallic construction materials for the Salt Cycle process environment. A silicon nitride bonded silicon carbide crucible was tested in an equimolar sodium-potassium chloride solution at 650-700 C. The salt reacted with the crucible. The resulting salt mixture was black and solid at 700 C. The test was discontinued after 24 hours. No analysis was obtained on the resulting salt mixture.

Reprocessing PRTR Spike Fuel Elements

Further determinations of hydrogen evolution during dissolution of Al-Pu-Ni-Si-Fe alloys in HNO_3-$Hg(NO_3)_2$ solutions were made. Sufficient data are now available, showing hydrogen evolution as a function of nitric acid and aluminum nitrate concentration, to permit calculation of hydrogen in the off-gas versus time for a variety of fuel dissolution schemes. The data continue to support an earlier conclusion that hydrogen evolution increases markedly as the silicon content of the alloys increases from a few tenths to one percent.

Some additional runs were made to determine the attack of Zirflex decladding solutions on Al-Pu-Ni-Fe alloy core material. Data obtained show decreased attack on the core as the composition of the initial decladding solution was

increased from 2 M NH_4F - 0.17 M NH_4NO_3 to 6 M NH_4F - 0.5 M NH_4NO_3. Extrapolation of laboratory data to anticipated process conditions indicates that plutonium losses during decladding should not exceed one to two percent for any of the decladding solutions tried.

Continuous Ion Exchange Contactor Development

Adsorption Kinetics for Thorium Nitrate Complex - Further studies on the adsorption of thorium from nitric acid solution on to Permutit SK anion exchange resin were made. Rates of adsorption at room temperature from 5, 6 and 7 M nitric acid at a thorium concentration of 2.3 g/l and from 7 M nitric acid at thorium concentrations ranging from 0.2 to 12 g/l were determined. Data obtained continue to fit the theoretical model for adsorption proposed in the July report. Diffusion coefficients range from 7.2×10^{-9} to 14.4×10^{-9} for the nitric acid and thorium nitrate concentrations studied. The following equation which gives the distribution coefficient (K_D) as a function of resin loading was derived from theoretical considerations.

$$K_D = \frac{k(1 - 2x)^2}{(1 - x)}$$

where $x = \dfrac{\text{moles of thorium per unit weight of resin}}{\text{total exchange capacity of resin (equivalents per unit weight)}/2}$

k = a constant

The distribution coefficients found for the adsorption of thorium from seven molar nitric acid fit very well the curve described by this equation.

MABIE Contactor - Shakedown studies were completed in the prototype continuous MABIE contactor which is a six-inch-diameter by eleven-foot long, dual-purpose column with seven loading and three scrub stages and a six-inch diameter by twelve-foot long elution column with six stages. An aqueous flow rate of 280 gal/hr-sq.ft. was obtained in the adsorption column at an agitator speed of 530 rpm. The aqueous flow was limited by the power available to drive the agitator.

Sodium breakthrough runs indicated some aqueous channeling. Mixing efficiencies of 76 and 83 percent were obtained at aqueous flow rates of 115 and 225 gal/hr-sq.ft., respectively. The lower efficiency of the prototype contactor, as compared to the near perfect mixing obtained in the three-stage contactor, is attributed partly to the lower agitator speed (470 rpm vs. 670 rpm) and partly to agitator design and scale up.

Studies were made with both columns operating together to develop an effective method of minimizing the carryover of "slip water" with the resin from one column to the other and to control the inter-column resin flow rate. Carryover of excessive high-acid "slip water" from the adsorption column to the elution column would result in a high-acid product stream and would also lower the elution efficiency. A four-inch diameter by twelve-inch long "disengagement" pot was installed between the lower ends of the columns.

The resin slurry was then force-circulated from the adsorption column through the pot and back into the column. The relatively large diameter of the pot allows the resin to settle out so that it is possible to keep the pot packed with resin. A small flow of eluant solution is introduced into the pot near the bottom diluting

the high-acid slip water. By controlling the outflow of resin from the pot to the elution column with a control valve, the amount of acid carryover is kept to tolerable limits. A similar device is located at the top of the columns, except that no dilution stream is necessary. Initial studies show good performance both in limiting acid carryover and in controlling the resin flow.

Jiggler Contactor - Operation of the Jiggler Contactor was improved during the month. Installation of the three-foot long scrub section in place of the previous one-half-foot long section apparently was contributory in stabilizing operation of the "A" Column. The greater mass of resin and the greater distance between the scrub and feed entry points are characteristics of the longer section which tend to reduce turbulence and fluidization. Redesign of the resin cycle cone, which is an inverted hollow cone or essentially a funnel at the bottom of the "A" Column, also improved column operation. Prior to redesign, the entire cone wall from its base to the outlet pipe attached at the apex was made of screen. Now, the screen wall extends from the four-inch diameter base to a point where the cone diameter is three inches. The cone wall from the screen to the outlet pipe is solid metal. The solid wall permits better resin settling into the cone during the compression stroke of the pulser.

Three runs, ranging from 5 to about 11 hours in duration, were made with thorium-containing feed. The "A" Column liquid was pulsed at 6 cpm with a 0.5-inch displacement (50 ml) in the four-inch column. Permutit SK resin (30-50 mesh) was used. Aqueous stream temperature at the inlet was about 50 C. Waste losses ranged from 16 to about 57 percent. These high losses are attributed to improper aqueous downflow from the "C" Column resulting either from inefficiency in that column or downflow of a part of the product stream due to a malfunction of the flow control arrangement. To check the possibility, however, that the loss may be stemming from the adsorption column, a control experiment will be made on that column alone.

Steady state as manifested by about 3/4 psi drop across the semi-fluidized bed in the adsorption section and a constant resin level in the elution column is reached in 30 to 45 minutes after start-up from a dense resin bed.

RADIOACTIVE RESIDUE FIXATION

Mineral Reactions

Additional study was made on the equilibrium distribution of cesium on clinoptilolite; comparison was made of the adsorption on unirradiated mineral with that on mineral having received 10^9 R. The results support the premise that this level of irradiation would not produce measurable effects in silicate minerals such as clinoptilolite and do not agree with earlier findings in which an apparent irradiation effect was noted. Investigation disclosed that the effects probably resulted from a coincidental variation in solution composition between experiments.

The rate of adsorption of ruthenium(III) and cerium(III) from 0.01 M Na^+ solutions on shallow beds of iron filings was found to be higher at pH 5 and 8 than at pH 2 or 11. This may be correlative with the more rapid formation of ferric oxide in the pH range 4 - 9. The loading of adsorbed ruthenium and cerium on the bed was linear with time until the material of the bed began to deteriorate.

A clinoptilolite column experiment was performed with a mixture of actual (supernatant solution from 103-A tank) and synthetic Purex high level waste diluted 20:1 with water. For this waste the mineral displayed a cesium capacity of 29 bed volumes and a capacity at least this great for other radioisotopes except Ru^{106}. Decontamination factors of 7×10^7 for Cs^{137}, and 1×10^4 for Sr^{90} were obtained and all other radionuclides studied (alpha emitters, rare earths, Co^{60}) were decontaminated to concentrations below their drinking water MPC values.

Clinoptilolite column experiments were also performed with diluted (20:1) synthetic Purex 1WW formaldehyde-treated waste spiked with radiocesium and radiostrontium. Columns were 180 cm long and were operated at a flow rate of 50 gal/ft^2/hr. Capacities of 37 and 31 bed volumes for cesium and strontium, respectively, were obtained. Column kinetics were good, with decontamination factors of 10^7 being obtained during the first 29 bed volumes in the case of Cs^{137} and the first 19 bed volumes in the case of Sr^{90}. The bed loading reached 90 percent at 39 and 36 bed volumes, respectively.

Condensate Streams

A run was completed using standard Decalso, a synthetic alumino-silicate zeolite, for studying the decontamination of Purex Tank Farm condensate. At flow rates of 4 - 12 ml/min/cm^2 the cesium decontamination factor was about 1000 and that for strontium about 20. Ruthenium, cerium and zirconium-niobium radioisotopes were also removed but with lower decontamination factors. Analysis of Purex Tank Farm condensate indicated that about 120 gallons of organic per day can be expected in the condensate if the total condensate flow is about 20 gpm. Since this organic has a tendency to plug soil columns and foul mineral beds, the possibility of burning the organic was given some attention. Using a pot type burner with no auxiliary heat source (except to start the burning) a mixture of 30 volume percent TBP in hydrocarbon diluent was burned. Considerable black smoke was evolved. Unburned TBP and carbon were left in the pot when the burning stopped. Using an auxiliary propane burner to maintain elevated temperatures the mixture burned more completely, leaving a dry black residue equal to about 5 weight percent of the feed. Black smoke was evolved at the start, but white smoke (probably P_2O_5) was given off towards the end of the test.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Radioisotopes in Soils

In preparation for studies of the natural and induced radioisotopes in soils, silts, and muds, a counting technique was developed and is presently being calibrated with standard radioisotopes. Two-hundred gram soil samples are ground to pass a 105 micron sieve and then suspended in 150 ml of two percent agar to provide a uniform sample eight-inches in diameter. These samples are counted on a nine-inch diameter, four-inch thick detector using gamma spectrometric techniques. A further improvement in sensitivity and selectivity will be gained when two large crystals can be obtained for use as a summing spectrometer.

P^{32} in Reactor Effluent Water

In order to study the contribution of an n,p reaction on sulfur to form P^{32} in reactor effluent water, five times the normal amount of sulfate ion was added to

the cooling water of two single pass reactor tubes. The P^{32} activity of these tubes only increased 30 percent as a result of this addition. Although other factors may complicate the analysis, these results indicate that sulfur contributes only a small part of the P^{32} observed in reactor effluent water. Since these conclusions contradict conclusions drawn from other experiments, further studies are still needed to determine the source of the P^{32}.

Radiation Protection Studies

The protection indices of 11 more compounds of biological interest were evaluated this month by the dye-competition technique to help understand the effects of radiation-produced free radicals on living tissue. Two of the compounds were proteins and the protection indices of these proteins were found to be only one-seventh to one-eighth that predicted from the sum of the indices of their component amino acid residues. These observations are compatible with the picture of proteins as being coiled or folded such that many of the amino acids are physically protected by those on the outer surface. Confirming studies will be made on less coiled or folded proteins.

Geology and Hydrology

A recently-completed deep well drilled to basalt southeast of 200 East Area provided new information regarding the Cold Creek syncline in the upper basalt structure. The axis of this synclinal trough lies approximately two miles south of the separation areas, trending in a general east-west direction. The depth to which this basin has been downwarped is now known to be approximately 200 feet below sea level, nearly 100 feet deeper than earlier believed. The basalt encountered in the bottom of the syncline is unlike that encountered in other locations. The texture is more porphyritic, with phenocrysts up to one-quarter inch in diameter. These inclusions are predominately olivine with some zeolites.

For a flow system containing liquids of different densities, a derivation was made of an equation for determining the potential within the volume occupied by the heavy liquid in terms of the potential if the volume were occupied by the lighter liquid. From this it was possible to derive a partial differential equation to express the potential distribution in the system. A numerical solution of this equation was obtained to compare against experimental results and thus to test the validity of the initial derivation. If valid, the expression could describe the liquid flow that would be induced by the difference in density. Initial laboratory findings roughly approximated those predicted by the equation but better agreement is needed to assure valid application.

The steady flow pattern and moisture distribution below a crib was obtained from a solution of the equation for partially saturated flow in soils by means of a computer program. The analysis included the case of the small two-foot crib experiment performed near Gable Mountain in an effort to obtain experimental verification. For this case it was found that only about 25 percent of the liquid would be expected to move through the column of soil below the crib having the same cross-sectional dimensions as the crib. As this soil volume is commonly used as a conservative estimate of "field column volume" in calculations of crib capacity, a safety factor of about 4 is introduced according to these results. Larger factors would be introduced for less homogeneous soil systems. The moisture content distribution associated with the above flow distribution was also obtained. The results have not yet been compared with the measurements made in the field experiment but a qualitative similarity in the shape of the wetted volumes is obvious.

Ground Waste Investigations

The permeability of soil for synthetic Purex high-salt waste was measured to assist with estimates of the situation that might develop if a storage tank were to leak. A fine-grained Hanford soil was used and its permeability for the salt solution measured in a falling-head permeameter. The filtered solution had a permeability of 4×10^{-4} cc/sec/cm^2 which may be compared with 6×10^{-4} cc/sec/cm^2 measured earlier with filtered synthetic Redox salt-waste and a similar soil. For unfiltered waste the sludge collecting on the soil offers additional resistance to flow, the permeability of the sludge decreasing as it is compacted. The permeability of Purex sludge was 2.3×10^{-3} cc/sec/cm^2 after five hours and 5×10^{-4} cc/sec/cm^2 after 16 hours in the permeameter. This may be compared with similar values for Redox sludge which had a permeability of 1.3×10^{-4} cc/sec/cm^2 after two hours and 3×10^{-5} cc/sec/cm^2 after 20 hours. All of these permeabilities are reported for unit hydraulic gradient.

Soil Chemistry and Geochemistry

Solutions of cerium, promethium, and europium were equilibrated with soil accompanied by 0.5 **M** alkali and 0.25 **M** alkaline earth salts at selected values of pH. The solutions contained a "trace" ($< 10^{-11}$ **M**) or 4.2×10^{-9} **M** added rare earth traced with the radioactive isotope. Stable neodymium was used as a carrier for Pm^{147}. The experiments were designed to compare the reactions of various rare earth species with soils.

At pH < 3 the rare earths were ionic. Their adsorption by soil ranged from 1 to 48 percent of the added nuclide, depending upon the species of accompanying ion. The competition of accompanying ions with rare earths increased in the order:

$$Li < Na \leq Mg < Ca < Ba \leq Sr \leq K \leq Cs$$

The adsorption of cerium and europium was identical in all cases. There was evidence that promethium is more completely adsorbed in trace concentrations than are the other rare earths, but at 4.2×10^{-9} **M** no differences were evident; these findings substantiate the conclusion that under the conditions studied the rare earth species are in identical oxidation states.

Work continued on investigation of the mechanism of selective cation adsorption by "open zeolites," i.e., zeolites which can accept any of the alkali metals and alkaline earth metals series. The cation replacement series were determined for the zeolites clinoptilolite, erionite, mordenite, and chabazite. All were found to follow the same sequence, i.e.,:

$$Cs^+ \succ Rb^+ \succ K^+ \succ Na^+ \succ Li^+, \text{ and } Ba^{++} \succ Sr^{++} \succ Ca^{++} \succ Mg^{++}$$

However, significant differences in the degree of cation selectivity exhibited by each zeolite were found. The similarity in replacement order in these different minerals suggested that some general property of the cations is operative, such as hydration in aqueous solution.

Research in which cation exchanges with mordenite and clinoptilolite in fused salts were measured gave the same sequence for these ions, ruling out ionic hydration as an explanation of the selectivity mechanism. When the temperature of these fused salt systems were raised enough to effectively dehydrate the zeolite

crystal lattice (460 C), the adsorption sequence appeared to be reversed, following a normal coulombic series. In these molten salt experiments the relative positions of Cs^+ and Li^+ were obtained to establish the sequence. The results are interpreted to mean that the water normally associated with the zeolite lattice is mainly responsible for the observed sequence from aqueous systems. The position of this lattice water relative to the path along which the exchanging cations diffuse may explain the differences in the degree of selectivity between the zeolites. This implies that cation selectivity is a function of cation diffusion rate, suggesting a method of further studying the mechanism.

Field Apparatus Development

A method of shaped charge perforating of light gage "Kai-Well" casing was demonstrated. To prevent fracturing of the casing a sleeve of six inch pipe is placed over the charge carrier, permitting much of the shaped charge energy to be dissipated, yet still passing enough energy from the charge to cleanly perforate the well casing. This development will permit "Kai-Well" casing to be used with attendant decrease in well cost.

Further tests of a detector of vertical flow in wells showed that vertical flow of 30 to 50 cc per minute exists in the well examined. The inherent sensitivity of the instrument requires great care in handling.

Micromeritics

Particle deposition velocities in conduits are found to be proportional to the diameter raised to the 0.84 power. A qualitative explanation of the diameter dependence was found in turbulence theory which postulates that the eddy diffusivity at the center of a duct should be proportional to Reynold's number at a constant velocity. This is essentially the same as stating that turbulence scale should be proportional to the conduit diameter for a given velocity. The higher centerline diffusivity as the conduit diameter is increased will result in more particles being brought near the wall. The potential for impacting through the laminar layer thus becomes greater giving rise to higher deposition velocities.

Additional tests and improvements on the moving wall elutriator gave further promise that the device would prove effective in separating particles into narrow size ranges. Fractionation of glass spheres 45 μ and smaller into three size ranges was accomplished without difficulty.

W. H. Reas

Acting Manager
Chemical Research and Development

WH Reas:cf

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

No significant changes occurred during August.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

Concentrations of I^{131} in the thyroid glands of jackrabbits were approximately three times greater than those observed one year ago. Values follow:

Location	μc/g Wet Thyroid Average	μc/g Wet Thyroid Maximum	Trend Factor
4 mi SW Redox	8×10^{-4}	2×10^{-3}	--
Prosser Barricade	3×10^{-4}	5×10^{-4}	-2
Wahluke Slope	1×10^{-4}	3×10^{-4}	-3

Columbia River Contamination

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

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

Fallout Contamination

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

Sample Type	Total Beta Average μc/g Wet Material	Trend Factor
Bone	8×10^{-5}	+4
Feces	2×10^{-5}	+4
Liver	2×10^{-5}	+4
Muscle	2×10^{-5}	+3

* Correction for July Monthly Report: Concentrations of gross beta emitters in Columbia River organisms collected at Hanford were reported approximately nine times greater than those observed one year ago. This should read . . . four and one-half times greater.

Effect of Reactor Effluent on Aquatic Organisms

Studies on the toxicity of reactor effluent were suspended while modifications of laboratory equipment are pending.

Small fish, 1-1 1/2" in length, were seined from a slough area below 100-H Area and also from the Yakima River. Examination of these fish revealed that about 25 per cent of those taken from the 100-H Area were infected with columnaris and furthermore, of some 8 fish returned to the laboratory and held in troughs for an additional four days, 7 became infected with the disease. No columnaris was recovered from fish taken from the Yakima River.

Chinook fingerling salmon which survived a previous test in which they were exposed to columnaris organisms, were examined a couple of weeks after and found to contain no columnaris organisms. From the same test, all of the fish which had died had shown positive test for this Myxobacterium.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Phosphorus

Approximately 20 pairs of tropical fish of the cichlid family have been selected for a toxicity test which will involve administration of P^{32} with food and which seeks to establish the body burdens at which spawning success is affected. Selection of pairs has been based on at least one successful spawning. Previous difficulties encountered in rearing the young cichlids have largely been overcome.

The feasibility of using a three-probe scintillation counter to monitor the Bremsstrahlung from P^{32} in mice was investigated. Studies with phantom sources showed the measurements to be nearly independent of mouse size. Similar studies are being made with live mice (P^{32} administered by intraperitoneal injection and stomach tube) to determine the effect of source distribution and size on whole body measurements.

Zinc

The relative uptake of radiozinc in three ewes and their full-term fetuses was investigated. The dams' tissues contained concentrations 3 - 6 times greater than in corresponding fetal tissues. It was noted that the liver and kidney cortex in the fetuses did not contain the high concentrations of Zn^{65} relative to the other tissues observed for ewes and rams.

Strontium

Oral administration of Sr^{90}-Y^{90} to rainbow trout at the rate of 0.5 μc/g of body weight per day for 21 weeks was lethal. The few fish which survived the complete course of the feeding died or were sacrificed near death during the first month post-administration. Leukopenia was evident and there was some indication of increased values for hematocrit, hemoglobin, and red blood count. Histopathological studies are under way.

A new group of trout is being acclimated to laboratory conditions in preparation for studies on the rate of assimilation and movement of Sr^{90} spiked pellets through the GI tract. Progress was also made in developing surgical techniques to permit the collection of urine from trout held in a metabolism tube.

No outstanding bone changes were revealed by X-ray plates of 56 miniature swine on the chronic toxicity of Sr^{90} study. Several minor changes were observed, however, and are being followed for possible significance. To date, six sows (2 from the medium [5 μc/day] level and 4 from the low [1 μc/day] level) have farrowed second generation pigs. All baby pigs appear normal.

The in vitro study on the comparative binding of calcium and strontium by plasma proteins was completed. Ca^{45} and Sr^{90} were found to be bound equally and binding was independent of enrichment of plasma calcium with $CaCl_2$. These results were unexpected and warrant further investigation. Three ewes were therefore started on a study to determine the effect of dietary level of calcium on the comparative binding of strontium and calcium in plasma.

Iodine

No important changes were observed in any of our iodine studies with sheep or swine during this month. The ratio of radioiodine in the thyroid to the quantity fed daily of the experimental sheep showed a general increase during August due to weaning of lambs.

Cesium

Effect of moisture stress on the uptake of Cs^{137} and potassium was studied in bean plants using sodium chloride as an agent to increase osmotic pressure in the solution in which bean plants were grown. Osmotic pressures of 4 and 8 atmospheres above that normally present in the nutrient solution were studied and compared with plants grown in normal nutrient.

Increasing the osmotic pressure in the nutrient solution increased the potassium content of leaves but decreased potassium content of stems. Some depletion of Cs^{137} was noted in stems but no effect of Cs^{137} content was observed of leaves.

These data are interpreted here as being due to osmotic pressure. They could also be interpreted as due to the sodium chloride and associated direct ion effects. It does appear, however, that once again there is a distinct difference in the pattern of movement of potassium and cesium within the plant.

Neptunium

Data for the first seven days of the 21-day retention experiment show the excretion of Np^{237} to be divided nearly equally between urine and feces following intravenous injection of the citrate complex. By the seventh day post-injection, the femur has replaced the liver as the organ containing the highest concentration of Np^{237}.

Plutonium

Following scrubbing of a $PuNO_3$-contaminated dermal cut in a rat, removal of the two-day scab removes all the remaining plutonium that is detectable with an alpha particle monitor - "Peppy".

Twenty-four intradermal injections of plutonium nitrate in doses varying from 0.0016 μc to 5 μc per site were made in a white miniature pig. This makes a total of four pigs injected intradermally with plutonium nitrate solution. All animals will continue to be monitored with a new scintillation probe built by Instrument Development in 300 Area. Two more white miniature pigs will be injected next month and all pigs will be kept for their lifetime to determine the effect of Pu^{239} injected into the skin of pigs.

Radioactive Particles

The extremely stable nature of plutonium dioxide deposited in dogs by inhalation was demonstrated. Immediately after a 15 minute exposure, about 1.6 per cent of the total dose was found in all tissues, excluding the sites of deposition and the respiratory and gastrointestinal tracts. This represents the fraction rapidly translocated from the sites of deposition, probably following solubilization. During the first 40 weeks following the exposure, 1.6 per cent of the total dose was excreted in urine and only 0.4 per cent more was found in all tissues, except lung and associated lymph nodes. Although not conclusive, further data suggest that plutonium excretion in urine is more closely related to the total amount of plutonium deposited than to the lung-lymph node burden. Other data are being examined to evaluate this possibility.

The initial results of a breeding program to provide healthy animals for inhalation studies are 18 beagle puppies.

Dog and rat exposures to cerium oxide, neptunium dust, and plutonium nitrate are planned for the next month.

Gastrointestinal Irradiation Injury

An experiment was initiated to determine intestinal absorption of I^{131}-labeled oleic acid and polyvinylpyrrolidone (PVP) after X-irradiation of that organ. The fatty acid is commonly used as a diagnostic tool for mal-absorption studies in humans, and PVP has been shown by us to be of diagnostic value for intestinal injury from radiation. Both of these agents were injected directly into the duodenum and measured after three hours in the plasma and 24 hours in the excreta. Results are not yet available.

An experiment was conducted to study the effect of bile fistula on PVP excretion. Results showed that biliary flow has, to a large degree, an influence on the diarrhea which is associated with gastrointestinal irradiation injury. It also promotes the excretion of PVP by a flushing action on intestinal contents.

Microbiological Studies

Additional experiments using U^{238} and cysteine with X-rays can be interpreted as indicating that potassium and phosphate are leaked from yeast cells through separate systems. Furthermore, it appears that there is a correlation between cysteine protection of viability and of retentivity. This correlation was observed in both haploid and diploid yeasts.

Project Chariot

Limnological and terrestrial invertebrate field studies are continuing at the Project Chariot site by three senior scientists and one assistant.

BIOLOGY OPERATION

HA Kornberg:es

C. Lectures

a. Papers Presented at Meetings

L. K. Bustad, "Miniature Swine in Radiobiological Research," AVMA Convention, Denver, Colorado, August 16, 1960.

L. K. Bustad, "Biological Effects of Sr^{90} in Miniature Swine," (written by W. J. Clarke," AVMA, Am. College of Vet. Toxicologists, Denver, Colorado, August 14, 1960.

b. Off-Site Seminars

R. F. Foster, "Radionuclides in Foods - Fresh Water Studies," U. S. Public Health Service Training Program, Cincinnati, Ohio, August 30, 1960.

c. Seminars (Biology)

None

d. Seminars (other than Biology)

University of Washington Summer Institute in Radiation Biology - Richland

R. C. Thompson, "Problems of internal emitters," August 9, 1960

J. E. Ballou, "Zn-65 Metabolism", August 9, 1960

D. G. Watson, "Isotope Transfer through Food Chains," August 9, 1960

M. F. Sullivan, "Gut Irradiation," August 10, 1960

L. A. George, "Skin Irradiation," August 10, 1960

N. L. Dockum, "Autoradiography," August 10, 1960

W. J. Bair, "Problems of Particle Inhalation," August 10, 1960

L. K. Bustad, "Large Animal Research," August 10, 1960.

AEC Radiological Physics Fellowship Program - Richland

W. J. Bair, "Inhalation of Radioactive Particles," August 15, 1960

L. A. George, "Mechanisms of Chemical Protection," August 15, 1960

Voc. Agric. Teachers Conference - Richland

L. K. Bustad, "Radiobiology Research at Hanford," August 22, 1960

D. Publications

a. HW Publications

W. J. Clarke and J. A. McKenney, "Biological Effects of Sr^{90} in Miniature Swine. Part I. Experimental Designs and Preliminary Observations," HW 66499 (UNCLASSIFIED) January 12, 1960.

b. Open Literature

F. E. Hungate and R. L. Uhler, "Relative availability of some Sr^{90} Compounds in Soil," Nature 187, p. 252-253, July 16, 1960.

[redacted]

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - AUGUST, 1960

ORGANIZATION AND PERSONNEL

There were no changes in personnel during the month of August.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Simulation Model

A simplified HAPO model is being studied. Basic data have been brought up to date and converted to a proper form for study.

Business Systems Studies

A meeting of the Plant Improvement Task Force was attended on August 24. Efforts of this committee are directed toward improving the approach used in 1959, and the different submittals of last year are being reviewed.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

Further work in this area is awaiting completion of the IBM processing of available data. These data are expected by late September or early October.

Fuel Element Failures

An analysis was made of rupture data from the control fuel elements in the run-to-rupture test evaluating bumper fuel elements. The exposures which must be reached by the test fuel elements without rupture before specified levels of significance are demonstrated were determined. A comparison was also made between the controls in this test and those used in the recently completed test evaluating the self-support concept.

In the normal run-to-rupture test, k ruptures are taken in n tubes, and the remaining tubes are discharged without rupture at the exposure level of the k^{th} rupture. For this situation, the estimate of the parameter of interest in the rupture model is available from previous work. On occasion, some or all of the remaining (n-k) tubes are discharged without rupture at exposures other than that of the k^{th} rupture. A revised estimate of the parameter has been determined for this situation.

Optimization of Reactor Operations

A report was issued presenting the results of the study to determine a supplemental crew size optimum with respect to total cost, including the cost of maintaining a supplemental crew of given size, expected overtime costs, and expected costs due to increased reactor outages when the crew size is smaller than required. The expressions given in this report were programmed for IBM calculation of a number of cases of interest.

[redacted]

[redacted]

Process Tube Leaks

Data are still being processed in order to test the adequacy of the mathematical model describing internal tube corrosion developed during July. In addition, consultations were held with personnel from F reactor regarding process tube leaks due to external corrosion.

Z Plant Information Study

The basic systems logic diagrams (programming structure) for the process control computer have been completed. These diagrams were reviewed and discussed with interested Z Plant personnel to determine whether or not major conflict with operating policy and procedure exists and to demonstrate the progress of the study.

Approximately 60 per cent of the detailed programming diagrams based on the above logic diagrams have been completed. These will no doubt be subject to change as the production line operation is put through its initial "shakedown" phases.

Reliability Studies

Further work has been performed on the problem of giving mathematical and probabilistic expressions for reliability of a control system. The derivation of the time-dependent probability law for simultaneous failures of any fixed number of devices out of a given number of identical independent devices has been completed. An asymptotic expression which is much simpler, for computational purposes, than the exact expression has been proven correct.

Work was initiated on the problem of designing a testing program to determine reliability parameters of panellit gage switches.

Work was begun on the derivation of a mathematical expression for a DC output curve as a function of count rate in a count rate circuit with dead time.

Inventory Studies

Some assistance was given in setting up a sampling procedure for the general supplies inventory to be taken in October. The procedure will use a combination of unit cost and line item value categories.

Redox Dissolver Study

Work continued on the formulation of a kinetic mechanism for the dissolution of uranium in nitric acid. The system appears to be amenable to mathematical solution under steady state conditions, although attempts to solve the system have not yet been satisfactory. The set of simultaneous equations expressing the semi-empirical model of the dissolver process that is compatible with available data have been solved; however, the particular form of the solution makes estimation of the model parameters impractical. Current effort is directed toward expressing the solution in a more tractable form with respect to parameter estimation.

[redacted]

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Total bond count data, indicative of porosity in the braze layer, were analyzed from a test conducted in the pilot plant to determine the effect of increased air pressures to the vibrators on porosity.

Comments were submitted upon request to personnel interested in setting up a data collection system for NPR fuel elements. It was pointed out that the mere collection of data in itself cannot answer pertinent questions about the process, and that provisions for data analysis must be included in any system. The need for reliable data was also stressed.

Data were analyzed from a pilot plant test designed to investigate the effect of variations in AlSi content within the duplex furnace on bond quality.

Welding tests were conducted to determine the effects of six welding variables on fuel element quality as measured by porosity and cracking characteristics.

Irradiation Processing Department

Assistance was given in the design of a test procedure to evaluate aluminum components from different vendors. The original test design permitted evaluation of only one alternate vendor at a time, and this has been revised so that any number of vendors may enter the evaluation program at any time.

Further work is being done in connection with the development of a model to describe uniform corrosion in the I and E fuel element, especially for fuel elements at high specific powers.

Mathematical assistance was given on the subject of linear programming and related techniques.

Further analytical work was done on the "net return" economic model. It is felt that certain important questions concerning this model have now been satisfactorily answered.

Chemical Processing Department

The final draft of the proposal to adopt part-by-part acceptance of fabricated parts is being prepared.

An analysis was made of the measured radiation exposure using pocket, wrist, and ring badges to estimate the effects on measured exposure of physical location and type of film packet.

At the request of personnel of the 234-5 Development Operation, a discussion was held to acquaint them with the services provided by this group, and to lay the groundwork for a possible series of meetings to consider more specifically how statistical principles of experimental design might be useful in connection with their development work.

Investigation continued on the mathematical processes involved in describing contours and on methods of mechanically and electronically interpreting these data so as to adequately guide existing lathes while reproducing these forms.

Relations Operation

Some assistance was given in a comparison of HAPO and Company salaries.

Construction Engineering & Utilities

Study of recent cost estimate data has been made to see how well previously estimated curves fit the data. In general, bids below $100,000 tend to exceed the range predicted by the fair cost estimate.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

3000 Program

Corrosion Studies

Further statistical analysis was done on an Al-Ni-Fe alloy corrosion experiment in light of additional data which extended the autoclave exposure time by a factor of two. Estimates were provided of the effects of heat treating time, heat treating temperature, and method of cooling on the corrosion rate of the aluminum samples as a function of time in a stream autoclave atmosphere. Additional work is being done with data from this experiment to further substantiate the aluminum corrosion parabolic-linear theory and to estimate the individual sample induction times.

Chemical Development

A combinatorial problem which recently arose in connection with a mathematical model for the diffusion of thorium ions into resin balls was solved. Specifically, a counting function was derived which expresses the number of ways K thorium-nitrate complexes, each possessing two negative charges, can unite with N resin molecules, each with one positive charge, if the resin molecules are arranged in a one dimension linear lattice. Current effort is directed toward generalizing the solution to higher dimensional lattices.

Fuels Development

The investigation of the mathematical theory of the metallurgically-idealized continuously dislocated crystal continued.

4000 Program

Swelling Studies

Mathematical and statistical development in connection with the reading and evaluation of electron micrographs of cross sectioned irradiated uranium specimens is practically complete and a rough draft final report of this work and several related empirical studies is being compiled.

[redacted]

[redacted]

Nondestructive Testing

Several meetings were held on possible methods of mathematically representing and interpreting the response signals received by nondestructive fuel element testing devices.

6000 Program

Biology

An application of the multicompartment migration model is being made using data from a rat experiment involving a single administration with W^{185}.

An analysis of data pertaining to the strontium-90 content of bones is currently underway.

Solutions were obtained to two geometrical problems concerned with the interpretation and corrections of data obtained by X-ray diffraction.

General

The six-day pilot work sampling study of the Analytical Laboratories weekly salaried personnel has been completed and is currently being analyzed. The results of the study will help guide the scheduling and conduction of the full scale study scheduled for early fall.

Analysis continued of data from high energy anti-coincident gas sample counting instruments to devise a good method of estimating background counting rate. The data dimension revision of the GCL IBM program has been completed and the new program is being used in the data analysis.

Routine statistical consulting was provided in connection with the evaluation of mass spectroscopy data.

MISCELLANEOUS

The operational characteristics of several alternatives to the current HAPO safety award plan were investigated.

Complete analytical solutions were obtained to two Fredholm integral equations which arose in the statistical theory of void distributions.

Contacts were again made with Chemical Processing Department managers soliciting candidates for the GE Computer Department training program at HAPO. Twelve persons have now been designated to attend the one week training session.

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:mw

[redacted]

[redacted]

12-7-74

PROGRAMMING OPERATION
AUGUST 1960

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. Modifications were made in the Monte Carlo routines for computing distances to region boundaries, for terminating expectation beams, and for displacement of particles across boundaries. The initial value acceleration routine in the Post Monte Carlo was removed, and an alternative method was formulated which provides that the relative mean sample variances approximate more closely the reciprocals of the importances even for a distorted initial distribution. The final section of the input code was mostly debugged, and a more complex problem was set up for testing the entire system.

The spectrum computation method described last month was incorporated in a FORTRAN cross-section averaging code which will be used to re-evaluate Westcott g and s factors. A revised treatment of resonance self-shielding was formulated. This method takes account of the resonance level structure of the different isotopes in a more detailed fashion than the previous method.

Fuel Cycle Analysis. The Meleager computations of batch recycle cases for the Advanced Pressurized Water Reactor were completed. A total of eight to nine cycles were required to reach the quasi-steady-state condition (all isotopes except Pu-242 in equilibrium). Since the physics analysis methods used are subject to error at high values of thermal utilization (f) and epithermal ratio (r) the cases involving very high plutonium enrichment levels are considered less reliable than the others. They were fortunately not important for the economics analysis in any case.

Other Activities

A preliminary study was made to determine the effects on the Plutonium Recycle Program of operating the PRTR with plutonium-only fuel. Operation of the PRTR as currently planned makes use of the Doppler effect in U-238 to obtain a negative temperature coefficient in the fuel, thereby achieving inherent control in the event of a power excursion. If no U-238 is present in the PRTR loading, as would be the case with a plutonium-only loading then some other means must be provided to control the magnitude of power excursions that may occur. This can be accomplished by alloying plutonium with a material that will give a negative temperature coefficient in the fuel and/or modifying the PRTR design. Modification to the PRTR would involve, as a minimum, provision of a fast-acting safety rod system. Other changes may be necessary as determined by a thorough re-evaluation of the PRTR design and reviews by the Reactor Hazards Branch of the AEC and the Advisory Committee on Reactor Safeguards.

The magnitude of the effects on the Plutonium Recycle Program of loading the PRTR with plutonium-only fuel will be dependent upon when this is to be accomplished. If the reactor is to start up with a plutonium-only loading then costs and delays will be greater than if such a loading is to be "phased in" as soon as reasonably practical after startup. A preliminary report was prepared and circulated for comment.

Plutonium Metallurgy Operation plans to measure reactivity as a function of exposure on Pu-Al fuel capsules irradiated in the MTR. Capsules are to contain "low" plutonium (5.5% Pu-240) and high exposure plutonium (13.1% Pu-240 and 28.9% Pu-240). Lifetimes of these capsules, based on heat generation, were calculated using the Meleager Code. Lifetimes relative to "low" plutonium were calculated to be 1.05 for the 13.1% 240 plutonium and 1.25 for the 28.9% 240 plutonium.

With information which was expected momentarily on the silicon content of representative and acceptable alloys, the materials standard for Mark I Pu-Al spike PRTR fuel elements was ready for issuance. This standard not only covers the quality of the aluminum base material particularly with respect to silicon content, but also establishes the range for the content of fissionable plutonium for each assembly. The latter requirement is of particular importance in the preparation of fuel containing plutonium of varying Pu-240 and Pu-242 content. However, the nickel content required is specified on the basis of total plutonium in order to assure alloy of suitable corrosion resistance.

The study of the economic features of close-coupled chemical processes for reactor fuels continues. So far the study indicates that the economics of a single reactor, close-coupled process are not attractive, however, by depending on other reactors the picture is definitely improved. In addition economic throw-away fuel cycles do not appear to be attainable. As long as fuel contains plutonium even high in non-fissionable isotopes (40+%) the residual Pu-239 and Pu-241 has significant value as a fuel and probably will justify recovery, especially in multi-purpose fuel processing plants. This is even more certain for the fuels which include uranium of only very slight enrichment.

Activities in support of PRTR startup included review and analysis of process specifications, operating procedures, and power tests. Startup Council has now approved 40 of the 45 process specifications and 58 of the planned 92 operating procedures.

The Plutonium Recycle Program Annual Report was submitted to Technical Publications for issuance.

2. SPECIFIC FUEL CYCLE ANALYSIS

Calculations of the apparent plutonium value in the Advanced Pressurized Water Reactor have been completed for the most timely ranges of the economic variables. Two methods of fueling the reactor were examined in order to reduce the number

of unknowns and permit an analytical solution for the value of the different plutonium batches. One case approaches self-sustaining recycle by successively charging the reactor with the plutonium available from the previous cycle and the balance of reactivity is made up with enriched uranium. In the other, self-sustaining plutonium recycle is not approached as the reactor is operated successively by plutonium enrichment of cascade tails by using any amount of plutonium required but of the same composition as the plutonium discharged from the previous cycle. Batch irradiation was used to conform with the intent of the APWR designers although checks are being made as to the value of plutonium if graded discharge is used for this reactor. Generally speaking, the higher the initial enrichment (initial k_∞) of a batch cycle the longer the exposure and the lower the fuel cost over a wide range of enrichments. However, variations in reactivity during a batch irradiation must be handled by control rods and/or burnable poisons.

The capital involved in various strength control systems and flux peaking problems with burnable poisons make it difficult to determine their dollar costs which should be done as part of the fuel cost for each value of initial k_∞. To avoid this evaluation, plutonium value analyses are performed for initial k_∞ values of 1.08, 1.116, 1.17 and 1.25 with no burnable poison present. A selection of the most plausible initial k_∞ value was then made. In the self-sustaining plutonium recycle example wherein enriched uranium is used in conjunction with the self-generated plutonium, there is an initial k_∞ value at which the fuel cost is a minimum due to the progressively higher cost per gram of U-235 as the U-235 enrichment level is increased. In the other studies wherein unlimited quantities of plutonium of various compositions are available, no minimum exists from 1.08 to 1.25 initial k_∞. This is a characteristic of plutonium as no separative duty is involved when altering its enrichment in U-238. However, the fuel cost declines very slowly after an initial drop while fuel exposure values exceed demonstrated practice by significant amounts. For these reasons, it appears that the data that the most plausible plutonium values from this study would be at an initial k_∞ of 1.17. The comparable number used in the APWR design report was 1.116.

The plutonium value analysis was made from a fuel cost relationship developed with Meleager physics data and a simplified fuel cost computation. The essence of the analysis is the development of a set of equations which involve the unknown batch value of the plutonium feeding a reactor, the unknown batch value of the plutonium ashes leaving the reactor, and the fuel cost. The feed and ash batch values are generally different. The value of a batch leaving the reactor is conditionally determined by using that batch as feed for the next cycle and so on. This is repeated until some logical constraint can be applied to the value of the last batch of ashes produced which removes the necessity of further cycles.

Tables 1 and 2 indicate the plutonium batch value in $/gram fissile for plutonium batch compositions corresponding to selected total exposure figures. Except for the 2 and 3 x 10^{-4} MWD/T compositions there are no points between the two modes where the same plutonium compositions are measured. For the matched plutonium compositions (2 and 3 x 10^{-4} MWD/T cumulative exposure) the recycle mode (uranium enriched - Table 2) yields a lower plutonium value ($12.25 and 12.90/gram fissile) than the plutonium enriched mode (Table 1) $15.65 and $16.10/gram fissile. The whys and wherefores of this difference involves several interrelated factors, some of which can be elucidated in further analysis of the data.

The uranium enriched or self-sustaining mode summarized on Table 2 nears equilibrium very early for Pu-239, Pu-240, and Pu-241 which is reflected in the slow decrease in the fissile value as exposure proceeds. This decrease is clearly due to Pu-242 and further analysis should permit establishing a weighting factor for Pu-242 for this mode. The higher plutonium values achieved with the plutonium enriched mode do not hold up as prolonged exposure occurs as shown in Table 1. The large relative increase in Pu-240 and Pu-242 in this case accounts for the difference. The relative importance of Pu-242 and Pu-240 will be shown with further analysis. In this case, the physics model (Meleager) is currently uncertain with the plutonium composition encountered above 100,000 MWD/T cumulative exposure. If the numbers are legitimate, it would appear that the material should be sent to fast breeders or other special applications when the cumulative exposure is above 50,000 MWD/T. If this were done, it would change the value of the plutonium produced in the first 50,000 MWD/T and hence optimization with the fast breeder is of considerable importance.

TABLE 1

Calculated Pu Values for the Plutonium Enrichment Series with an Initial Reactivity of 1.17

Exposure MWD/T x 10^{-4}	Isotopic Concentrations*				Value $/gram Fissile
	R_{39}	R_{40}	R_{41}	R_{42}	
1	0.820	0.145	0.070	0.0	12.50
2	0.710	0.185	0.120	0.050	15.65
3	0.625	0.220	0.155	0.070	16.10
4	0.565	0.250	0.185	0.095	15.90
5	0.520	0.275	0.205	0.135	15.55
7.5	0.450	0.320	0.230	0.235	13.40
10	0.405	0.370	0.239	0.355	11.70
12.5	0.380	0.385	0.230	0.460	10.40

*The R value for a plutonium isotope is the ratio of its concentration to the total batch concentration excluding Pu-242.

The plutonium values in Tables 1 and 2 are for no incremental plutonium handling costs and while the numbers are conservative from some viewpoints, they require further study to fully qualify the results. Full investigation of the parameters involved will be done as soon as the economic code used for this study is completely programmed for the IBM-709 - sometime next month.

TABLE 2

Calculated Pu Values for the Uranium Enrichment Series with an Initial Reactivity of 1.17

Exposure MWD/T x 10^{-4}	Isotopic Concentrations* R_{39}	R_{40}	R_{41}	R_{42}	Value $/gm Fissile
1	0.740	0.135	0.045	0.025	11.40
2	0.695	0.176	0.105	0.050	12.25
3	0.665	0.195	0.140	0.075	12.90
4	0.640	0.205	0.155	0.100	13.40
5	0.628	0.207	0.165	0.120	13.55
6	0.622	0.208	0.170	0.142	13.40
7	0.618	0.208	0.175	0.160	13.15
8	0.615	0.208	0.177	0.177	12.80
9	0.615	0.208	0.177	0.190	12.50
10	0.613	0.207	0.180	0.225	12.25
12.5	0.613	0.207	0.180	0.245	11.85

Note: This cycle approaches self-sustaining plutonium recycle equilibrium.

*The R value for a plutonium isotope is the ratio of its concentration to the total batch concentration excluding Pu-242.

B. OTHER ACTIVITIES

The Plant Improvement Program Task Force was reconvened for the purpose of issuing a revised version of the Plant Improvement Report. The format and contents of the report are currently being examined to determine where changes are necessary.

A program proposal in the field of fast breeder reactor development was prepared and distributed to other HLO components for comment.

Arrangements were completed with the University of Washington Center for Graduate Study to conduct a course in electronics, as requested by several Hanford personnel.

Assistance was rendered in arranging eight tours involving 88 persons through HLO and HAPO facilities. Of special interest were visits by J. A. McCone, Atomic Energy Commission Chairman, and the other Commissioners; C. H. Linder, General Electric Vice President; and E. J. Bloch, AEC Assistant General Manager for Manufacturing.

Chas A Rohrmann
for Manager, Programming

CA Rohrmann·dl

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF AUGUST, 1960

A. ORGANIZATION AND PERSONNEL

R. F. Ballard was reactivated from illness leave on August 1, 1960. T. E. Ludlow transferred to CPD effective August 8, 1960. T. M. Beasley, Engineer, was added to the rolls of Radiation Monitoring on August 15, 1960. The force of the Radiation Protection Operation totals 135.

B. ACTIVITIES

There were no cases of plutonium deposition confirmed during the month. The total on record remains at 262 of which 257 occurred at HAPO. There are 188 employees currently on the active rolls with plutonium deposition.

Several unusual badge film exposures were observed during the month. Two of these involved employees who wore their badges while undergoing diagnostic or therapeutic X-ray treatment. A third employee who had not entered any radiation zones had carried his wrist watch in a shirt pocket thereby exposing his badge to about seven (7) rads of beta radiation including 100 mr of gamma. Further investigation indicated a surface dose rate from the face of the watch of some 750 mrads/hr due to radium and daughter products on the luminous dial.

The badge disbursement building west of 300 Area and adjacent to the 3705 Building has been completed. It will be used primarily for self-service badge issuance to major construction workers.

The Whole Body Counter operated at 18% of capacity during the month. Operation was limited by new equipment installation problems and electronic maintenance difficulties. A detailed study of the capabilities of the plutonium wound counter revealed two items of interest. First, that plutonium could be spread throughout an area one centimeter in diameter and still be measured satisfactorily when a point source was used for calibration; and second, the positioning of a wound under the counter can be in error by as much as 0.8 cm without affecting the measurement.

Radiation Monitoring services were provided during inspection and testing of equipment at the Hot Semiworks in 200-E Area. Preparations are being made to staff the facility should plans materialize for reactivation of the building to separate fission products.

A fire occurred in a plutonium hood in the 234-5 Building on August 23, 1960. Process operators observed the fire as an orange flash and notified the fire department. The hood filters remained intact and the fire was practically extinguished before arrival of the fire department. Although the cause of the fire was uncertain, a ruptured cooling coil was suspected. No personnel nor air contamination resulted from the incident and no contamination was spread outside the hood.

Pneumatic loading of molten plutonium aluminum alloy into zircaloy tubing at 231 Building was interrupted when the tubing ruptured, resulting in a spread of contamination to the building duct level. There was no exposure of personnel; however, contamination in excess of 80,000 d/m per probe area occurred on the floor of the duct level. The contaminated area was cleaned to 5,000 d/m per probe area nonsmearable and the floor was repainted.

A body dose rate of 35 r/hr occurred at the 327 Building basin when an irradiated fuel element was inadvertently raised during cleaning operations. The individual's badge film dosimeter showed a dose of 135 mr which confirmed the estimated dose of 150 mr.

The control limit of 10 curies of I^{131} to the environs per seven-day period was exceeded for several periods during the period from August 5 through September 8, 1960. The average daily emission from the combined Purex and Redox plants was 2.2 curies per day with a maximum of 7.2 curies on September 8 and a maximum of 24.5 curies during any seven-day period. Environmental monitoring sampling data during the recent periods are not complete at this time. No undue amount of I^{131} was measured in the thyroids of locally slaughtered cattle during the past two weeks.

Concentrations of about 2×10^{-4} μc $(I^{131})/g$ of sheep thyroids were reported through the AEC Division of Biology and Medicine for animals slaughtered in Seattle on August 2, 1960. Investigation of Hanford effluent releases shows that the I^{131} emitted in early July may have been the source of the contamination. A release of about 19 curies on July 6 coincided with meteorological conditions which conceivably could have permitted the released effluents to move across the Cascade Mountain Range. Although this information is of considerable interest, the level of I^{131} activity reported was well below that which could be considered harmful. Experimental animals fed low chronic doses of I^{131} have shown no thyroid damage throughout their lifetime although carrying thyroid burdens 500 times higher than that detected in the Seattle sheep.

A British review of the Windscale Incident indicates 0.5 μc $(I^{131})/m^2$ on pasture grass results in a suggested maximum permissible emergency concentration of 0.065 μc $(I^{131})/l$ of milk. The capability of present aerial survey equipment to detect contamination on vegetation at this level is questionable. Improved detection limits should be possible by the use of a single channel gamma analyzer which is under modification for aerial survey use.

Discussions were held with Washington State Game Department representatives regarding the possibilities of conducting a census to determine the ultimate disposition of fish and waterfowl harvested by local sportsmen. As a result of these discussions, a proposed contract was prepared for comment.

A program to sample mud deposits behind the dams on the Columbia River is in the final stage of planning. A derrick and other mechanical equipment necessary to perform this work has been ordered.

Several prototype badges of the new Hanford design were fabricated. Examination of the prototypes has provided additional design insight. Efforts are being directed toward establishing a filter system capable of distinguishing between mixed doses of various gamma and beta energies. A solder filter composed of tin and lead has been found to exhibit a linear density-dose relationship from 82 keV to 1 meV. Attempts to extend the linearity to 60 keV by varying the filter composition and thickness are continuing.

The glass dosimetry study neared completion. The Bausch and Lomb microdosimeter reader was modified with the replacement of the micro-ampere meter with one of increased sensitivity and with provisions for the use of an external meter or chart recorder. The maximum error to be expected in dose evaluation with reasonably high energy gamma rays and this system ranges from $\pm$ 50% at 5 r or below, to $\pm$ 12% at 20 r, to $\pm$ 3% at 100 r or above. The useful range extends to some 10,000 r.

A 40 liter ionization chamber with a Keithley Electrometer was studied for effectiveness in aerial survey applications. Flights over the 3745 Building at elevations from 100 to 1,000 feet indicated that it was possible to detect a half-gram radium source when flying at 140 miles per hour at 1,000 feet with this equipment. The use of this large chamber to measure the dose rate at the field location where the Victoreen Model 362 and the stray radiation chambers are being studied indicated essential agreement between the stray radiation chambers and this large chamber device. Dose rates at locations within 50 yards of this test area varied from 9.5 μr/hr to 14 μr/hr.

C. EMPLOYEE RELATIONS

Five suggestions were submitted by personnel of the Radiation Protection Operation during the month bringing the year-to-date total to 27. One suggestion was evaluated and rejected. Ten suggestions submitted by RPO personnel are pending evaluation.

There was one medical treatment injury during the month for a frequency of 0.44. No security violations occurred during August.

Radiation protection training included: Completion of the training program for the AEC Radiological Physics Fellowship Students which included one lecture on Civil Defense and Plant Emergencies; two 2-hour orientation talks presented to Plutonium Metallurgy and Biology Research personnel; five orientation talks to varied employee groups; several round-table discussions on PRTR problems; and a continuation of the series of PRTR lectures presented to non-exempt employees.

D. SIGNIFICANT REPORTS

HW-65534 "Evaluation of Radiological Conditions in the Vicinity of Hanford" January through March, 1960, by Radiological Evaluation Working Group.

HW-66309 "Plutonium Contaminated Injury Case Study and Associated Use of Na_4EDTA as a Decontaminating Agent" by R. H. Wilson and W. B. Silker.

HW-66344 "A Study of Mortality from Congenital Malformation for Benton County, Washington" by R. C. Henle.

HW-66415 "Environmental Radiological Consequences of Increased Reactor Production" by I. C. Nelson.

HW-66420 "Analysis of Radiological Data for the Month of July, 1960" by R. L. Junkins.

HW-66088 "A Finger Ring Ionization Chamber for the Measurement of Production Plutonium Hand Dose" by L. G. Faust.

HW-66670 "Monthly Report - August 1960, Radiation Monitoring Operation" by A. J. Stevens.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-July 1960 - Mid-August 1960)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.3	% MPC_{GI}*
Separations Areas	Gross Beta	1.0×10^{-7}	µc/cc
Pasco	Isotopic	3.9	% MPC_{GI}**
Kennewick	Isotopic	1.0	% MPC_{GI}**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	8.0×10^{-9}***	µc/cc
100-F Area	Isotopic	1.0	% MPC_{GI}*
Hanford	Isotopic	1.2	% MPC_{GI}*
Pasco	Isotopic	9.0	% MPC_{GI}**
McNary Dam	Gross Beta	1.2×10^{-6}	µc/cc
Vancouver, Washington	Isotopic	0.4	% MPC_{GI}**
Atmosphere			
I^{131} Separations Areas	I^{131}	5.9×10^{-13}	µc/cc
I^{131} Separations Stacks	I^{131}	1.7	Combined curies/day
Active Particles - Project	--	1.8	ptle/100 m^3
Active Particles - Environs	--	0.3	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	2.0×10^{-6}	µc/gm
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/gm
Eastern Washington and Oregon	I^{131}	$< 1.5 \times 10^{-6}$	µc/gm
Fission Products less I^{131} - Wash. and Ore.	Gamma Emitters	$< 1.0 \times 10^{-5}$	µc/gm

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

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

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

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
August	0	0
1960 to Date	1	3

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
August	12,676	219	8	1
1960 to Date	125,196	1,696	30	8

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packe mrad(ow)	mr(s
August	10,268	850	198	50	42	15.79	14.9
1960 to Date	90,889	7,174	1,297	333	480	10.93	17.6

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
August	1,284	1	0	0	8
1960 to Date	8,029	3	0	0	34
Fast Neutron					
August	136	3	1	0	0
1960 to Date	1,210	76	30	0	21

Bioassay

	August	1960 to Date
Plutonium: Samples Assayed	404	5,243
Results above 2.2×10^{-8} µc/sample	27	325
Fission Products: Samples Assayed	429	5,164
Results above 3.1×10^{-5} µc FP/sample	7	10
Uranium: Samples Assayed	247	2,267
Confirmed Plutonium Deposition Cases	0	13*

Whole Body Counter

	Male	Female	August	1960 to Date
GE Employees				
Routine	31	4	35	568
Special	3	0	3	20
Terminal	0	0	0	1
Nonemployees	7	1	8	35
Pre-employment	3	0	3	8
Total	44	5	49	632

*This brings the total number of plutonium deposition cases which have occurred at Hanford to 257.

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples	Following Period of No Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples
Fuels Preparation	17	3.1	55	7.9	2.4	57
Fuels Preparation*	0	0	0	0	0	0
Hanford Laboratories	33	6.3	20	13	3.9	23
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	12	4.1	39	13	2.9	37
Chemical Processing*	21	4.9	7	16	3.3	5
Special Incidents	0	0	0	0	0	0
Random	14	5.1	4	0	0	0

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

Thyroid Checks	August	1960 to Date
Checks Taken	19	179
Checks above Detection Limit	2	5
Hand Checks		
Checks Taken - Alpha	29,562	251,926
- Beta-gamma	39,012	361,544
Skin Contamination		
Plutonium	22	171
Fission Products	33	304
Uranium	1	36

CALIBRATIONS

	Number of Units Calibrated August	1960 to Date
Portable Instruments		
CP Meter	970	7,271
Juno	284	2,370
GM	806	6,277
Other	152	1,428
Total	2,212	17,346
Personnel Meters		
Badge Film	1,800	11,302
Pencils	-	1,912
Other	475	3,387
Total	2,275	16,601
Miscellaneous Special Services	798	4,391
Total Number of Calibrations	5,285	38,338

A R Keene
Manager
Radiation Protection

AR Keene:VMM:kc

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - AUGUST, 1960

GENERAL

There was one security violation charged to the Operation.

There were no major injuries; the minor injury frequency rate was 3.77, which is considered about average experience for safety performance.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 17,150 hours. This includes 13,665 hours performed in the Technical Shops, 2,723 hours assigned to Minor Construction, 237 hours assigned to other project shops and 525 hours assigned to off-site vendors. Total shop backlog is 16,345 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 6.1% (1,095 hours) of the total available hours.

Distribution of time was as follows:

	Man-Hours	% of Total
Fuels Preparation Department	2,725	15.9
Irradiation Processing Department	657	3.8
Chemical Processing Department	870	5.0
Hanford Laboratories Operation	12,848	75.0
Construction Engineering & Utilities	22	.2
Miscellaneous	28	.1

Requests for emergency service remained at a higher than average level, requiring an overtime rate of 6.1%. However, a reduction of 2.4% was achieved over the previous period.

RADIOGRAPHIC TESTING OPERATION

Accomplishments

A total of 5,912 tests were made, of which 1,145 were radiographic (including x-ray and gamma-ray) and 4,767 were supplementary tests. Out of a total of 2,881 man-hours, 858 (29.8%) were in connection with radiographic tests, and 2,023 (70.2%) were used on supplementary tests. The supplementary test work included: magnetic particle; penetrant (fluorescent O.D. and I.D.); stress analysis; surface treatment (steam-detergent cleaning and vapor degreasing); and ultrasonic (flaw detection, core integrity, bond testing and thickness measurements).

The number of pieces handled this month totaled 4,613 items. The feet of material represented by these items amounted to 56,192 feet. Work on tubular components continued to account for a large percentage of the footage of material tested.

Work was done for 22 organizational components representing most of the operating departments and service organizations. A total of 47 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 35 different occasions for advice and information on general testing theory and applications for other than the jobs tabulated in Part II - Testing Statistics.

Work on the NPR process tubes is progressing slowly. Preparation of the facilities for the full-scale treatment and testing is taking longer than Kaiser Engineers had anticipated. Actual testing and treatment of NPR process tubes has proceeded as far as possible on existing equipment and on the tubes available. Delivery of new tubes has been curtailed to take advantage of premiums for quantity shipment.

Outstanding success has been achieved in making ultrasonic wall thickness measurements on the full-sized NPR process tubes. The recordings being obtained have yielded valuable information regarding the tube fabrication.

The first phase of the stress analysis work at the DR-reactor has been completed. This work consisted of preparation of gages and installation on the reactor.

Space has been acquired in the 314 building to allow the consolidation of sheath tube treatment and testing facilities. Considerable progress has been made in preparation of the area and the installation of equipment. Testing rates of 150 tubes per week are being approached with the existing facilities. Work on these tubes includes: vapor degreasing; steam-detergent cleaning; double ultrasonic scanning; and O.D. and I.D. fluorescent penetrant testing. At the present testing rate it has been possible to keep up with the incoming supply. Receipt of material from the tubing vendors has been sporadic.

Radiographic Testing personnel participated in an on-site course on the fundamentals of radiography presented by representatives of the Budd Company. The course was three days long, covering all aspects of radiography.

Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces	Description
CE&U	526	312	523	Film interpretation of radiographs Weed-X-Corporation of California to the PRTR site; Radiograph two 6' section of electrical cable to detect irregularities in the insulation and copper sheath.
HLO	3,952	52,234	3,844	Zr-2 clad UO_2 fuel rods; Thermocouple clusters; Single thermocouples; Zr-2 clad Pu Fuel rods; Unmachined TPU fuel rods; Machined TPU fuel rods; Radiograph thermocouples imbedded in iron oxide; Radiograph two sheaves and a crane hook; Radiograph fuel elements on birch fabrication and development program; Radiograph UO_2 fuel elements for UO_2 fuel element program; Radiograph of fuel elements for the palm fabrication and development program; .505" I.D. x .005" wall S/S tube; .495" I.D., Zr-4 tubes; .680" I.D., Zr-4 tubes; TPU fuel rods; 304-L, .005" wall S/S tubes; Fluorescent penetrant examination of two sheaves and a crane hook & pins; Magnetic particle test crane hook; Vidigage tests of Hastaloy, Inconel, Constanton, and S/S tubing; Vidigage NPR tubes; Vidigage on conditioned NPR tubes.
IPD	1,434	3,646	246	Radiograph welds on 2-1/2" sch 80 piping in 1706-KER Bldg.; Fluorescent penetrant tests 17 front face nozzles from 105-D reactor; Radiograph welds on the CEP-3 Loop in 1706-KER Bldg.; Radiograph pipe to bar weld 3/4" sch 160 pipe 1" thick bar; Radiograph welds on NPR dump system; Radiograph front face nozzles from 105-KW reactor; X-ray welds - NPR tubes; Fluorescent penetrant examination of 12 front face nozzles 2" O.D. x 12" long; Penetrant test "C" type ribless tubes; Stress analysis on the crossheaders (rear face) of 105-F reactor; Immerscope "C" type ribless tube.
Total	5,912	56,192	4,613	

CONSTRUCTION OPERATION

There were 50 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $178,067. Eighty new orders, 11 supplements and adjustments for underruns amounted to $98,124. Expenditures during the month on HLO work were $112,898 (Includes C.O. Cost). Total J. A. Jones backlog at month's end was $163,293.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of mo.	48	168,987	2	9,080
Issued during the mo. (Inc.Sup.& Adj)	80	95,724	0	2,400
J.A. Jones Expenditures during mo. (Inc.C.O. Costs)		109,027		3,871
Balance at month's end	63	155,684	2	7,609
Orders closed during month	65	83,246*	0	0*

* Face Value of Orders Closed

FACILITIES ENGINEERING OPERATION

Projects

There were 16 authorized projects at month's end with total authorized funds of $5,071,265. The total estimated cost of these projects is $7,026,000. There were no new projects authorized, one new project proposal submitted to the Commission and no projects completed this month. Approximately $2,300,000 of the authorized funds for project activity remain as unexpended at month's end.

The following summarized the status of FEO project activity:

Number of authorized projects at month's end	16
Number of new projects authorized during month	0
Projects completed during the month	0
New project proposals submitted to AEC during month CGH-907 Strontium-90 Interim Program	1
New projects awaiting AEC approval: CGH-832, Full Scale Physical Constants Testing Reactor CGH-874, Consolidation of Plutonium Metallurgy Facilities CAH-901, Structural Material Irradiation Test Equipment CGH-902, Uranium Scrap Burning Facility CGH-907, Strontium-90 Interim Program	5

The attached project report details the status of individual projects.

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals.

Title	Status
329 Building Ventilation Mod.	Work progressing to completion.
Pressure Vessel and Code Piping-Engineering & Inspection Service	This is a continuing work program on HLO vessels, pressure systems and related safety devices.
Laboratory Furnace Installation Room 39-B, 326 Building	Engineering and field work is complete.
Glove Boxes, 325 Building	Fabrication is complete and appurtenances are being installed. Installation in laboratory will start during September.
Equipment for Critical Mass Studies	Materials on order. Detail design is about 85% complete.
Fire Detection System - 314 Building	Installation work 85% complete.
Criticality Alarm - 300 Area	Installation work about 75% complete.
Reactor Effluent Filter - Pilot Test Facility - 100-D	Facility complete and filter tests are being performed.
Improvement to Animal Waste Disposal System	Design work complete. Field work in progress.
Horizontal Control Rod and Drive for Tamper Tank (Critical Mass)	Design work is progressing.
Study 325 Building Ventilation System	Engineering work in progress.
Ventilation Improvements to 325 Basement Mezzanine	Engineering work is complete. Field work will start during September.
Basement Access Enclosure - 325 Bldg.	Engineering work has started.
Air Conditioning Study - 222-U Bldg.	Engineering work has started.
Operating Spare Parts - 308 Building	List of spares being compiled.

Title	Status
Irradiation Studies Loop	Design complete. Fabrication in progress.
Breakaway Corrosion Loop	Design in progress.
Review of Pressure Systems PRTR	Primary and secondary systems nearing completion. Helium system will be next on the agenda.

Drafting and Design Services

Work load in central drafting room (3706 Building) is constant with heavy backlog. Branch offices in 306 and 308 Buildings have steady work loads with heavy backlog in 308 office.

Major design and drafting work in progress includes the following:

1. High Level Utility Cell - 327 Bldg. - Special Tools (50% complete).
2. PRTR Fuel Element Rupture Facility - Special design work of miscellaneous type.
3. PRP Critical Facility - Detail of in-cell piping, ventilation, instrumentation and electrical work (19 drwgs. - 90% complete).
4. Physical and Mechanical Properties Test Cell - 327 Building - Special equipment design (35 drawings - 40% complete).
5. Irradiation Studies Test Loop - "C" or "K" reactor (12 drawings required - work completed).
6. Structural Materials Irradiation Test Facility - Scope design - (25 drawings required - 30% complete).
7. Loading Dock Enclosure - 321 Building (3 drawings - completed).
8. Test Equipment for Gas Cooled Reactor - (10 drawings required - 50% complete).
9. Hot Semi Works Building - Cell equipment revisions - work started.
10. Fuel Element Wire wrapping machine (12 drawings required - 90% complete).
11. Shipping Cask - 500-gallon capacity - (80% complete).

In addition to the above work miscellaneous small design-drafting jobs are in progress.

Approximately 215 drawings including sketches, work sheets, and formal drawings were completed during the month of August.

Plant Maintenance and Operation

Costs

Maintenance	$ 18,976	97.0
Janitor Services	16,802	98.0
Operators	12,826	98.0
Utilities	35,986	102.0
Engrg. Serv. and Administration	5,582	94.0
Total	$ 90,172	99.0

Analysis of Costs

The costs for the first month of the fiscal year ran as expected.

Miscellaneous

Approximately 19,700 square feet of prints were reproduced during the month.

The total estimated value of the 12 requisitions issued during the month was $1,500.

Installation of six replacement hoods was completed at 747 Building, Bio-Assay Laboratory.

Intensive rehabilitiation of 306 Building heating and ventilating system was i initiated this month.

TECHNICAL INFORMATION OPERATION

A final draft of instructions concerning the handling of research and development reports resulting from HAPO subcontracts or ATH work agreements was completed and distributed to contract administrators and those responsible for technical liaison on ATH work. The release incorporated a number of suggestions from Departments who reviewed the preliminary draft.

A working draft of the proposed new document access system was distributed to HOO and HAPO personnel concerned with the problem. A meeting to discuss the new system has been arranged for early in September.

A program document setting forth the plan to automate the issuance, routing and mailing activities of the Classified Files was issued. Studies indicate that the project is feasible and offers an opportunity for cost reductions. Arrangements to obtain the required equipment are underway with operation of the new system by April-May, 1961.

Progress was made during the month on the Files' microfilming program. The new microfilming equipment ordered by the Records Center to handle the program is on-site. The additional equipment destined for Files' use --- the M & M readerprinter, the microfilm scanner, the jacketing machine --- is either on hand or in transit. The necessary work space is being readied at the Records Center. It is expected that the microfilming of Files' holdings can begin during September.

The HAPO Patent Attorney has developed instructions which will be printed in the personal notebooks issued to Plant personnel. Previously, the instructions for recording information which could constitute the subject matter of an invention, were distributed separately at the time a notebook was requested from Classified Files.

File Record Cards are now being made for all new UNCLASSIFIED microcards added to the collection. Previously, it had been decided not to make cards for each microcard but this proved to be a mistake. As time permits File Record Cards will be made for the unclassified micorcards already in the collection.

Technical Information was requested by Engineering Files to take over the responsibility for sets of aperture cards which contain microfilmed engineering drawings. Engineering Files had been handling each card separately. Normally, a number of drawings, thus a number of aperture cards, make up the file on any one project. Personnel in the field suggested that the cards be set up and handled as sets similar to the way sets of slides are handled. After some study it was agreed that it was not necessary for Technical Information to assume the responsibility for the aperture cards in order to change the procedure for their handling. Engineering Files agreed they could develop a procedure for handling sets of the cards under one identification number rather than controlling each card separately.

Work on declassification review of the older Hanford documents contained in Files proceeded smoothly during the month. Approximately 578 of the older documents were reviewed under the program.

Work was undertaken on stripping the Files Reference Catalog of personal author cards containing information indexed and available in Nuclear Science Abstracts. Over 8,000 cards have been pulled from the Catalog, representing a gain in space of more than five full Catalog drawers. This space is essential to keeping the Catalog within its present confines.

Material gathered last month for proposed lectures on Instruction Manual Writing proved useful in answering an off-site request for similar material to be used by the Fischer and Porter Company, Warminster, Pennsylvania, in establishing their own Standard Maintenance Manual procedures. A copy of the bibliography on Instruction Manuals, two photostats, and the lecture notes were forwarded to Fischer and Porter. Under separate cover, a typical HAPO Manual was also forwarded by Industrial Engineering, IPD.

At the request of the Specialist, Professional Placement, the Specialist, Technical Information Procedures undertook a study of the procedures of the HLO Professional Placement Office. A series of meetings is being held with Professional Placement personnel to discuss recommended changes and ways of automating certain of the routines. A report on the study will be prepared following conclusion of the meetings.

Work Volume Statistics

	July	August
Document Distribution and Files		
Documents routed and discharged (copies)	14,515	19,347
Documents issued (copies)	11,818	12,566
Documents sent off-site (copies)	6,687	7,597
Document reserves filled (copies)	634	667
Documents picked up and delivered	17,933	20,764
Document Accountability		
Holders of classified documents whose files were inventoried	642	307
Documents inventoried in Files (copies)	16,789	25,530
Documents destroyed or retired (copies)	2,967	4,561
Documents revised (copies)	1,441	1,164
Documents pulled and documents filed (copies)	9,476	8,041
Documents reclassified	545	663
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	214,807	215,465
Reference and Publication		
Books cataloged (new titles)	85	127
Books added to the collection (volumes)	230	296
Ready reference questions answered by professional staff	150	100
Literature searches by professional staff	90	89
Reports abstracted (titles)	207	304
Formal reports prepared (titles)	12	17
Off-site requests for HAPO reports (copies)	324	450
Reports released to CAP (titles)	28	48
Library Acquisitions and Circulation		
Books ordered (volumes)	446	244
Periodicals ordered	25	58
Books circulated (volumes)	1,704	1,676
Periodicals circulated (issues)	3,015	3,221
Inter-Library loans	84	72
Films borrowed or rented	11	12
Industrial film showings	61	65
Bound periodicals added to the collection	201	88

Library Collection

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	29,916	8,521	1,656	2,016	42,109
No. of bound periodicals	14,089	8	1,526	97	15,720
	44,005	8,529	3,182	2,113	57,829

Classification and Declassification	July	August
Documents, including drawings and photographs reviewed for downgrading or declassification	252	696
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	12	40
Documents submitted to Declassification Branch, Oak Ridge	8	265

J L Boyd

Manager
Laboratory Auxiliaries

JL Boyd:jw

HW-66[illegible] [illegible]

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

MONTHLY PROJECT REPORT

MANFORD LABORATORIES OPERATION

Period Ending August 26, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PERCENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CG-731	Critical Mass Laboratory		$1,000,000	100	100	5-22-58	----	2-26-59
		$990,000	3-23-59	100	100	6-4-59	6-30-60	6-30-60

USING COMPONENT: Reactor & Fuels R & D

PEC ENGINEER: DS Jackson

Project Engineer: DL Ballard

REMARKS:

Work by J. A. Jones forces is continuing on hoods and miscellaneous clean-up items. Final assembly of the reactor control system by Vendor has indicated some adjustment work is necessary.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PERCENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CA-744	Metallurgical Development Facility-306 Building		$2,685,000	100	100	6-30-58	----	9-30-59
		$2,650,000	11-5-58	100	100	3-20-59	9-1-60	9-1-60

USING COMPONENT: Reactor & Fuels R & D

PEC ENGINEER: JT Lloyd

Project Engineer: KA Clark

REMARKS:

Startup of the arc melt furnace is in progress. The project will be closed as of September 1, 1960, with exceptions. The punch list has been prepared for the remaining contractor work. Work is 100% complete.

Cost & Commitments to 8/14/60 $1,231,808

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PERCENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-822	Pressurized Gas Cooled Facility		$995,000	100	NS	8-19-59	----	4-29-60
		$995,000		100	8		7-31-60	NS

USING COMPONENT: Reactor & Fuels R & D

HLO ENGINEER: DP Schively

REMARKS:

Supplement No. 1 to the Phase "C" Construction, Specifications HWS-5595, has been issued for installation of the Phase "A" package by Minor Construction. The Phase "A" package is being fabricated by Struthers-Wells and is now approximately 98% complete.

Cost & Commitments to 8/14/60 $791,545

AM-7300-019 (4-60)

1247997

HW 66544 DEL

BUDGET CLASSIFICATION
Plutonium Recycle Test Reactor Facilities-58-e-35

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 6, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-841	High Pressure Loop	$1,375,000	$50,000*	0 / 0	0 / 0	4-12-59* / NS	--- / None	NS / None

USING COMPONENT: Reactor & Fuels R & D

HLO ENGINEER: JG Fox

REMARKS:

A revised project proposal is being held up pending a program review. A stop-charge action was issued, for all work on this project, on March 27, 1960. All costs of $30,385, incurred against this project were transferred to expense.

*Title I only.

Cost & Commitments to 8-14-60 $ 0

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-842	Critical Reactivity Measuring Facility	$360,000	$360,000	83 / 74	0 / 0	11-17-59	4-30-61	11-18-60 / 4-30-61

USING COMPONENT: Reactor & Fuels R & D

HLO ENGINEER: WS Kelly

REMARKS:

Building bids opened 8/17/60. George Grant Company was the low bidder. Lock bid awarded to Henry Pratt Company.

Cost & Commitments to 8-14-60 $43,377

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-867	Fuel Element Rupture Test Loop	$1,500,000	$730,000 7-26-60	10 / 10	0 / 0	8-1-60 Not Authorized	---	2-1-61 / ---

USING COMPONENT: Reactor & Fuels R & D

HLO ENGINEER: PF Walkup

REMARKS:

AEC Work Authorization No. CAH-867 dated 7-27-60 authorized G. E. Company $730,000 for design, Title III services, related management services, procurement and warehousing of long term and engineered materials, calibration of instruments, and utility tie-ins. Procurement started 8-15-60 for long term delivery items - heat exchangers, pumps, and circuitry pressure tubing. Bids opened 8-17-60 for 309 Annex Building.

Cost & Commitments to 8-14-60 $97,187

1247008

AM-7300-019 (4-60)

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 26, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION: AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT: CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE: DESIGN / CONST.
CGF-819	Increased Laboratory Waste Facilities 300 Area	$193,000	$193,765 2-19-60	100 100	NS 23	2-5-60 6-8-60	--- 5-31-61	5-1-60 2-1-61

USING COMPONENT: Chemical R & D

FEO ENGINEER: JJ Peterson

REMARKS:

Steam line has been installed and tested by the fixed price contractor. Insulation of the line is in progress. Excavation has started for the foundation on the storage building.

CPFF forces have excavated and poured footings for the load out building.

Cost & Commitments to 8-14-60 $131,021

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION: AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT: CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE: DESIGN / CONST.
CGF-860	Access for PRTR Fuel Elements - 327 Building	$81,000	$81,000 10-8-59	100 100	100 96	10-19-59 1-4-60	--- 8-15-60	4-1-60 9-15-60

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: JJ Peterson

REMARKS:

Lump Sum work was accepted on 8/12/60. CPFF forces are fabricating filter handling equipment. Work remaining to complete the project is not affecting building operations.

Cost & Commitments to 8-14-60 $65,372

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION: AMOUNT / DATE	PROJECT PROGRESS IN PER CENT: DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT: CONST. SCHED. / CONST. ACTUAL	STARTING DATE: DESIGN / CONST.	DIRECTIVE COMP. DATE: DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE: DESIGN / CONST.
CAH-864	Shielded Animal Monitoring Station - 100 F	$49,000	$52,000 4-18-60	100 100	100 85	10-22-59 5-5-60	--- 7-24-60	2-4-60 9-15-60

USING COMPONENT: Biology

FEO ENGINEER: JT Lloyd

REMARKS:

Plant forces installed the two transformers and messenger line. Installation of air conditioner is in progress. A. E. C. will consider raising it to furnish adequate headroom. Painting is in progress; also electrical work.

Cost & Commitments to 8-14-60 $11,027

AM-7300-019 (4-60)

BUDGET CLASSIFICATION
General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 26, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
				DESIGN	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CGH-874	Consolidation of Plutonium Metallurgical Facilities	$285,000	None	0	0	1*	---	5*
			None	0	0	2*	---	11*
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: JT Lloyd		

REMARKS:

A project proposal requesting authorization of the project and of total funds in the amount of $285,000, was submitted to HOO-AEC on 10-8-59.

*Months after authorization

Cost & Commitments to 8-14-60 $ 0

CGH-877	Pyrochemical Test Facility - 321-A Building	$70,000	$70,000	100	90	12-8-59	---	4-17-60
			11-17-59	100	82	2-17-60	9-30-60	9-30-60
		USING COMPONENT: Chemical R & D				FEO ENGINEER: RC Ingersoll		

REMARKS:

All hoods are in place and exhaust duct inside the building has been installed. The bottle storage is essentially complete. Piping and electrical work are proceeding.

Cost & Commitments to 8-14-60 $ 60,668

CAH-878	Additional Facilities for Isotope Study on Animals - 141 C Building Addition	$63,000	$66,000	100	100	12-7-59	---	4-17-60
			4-18-60	100	93	5-5-60	7-24-60	9-1-60
		USING COMPONENT: Biology				FEO ENGINEER: JT Lloyd		

REMARKS:

The new building has been erected and openings to present building are completed. Additional work on animal pens is required. The silo has not been erected. Installation of electrical system is in progress.

1248800

Cost & Commitments to 8-14-60 $5,606

HW 66644

BUDGET CLASSIFICATION
General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 26, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
				DESIGN	CONST.			
			AMOUNT	SCHED.	SCHED.	DESIGN	DESIGN	DESIGN
			DATE	ACTUAL	ACTUAL	CONST.	CONST.	CONST.
CAE-885	Geological & Hydrological Wells - FY 1960	$69,000	$69,000	100		2-15-60	---	4-1-60
			2-5-60	100	35	6-8-60	11-15-60	2-15-61

USING COMPONENT: Chemical R & D

FEO ENGINEER: HE Ralph

REMARKS:

Contractor is now 8 per cent behind schedule for HLO portion of contract. 750 feet of hole has been completed. Three rigs are operating two and twelve hour shifts in an attempt to meet our schedule.

Project Status: CAE-885 - 17% behind schedule
CAE-843 - 16% ahead of schedule
CAE-791 - 90% ahead of schedule.
Contract total - 35% complete (6% behind schedule)

Cost & Commitments to 8-14-60 $5,565

CAE-896	Stress Rupture Test Facility	$80,000	$7,500*	5	NS	7-29-60	---	12-15-60
			6-14-60	5	0	---	---	---

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RK Waldman

REMARKS:

Design is progressing according to schedule.

* Interim authorization for design only.

Cost & Commitments to 8-14-60 $5,013

CAE-902	Uranium Scrap Burning Facility	$36,000	None	0	0	2*	---	8*
			None	0	0	6*	---	38*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RK Waldman

REMARKS:

This project proposal was submitted to HOO-AEC for authorization on June 16, 1960.

* Weeks after authorization

Cost & Commitments to 8-14-60 $ 0

AM-7300-019 (4-60)

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 60-a-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 16, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-866	Shielded Analytical Laboratory 325 Building	$750,000	$60,000 / 5-31-60	21 / 21	0 / 0	6-27-60 / ---	NS / ---	11-31-60 / 1-1-62

USING COMPONENT: Chemical R & D

FEO ENGINEER: RW Dascenzo

REMARKS:

Preliminary design was completed on July 31, 1960. Title II is proceeding by the architect-engineer on all phases.

Cost & Committments to 8-14-60 $8,798

CAH-870	Facilities for Recovery of Radioactive Materials -325A Building	$486,000	$486,000 / 3-22-60	100 / 100	28 / 32	9-18-59 / 6-1-60	--- / 6-1-61	3-1-60 / 6-1-61

USING COMPONENT: Chemical R & D

FEO ENGINEER: RW Dascenzo

REMARKS: 1) Placed concrete in wall on N line to 400 ft-8 in. elevation. Concrete in Col. 4 line was not placed as conflict exists between A-E and contractor as to placement of structural steel flanges in concrete. 2) Second set concrete cover slabs were poured. 3) One load of structural steel was delivered to site. 4) Excavation for vaults was made. 5) Working slab under vaults was poured. 6) Concrete in Col. 4 was poured. 7) Forming is being completed for wainscoat wall. 8) The Royal Co. is installing duct work in the basement. 9) Vault A stainless steel liner has been completed. 10) Third placement of concrete for cover slabs was made. 11) Stripped forms on basement walls and backfilled about 7 ft. high on N. side of building.

Installation For Support of Bio-Medical Research - 60-h-1

Cost & Committments to 8-14-60 $24,185

CAH-888	Biology Laboratory Improvements	$340,000	$30,000 / 5-3-60	--- / 4	--- / ---	8-8-60 / ---	--- / ---	2-15-60 / ---

USING COMPONENT: Biology

FEO ENGINEER: JT Lloyd

REMARKS:

The architect-engineer, B. D. Rohna & Company, Inc. has completed two alternate arrangement drawings and submitted them for selection and/or comment. General Electric has decided on the original layout as was incorporated in the design criteria. The architect has been supplied with all drawings, specifications, Hanford Standards, tracing sheets and drawing and specification numbers requested by them. Results of trip to ANL for Irradiation Facility Scope are being studied.

1246002

Cost & Committments to 8-14-60 $7,332

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 61-a-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 26, 1960 7

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CAH-832	Full Scale Physical Constants Testing Reactor	$915,000	None / None	0 / 0	0 / 0	--- / ---	--- / ---	--- / ---

USING COMPONENT: Physics & Instruments R&D

FEO ENGINEER: RW Dascenzo

REMARKS:
No approval has been received from HOO-AEC on the preliminary project proposal requesting preliminary engineering funds.

Cost & Commitments to 8-14-60 $ 0

CGH-907	Strontium-90 Interim Program	$420,000	None / None	0 / 0	0 / 0	1/2* / 1*	--- / ---	3-1-61 ** / 3-1-61 **

USING COMPONENT: Chemical R & D

FEO ENGINEER: H. Radow

REMARKS: The project proposal has been submitted to the Commission and is being walked through to expedite the very earliest issuance of a Directive. The Work Determination has been received on the basis of the CPFF construction service contractor doing the work and arrangements have been made so that field work can start as soon as funds are made available.

* Months after authorization. ** Project Proposal Estimate

Cost & Commitments to 8-14-60 $ 0

Equipment Not Included in Construction Projects - Program Class 2900

CG-785	In-Reactor Studies Equipment 105-K Area	$325,000	$276,000 / 12-8-58	100 / 100	82 ** / 82	1-5-59 / 3-22-60	12-31-60	9-1-60* / 3-1-61*

USING COMPONENT: Reactor & Fuels R&D

FEO ENGINEER: H. Radow

REMARKS:

Full scale field activity has resumed with manpower back to the normal complement.

* Estimated total cost & completion dates in revised project proposal submitted to the Commission.
** Per current construction status schedule submitted to the Commission for approval.

Cost & Commitments to 8-14-60 $251,063

AM-7300-019 (4-60)

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 16, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / CONST. ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CGH-805	High Temperature Tensile Testing Cell - 327 Building	$170,000	$150,000 / 2-25-59	100 / 100	0 / 0	8-26-58 / 8-20-60	--- / 3-1-60	6-15-59 / 3-1-61
			USING COMPONENT: Reactor & Fuels R & D			FEO ENGINEER: RW Dascenzo		

REMARKS:
Procurement is continuing. Some difficulty has been encountered in the castings as to machine finishes. Also many of the castings have had porosity, greater than permitted under specifications, which has had to be corrected.

In order to evaluate the revised project proposal request, AEC requested additional information concerning the existing and future equipment. These data were furnished by letter to AEC.

Cost & Commitments to 8-14-60 $105,582

CGH-834	Modifications & Additions to High Pressure Heat Transfer Apparatus - 189-D Building	$700,000	$700,000 / 4-8-59	100 / 99*	87 / 85	4-20-59 / 4-22-59	/ 10-15-60	7-1-60 / 10-15-60
			USING COMPONENT: Reactor & Fuels R & D			FEO ENGINEER: H. Radow		

REMARKS:
It now appears that resumption of field activity cannot occur until late September at the earliest. This is due to a hold-up in vendor progress on the water storage vessel, caused by higher priorities on other defense orders.

*Final phase of design cannot be completed until vendor's design of the quick-acting valve assembly is finished.

Cost & Commitments to 8-14-60 $673,089

CGH-857	Physical and Mechanical Properties Testing Cell - 327 Building	$500,000	$75,000 / 10-1-59	55 / 55	0 / 0	10-20-59 / NS	--- / ---	12-1-60 / 7-1-63
			USING COMPONENT: Reactor & Fuels R & D			FEO ENGINEER: RW Dascenzo		

REMARKS:
The design schedule has been submitted to the AEC for approval. Detail design of the cell structure is continuing. The status of the equipment design is as follows:

Impact Testing Machine - 100 %
Universal Testing Machines - 50%
Fatigue Testing Machines - 50%
Electrical Resistivity Machines - 0% - No suitable design concept can be found.
Delatometer Machines - 0% - No suitable design concept can be found.
Creep Testing Machines - 90%

1246004

Cost & Commitments to 8-14-60 $24,802

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Phase 2000

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

Period Ending August 14, 1960

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED.	PROJECT PROGRESS IN PER CENT CONST. ACTUAL	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN	ESTIMATED OR ACTUAL COMP. DATE CONST.
CAH-358	High Level Utility Cell - 327 Building	$500,000	$70,000	5-1-59	55	45	0	0	10-20-59	NS	---	--	11-1-60	11-1-61

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: RW Dascenzo

REMARKS:

The design schedule has been submitted to AEC for approval. The detail design of the milling machine is being commented upon. Progress has been slow due to vacation schedules. Comment prints have also been issued on the cell structure.

Cost & Commitments to 8-14-60 $29,048

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT DESIGN ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED.	PROJECT PROGRESS IN PER CENT CONST. ACTUAL	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN	ESTIMATED OR ACTUAL COMP. DATE CONST.
CAH-901	Structural Material Irradiation Test Equipment - "ETR"	$125,000	None	---	0	0	0	0	9-15-60*	4-15-61*	---	None	3-1-61*	10-1-61*

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: DS Jackson

REMARKS:

A project proposal requesting authorization of the project, and total funds in the amount of $125,000, was submitted to HOO-AEC on 7-10-60.

* Based on AEC authorization by 9-1-60.

Cost & Commitments to 8-14-60 $ 0

USING COMPONENT

FEO ENGINEER

REMARKS:

AM-7300-019 (4-60)

1240005

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of August 31, 1960, the staff of the Hanford Laboratories totalled 1411 employees, including 680 exempt and 731 weekly salaried. Of the total, 585 possessed technical degrees, including 353 B.S., 129 M.S., and 103 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for August was 1.48 as compared with 1.97 for the preceding month. There were no disabling injuries or serious accidents during the month. There were 6 security violations, bringing the total for the year to date to 23, as compared with 31 for the corresponding period last year.

PROFESSIONAL PLACEMENT

One Ph.D. candidate visited Richland during the month for interview. Four offers were extended, and offers were accepted by an experienced Ph.D. botanist and an inexperienced Ph.D. chemist. A total of ten Ph.D. acceptances were received during the recruiting year beginning September 1, 1959 and ending August 31, 1960.

Five Technical Graduates were added to the rolls, six accepted permanent assignment and six terminated, including four Engineering and Science Program members, one military leave and one temporary summer employee. At month's end there were 78 Technical Graduates, including four members of the Engineering and Science Program and one Technician Trainee on program rolls.

The 1959-60 recruiting year officially was completed on August 31, 1960. For the Technical Graduate Program, 196 offers were extended and 82 acceptances were received. In the experienced category, 114 offers were extended and 65 acceptances were received. Included in this total are 28 offers for HLO components resulting in 18 acceptances.

EMPLOYMENT

Eighteen weekly salaried vacancies were filled during the month. At month's end there were 22 weekly salaried vacancies in HLO.

TRAINING

Twenty-seven HLO exempt employees completed the second section of "Technical Report Writing" under the instruction of Professor E. Elliott of the University of Washington.

for
Manager
Professional Placement
and Relations Practices

TG Marshall:lmh

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	July	Aug.
Requisitions		
At end of month	22	22
Cancelled	1	1
Received	19	19
Filled	23	18

Nonexempt Transfer Request	July	Aug.
Transfers		
Active cases at end of mo.	79	77
Cancelled	1	1
New	5	0
Effected	1	1

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to August 31, 1960

	Cases Considered	Visits to Richland: Invited	Visited	To Visit	Offers*: Extended	Accepted	Open	On the Roll**
Ph.D.	664	155	59	10	33	10	4	6
Exp. BS/MS	528	120	96	-	114	65	1	61
Prog. BS/MS	494	-	-	-	196	82	-	79

*Offer totals include offers open on 9/1/59
Ph.D. 3
Exp. BS/MS 6

** On the Roll totals include 1958/59 Carryover acceptances and one 1957/58 Ph.D. Carryover.

B. Technical Recruiting Activity - HLO - September 1, 1959 to August 31, 1960

	Cases Considered	Visits to Richland: Invited	Visited	To Visit	Offers*: Extended	Accepted	Open	On the Roll**
Ph.D.	664	155	59	10	27	9	2	5
Exp. BS/MS	256	27	20	-	28	18	1	16

In addition to the above activity, 20 exempt employees have transferred into HLO from other HAPO departments and 30 technical graduates have accepted Off-Program placement in HLO to August 31, 1960.

C - Technical Graduate and Technician Training Program
Month Ending August 31, 1960

	TG Program	TT Program
Number of Personnel on Assignment	78	1
(HAPO Tech Grad Program 74		
(Western District E.P. 4		
Distribution of Assignments by Departments		
HLO	23	0
IPD	31	1
FPD	12	0
CPD	7	0
CE&UO	4	0
C&AO	1	0
Distribution of Assignments by Function		
R&D or Engineering	46	1
Other	32	0

FINANCIAL OPERATION MONTHLY REPORT
AUGUST 1960

Personnel

There were no personnel changes during August.

Activities

GENERAL ACCOUNTING

Travel during the first two months of FY 1961 has not varied significantly from the same period in FY 1960. Number of trips for this period in FY 1960 was 192 trips compared to 184 trips in FY 1961.

A revised allocation of HAPO FY 1961 funds for attendance at Off-Site Courses and Seminars increased HLO allocation to $4,200, an increase of $700.

Approval was obtained for the transfer of fee funds within HLO as follows:

	Previous	Revised
Travel Variation	$ 500	$ (500)
All Other	7 100	8 100
	$ 7 600	$ 7 600

Expenditures and commitments for equipment for the first two months of FY 1961 are approximately the same as for FY 1960, however, our In Process Items (purchase requisitions and appropriation requests) this fiscal year are running ahead of FY 1960 by more than $100,000 which should indicate better performance in the second and third quarters.

Three hundred seventy-nine new movable cataloged equipment items were tagged and entered on record during the month. The total HLO movable cataloged equipment items at August 31, amounted to 12,337 representing a 100 percent increase since September 1956.

An inventory was taken of all movable cataloged equipment purchased under Projects CA-747, Plutonium Fabrication Pilot Plant and CG-731, Critical Mass Laboratory to prepare for project unitization and to establish both Financial and Custodial control of project purchased equipment. A total of 435 items were physically inventoried and tagged under these two projects. The inventorying and tagging of the equipment was accomplished with help from Contract and Accounting.

Reconciliation of the physical inventory of movable equipment in custody of Chemical Research and Development Operation is complete and a report of results was issued. Two thousand four hundred and two items valued at $1,859,343 were physically counted. Eight items valued at $2,024 were not located during the inventory. Thirty-seven items valued at $17,893 were inventoried which were not recorded in property records. The percentage of missing equipment to adjusted

book balance (0.33%) does not appear excessive, however, six of the eight missing items were charged to one Subsection, indicating a need for improved control. The inventory also revealed that there were a large number of equipment items which from all appearances had not been in use for some time. It was recommended that equipment for which an immediate need is not foreseen be transferred to the Laboratory Equipment Pool.

A summary report of findings in connection with the FY 1960 physical inventory of movable cataloged equipment in the custody of Hanford Laboratories was prepared and distributed. A comparison of the inventory balance $11,718,226 (11,721 items) with the adjusted book balance $11,726,818 (11,759 items) disclosed a shortage of 38 items valued at $8,592 compared with 24 missing items in FY 1959. Unrecorded items added to record during the fiscal year inventory totaled 194 items valued at $99,340 compared with 32 items valued at $8,118 in FY 1959. There is a need for increased vigilance on the part of custodians to minimize future losses and unrecorded equipment.

Preparations were completed and a procedure distributed for the annual physical inventory of precious metals and special materials to be taken on September 28, 29, and 30, 1960. This inventory will be witnessed and reconciled by Contract and Accounting personnel. To assist C&AO in preparing a detailed inventory schedule, a listing was prepared of all Sub-custodians (93), their location, type of materials on hand and quantities as of August 29, 1960.

Fifty-one items valued at $8,884 were received at the Laboratory Equipment Pool during the month of August. Three items valued at $960 were placed in lieu of placement requisitions. One item valued at $12,300 stored for the convenience of others was withdrawn and 17 items valued at $13,599 were received during the month. There are 437 items valued at $175,847 located in the storage area at month end.

Fourteen pieces of zirconium valued at $5,230 were received at the Laboratory Equipment Pool during August and 14 pieces valued at $1,820 were disbursed. The following materials were on hand at August 31, 1960:

Beryllium	$ 33
Palladium	995
Platinum	5 281
Silver	11
Zirconium	64 780
	$ 71 100

A listing of zirconium inventory by piece numbers, type of material and size physically located in the Laboratory Equipment Pool was distributed to HLO interested personnel.

Arrangements were made for the physical inventory of Hot Semi-Works to begin September 19, 1960. The physical count will include all fixed property within the perimeter of the Hot Semi-Works exclusion area fence, including movable property and the building which houses such property. The physical count of fixed assets will be taken by C&AO personnel assisted by HLO Financial and Custodial personnel.

The FY 1961 physical inventory of movable cataloged equipment began August 23, 1960, with the inventory of equipment in the custody of the Radiation Protection Operation. The field work in connection with the inventory count is scheduled to be completed September 17, 1960.

COST ACCOUNTING

The General Manager - HAPO on August 9, 1960, made the initial allocation of FY 1961 operating funds to HAPO components which was based on the Financial Plan received from HOO-AEC on July 21, 1960. Program amounts allocated to Hanford Laboratories were allocated to HLO Sections in a manner agreeable to the Section Managers and control budgets were established for Sections as follow:

(Amounts in Thousands)

Chemical Research and Development	$ 4 185
Reactor and Fuels Research and Development	10 719
Physics and Instrument Research and Development	2 286
Biology	1 310
Operations Research and Synthesis	396
Radiation Protection	2 012
Laboratory Auxiliaries	4 765
Financial	332
Professional Placement and Relations Practices	888
Programming	360
Assessments from HAPO	1 877
Intra HLO Eliminations	(3 727)
Total HLO Control Budget	$ 25 403

One program code was established and two were cancelled during the month as follow:

Program Code	Title	Remarks
.80	Neutron Flux Monitors	New research and development program sponsored by Division of Reactor Development.
.41	Metallurgy II	Both codes cancelled - category designations have been eliminated.
.51	Reactor II	

The preparation of expense codes ("I" work orders) for accumulating maintenance cost detail for PRTR operation is complete and will be incorporated in the IBM work order system starting October 1. This system will provide weekly cost detail by type of maintenance, by specific piece of equipment and monthly maintenance costs by process system within the reactor facility. At the

present time four types of maintenance (modifications, preventive maintenance, repair, and logged) and twenty-six process systems have been established for reporting purposes requiring approximately 800 expense codes.

Radiological Development Operation (7840) will utilize the work order system to segregate radiological development costs by functional categories. Twenty expense codes ("I" orders), each representing a functional category, were established on August 22, 1960, to separately identify salaries, materials and indirect expenses of the Radiological Development Operation. All personnel of this component will submit weekly Time Distribution Reports segregating their time to the appropriate "I" orders.

Arrangements were made with the Professional Placement and Relations Practices Operation to accumulate expenses associated with certain training programs conducted in HLO, e.g., Business Operations in Our Changing Environment and Professional Business Management I. A quarterly report will be prepared and submitted to Contract Accounting.

Action as indicated occurred on the following projects during the month:

Physical Completion Notices Issued

CA-747 Plutonium Fabrication Pilot Plant *

Construction Completion and Cost Closing Statements Issued

CAH-827 Automatic Columbia River Monitoring Station *
CAH-837 Animal Pens, Isolation and Examination Facilities *
CAH-847 Geological and Hydrological Wells, FY 1959 *

*AEM Services only.

There were 80 new authorizations for $51,578 and 11 supplements for $46,546 issued to J. A. Jones Construction Company during the month. Work was physically completed on 65 authorizations and 65 authorizations amounting to $163,293 were still open at month end.

GENERAL

The Audit of Travel and Living was completed. The activities audited were above satisfactory.

A competitive position study was started during the month. Letters containing the study procedure and requests for particpation were provided to Section Managers. It is expected that information collection through interviews with contributing scientists will begin early in September.

Thirty-three employees were on approved leave from Hanford Laboratories as of August 17, 1960, for reasons as indicated below:

	Exempt	Salaried	Total
Military Leave	9	2	11
Pregnancy	0	9	9
School	7	0	7
Illness	0	2	2
Personal	2	0	2
Lack of Work	0	2	2
Total	18	15	33

Information relative to school of first degree, course, year of graduation, post-graduate school, post-graduate course and highest degree attained is being assembled for reports required by Employee Compensation Services.

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 411	690	721
Additions and Transfers In	28	10	18
Removals and Transfers Out	28	20	8
Employees on Payroll at End of Month	1 411	680	731

Overtime Payments During Month	August	July
Exempt	$ 5 196	$ 6 071
Non-Exempt	17 428	14 165
	$22 624	$20 236

Gross Payroll Paid During Month		
Exempt	$583 584	$585 349
Non-Exempt	356 048	343 161
	$939 632	$928 510

Participation in Employee Benefit Plans at Month End	August		July	
	Number	Percent	Number	Percent
Pension Plan	1 223	99.5	1 209	99.4
Insurance Plan				
Personal Coverage	1 369	99.8	1 365	99.8
Dependent Coverage	979		975	
U.S. Savings Bonds				
Stock Bonus Plan	77	38.5	79	39.7
Savings Plan	90	6.4	90	6.4
Savings & Security Plan	1 060	83.7	1 062	83.7
Personal Accident Insurance	789	57.3	761	56.6

Insurance Claims	August		July	
	Number	Amount	Number	Amount
Employee Benefits				
Life Insurance	1	$14 781	0	$ 0
Weekly Sickness & Accident	16	855	21	909
Comprehensive Medical	28	2 715	47	4 131
Dependent Benefits				
Comprehensive Medical	57	5 038	128	12 249
Total	102	$23 389	196	$17 289

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
R. G. Wheeler	A Device for Locking Coaxial Nuclear Fuel Elements Together
J. T. Russell	Nuclear Particle Detectors
R. H. Moore	A Pyrochemical Process for Preparation, Reconstitution, and Decontamination of U-Al and Pu-Al Fuels (HW-66435)
R. H. Moore, W. L. Lyon	A Pyrochemical Process for the Separation and Recovery of Np and Pu (HW-66340)
F. M. Smith, R. P. Roberts	Recovery of Technetium from Neutralized Purex Waste Supernate
J. Dunn	Dissolver for Radioactive Materials
O. H. Koski	The Design of High Power Factor Low Frequency Induction Heaters
H. A. Treibs	Shield for CP Meter
Milton Lewis	A Nuclear Magnetic Deflection Apparatus for Isotope Separation
G. R. Bauer	Strip Film Cutting (July 14, 1960)
G. R. Bauer	Hoist for Lifting in a Confined Space

F. W. McBaugh for H. M. Parker